RURAL/URBAN DIVIDES IN MOBILE COVERAGE EXPANSION

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Abstract

The hypothesized benefits to individuals and households in developing countries of mobile technology include access to direct price, weather, and other valuable information and facilitating financial inclusion through digital financial services. Although the empirical support is thus far mixed, the World Bank (2012) details evidence of benefits from mobile technology in agriculture, health, finance, economic development, governance, education, and gender equality.

In this paper, we use the most recent available data to estimate access to mobile coverage, expressed as the percentage of the population that is covered both overall and in rural and urban areas, and use spatial analysis to identify where these populations are concentrated. We find that although mobile coverage has increased significantly in recent years, rates of coverage expansion are slowing as easier to reach urban populations are now almost entirely covered and the remaining uncovered populations are more dispersed in rural areas and therefore more difficult and costly to reach.

Remoteness and a lack of supporting infrastructure contribute to a high cost base for the proliferation of mobile networks in most of these uncovered areas. In addition, the potential return on investment is sometimes not favorable due to low population densities and a largely low-income customer base, hypothesized to slow (and potentially end) the expansion of mobile coverage by private mobile network operators (MNOs) in developing countries. Efforts to expand mobile access include government efforts to foster stable regulatory environments and promote competition among MNOs and the promotion of new mobile access technologies by private companies. But it is unclear how closely market liberalization is associated with coverage, and whether some form of subsidization or public provision is necessary to achieve universal coverage.

We test the assumption that levels of mobile coverage are related to the degree of market liberalization at the country level. We find no significant relationships between mobile coverage and the number of MNOs or the Herfindahl-Hirschman Index (HHI) of market concentration in the mobile industry, but a strong and significant relationship with the CPIA Business Regulatory Environment rating, an indicator of general market liberalization. This result indicates that general market liberalization to promote competitiveness in both the mobile industry and in complementary industries may support mobile coverage expansion.

We also find a strong negative relationship between mobile coverage and the rural proportion of the population, and a strong positive relationship between coverage and GNI per capita, highlighting the importance of demand side factors in coverage expansion. However, we cannot assess whether market liberalization alone will be sufficient to reach universal mobile coverage, especially for rural populations, without also increasing GNI per capita or subsidizing expansion costs to less profitable areas. Our findings have significant implications for policymakers, as without efforts to promote coverage expansion, the largely rural, agricultural, and low-income populations without mobile coverage are likely to be increasingly disadvantaged by their inability to access information and financial services, among other potential benefits of mobile technology.

Key words: mobile network; mobile coverage; competition; market liberalization; spatial analysis

Introduction

The Global System for Mobile Communications Association (GSMA) labels the 10 to 15 percent of the world's population estimated to lack access to mobile coverage as the "the final frontier of connectivity" (GSMA, 2014). This population of individuals is widely held to be primarily located in developing countries, and especially concentrated in rural areas. Remoteness and a lack of supporting infrastructure contribute to a high cost base for the proliferation of mobile networks in most of the areas that currently lack coverage (GSMA, 2015). In addition, the potential return on investment for mobile operators is sometimes not favorable due to low population densities and a largely low-income customer base (Buys, et al., 2009), hypothesized to slow (and potentially end) the expansion of mobile coverage by private mobile network operators (MNOs) in developing countries.

Reaching the "final frontier" in developing countries is an important policy issue, as mobile technology is associated with various positive economic and social outcomes (for reviews, see World Bank, 2012; Aker & Mbiti, 2010; Bhavnani et al., 2008). However, the absence of publicly available data limits our understanding of exactly where this uncovered population is, and how much coverage expansion is slowing. The most recent studies of mobile coverage and adoption across multiple developing countries present coverage data from 2010 (World Bank, 2012). Our first goal is to update the literature on the state of mobile coverage rates in developing countries in Africa and Asia. We use 2012 industry coverage data from the GSMA and Collins Bartholomew and population density data from LandScan to estimate access to mobile coverage, expressed as the percentage of the population that is covered both overall and in rural and urban areas.

Identifying currently uncovered populations is most important if market returns are insufficient to induce private companies to expand coverage. The potential revenue from these areas is unlikely to change dramatically, as population densities and income change slowly. Concerns about the commercial viability of expanding coverage to the "final frontier" has led analysts to focus on the supply side, and the cost of providing coverage. The GSMA mentions infrastructure sharing by network operators, use of renewable energy at cell sites, and the promotion of new mobile access technologies by private companies such as Google, Facebook, and Microsoft as possible ways to reduce costs (GSMA, 2015; GSMA, 2014). Other proposals for expanding mobile access focus on government efforts, including fostering stable regulatory environments, promoting privatization and competition among mobile service providers (Bhavnani et al., 2008; Buys, Dasgupta, Thomas, & Wheeler, 2009), using public finances to (co) fund roll-out in uneconomic rural areas, licensing of low frequency spectrum in combination with coverage obligations, and reducing taxes on mobile operators (GSMA, 2015). But it is unclear if market liberalization and innovation will suffice to reach universal coverage, of whether some form of subsidization or public provision is necessary.

Our paper is organized as follows: We begin by reviewing the literature on mobile coverage in developing countries, including factors hypothesized to support expanded coverage. Next, we use proprietary 2012 coverage data to update estimates of the number of people living outside of mobile coverage, and compare levels of coverage for urban and rural populations. We use spatial analysis to identify "uncovered" areas globally and in different regions of Africa and Asia. We overlay these coverage maps with data on population density to highlight areas with significant populations that do not have mobile coverage. We compare our coverage estimates to data from previous years and estimates from the most recent literature to provide a picture of

recent trends in coverage expansion. Our final contribution to the literature is a simple test of the assumption that levels of mobile coverage are related to the degree of market liberalization at the country level, as proxied by the number of mobile network operators, the Herfindahl-Hirschman Index (HHI) of concentration in the mobile industry, and the CPIA Business Regulatory Environment Rating.

Together, these contributions present an updated review of the state of mobile coverage in developing countries, to inform decisions of policy-makers and organizations interested in using mobile technology as a tool for development.

Literature Review

The hypothesized commercial benefits of mobile coverage, as recently classified in new work by Dillon, Aker, Blumenstock, & Kamazi (2015), include reducing price heterogeneity across markets (Aker, 2010; Aker & Fafchamps, 2010; Jensen, 2007; Rashid & Elder, 2009), providing direct price, weather and other valuable information to farmers (Aker & Mbiti, 2010; Dillon, 2011; Gakuru, Winters, & Stepman, 2009; Fafchamps, & Minten, 2010; Camacho & Conover, 2012; Nakasone, 2014) and facilitating financial transactions through mobile money (Kendall & Voorhies, 2014; Blumenstock, Eagle, & Fafchamps, 2014; Aker, 2014; Must & Ludewig, 2010; Scott, Batchelor, Ridley, & Jorgensen, 2004). The World Bank's 2012 "Maximizing Mobile" report details evidence of benefits from mobile technology in seven areas: agriculture, health, finance, economic development, governance, education, and gender equality. The empirical support is thus far mixed, though the widespread and rapid adoption of mobile phones suggests that the ability to communicate, if only among family and friends, has value to customers, even if applications to markets have been slower to emerge (Dillon et al., 2015).

Despite considerable activity over the past decade around the benefits of mobile access, less recent work has been done on mobile coverage in developing countries – possibly due to limited publicly available data. The latest country-level estimates of mobile coverage are in the World Bank's 2012 report, "Maximizing Mobile." The World Bank estimates that 90% of the overall global population had mobile coverage in 2010, though the average level of coverage is 94% of the population in a subset of 100 countries with data availability in 2010. The report analyzes these 100 selected countries and finds significant gains in coverage among low and middle income countries, from 82% of the population in 2005 to 91% in 2010. However, the report does not analyze whether or how trends in coverage expansion may be changing, and excludes many developing countries for which data were not available.

We do know that as of 2010 mobile coverage rates were continuing to increase across Africa and Asia, although the rate of increase was slowing as networks expanded into less economically viable areas, such as areas with low population density, low road density, or that are not connected to the country's electricity grid (Williams, Mayer, & Minges, 2011; Bhavnani et al., 2008). These trends are also reflected in the growth in unique mobile subscriptions, which was below 1% in Europe and North America but nearly 12% in sub-Saharan Africa in 2014 (GSMA, 2015). A 2010 study from the Center for Global Development reports that 60% of the population of sub-Saharan Africa had mobile phone coverage in 2008 compared to 10% in 1999.

Several studies find that coverage is strongly and positively associated with potential demand factors, such as population density and per capita income, and with the competitiveness of the mobile phone sector. However, cost drivers such as higher elevation and distance from main roads and urban centers are negatively associated with coverage expansion (Aker & Mbiti,

2010; Buys et al., 2009; World Bank, 2012; Williams et al., 2011). These demand and cost factors differ for rural and urban populations, leading to disparities in coverage expansion.

Much of the literature on mobile coverage contends that market liberalization is needed to expand mobile coverage (Buys et al., 2009; Donner, 2008). Most of this literature focuses on liberalization specifically in the mobile industry. Stovring (2004) contrasts the broad successes of liberalized, competitive mobile markets with the poorer record of many African nations' fixed-line privatization initiatives. Wallsten (2001) supports this analysis, reporting that between 1984 and 1997 competition from mobile providers in African and Latin America had more impact on overall telephone penetration than privatization of landline providers. Ibarguen (2003) argues that successful liberalization of the wireless spectrum in Guatemala has led to high mobile penetration rates, relative to other Latin American countries.

Many studies highlight the importance of competition between mobile network operators (MNOs). Varoudakis & Rossotto (2004) describe the relative lack of liberalization of mobile networks in the Middle East and North Africa, and find a relationship between higher levels of mobile penetration in competitive markets like Jordan and Egypt than in less competitive ones like Iran, Syria, and Libya. Aker & Mbiti (2010) suggest that the increase in mobile coverage in Africa is related to changes in the mobile market structure of African countries. In 1999, 85% of African countries provided all international mobile traffic through an incumbent monopoly, and under 10% of countries had fully liberalized markets where MNOs were granted their own international gateway licenses. By 2009, nearly 50% of African countries had fully liberalized markets, around 25% had partially deregulated markets, and under 30% still had mobile network monopolies. The World Bank (2012) finds that even in countries with low mobile tariffs, lack of competition between MNOs leads to lower mobile coverage, limiting mobile access. Williams et

al. (2011) report that although most countries have at least three operators, evidence exists that most countries can support more operators. Further, they find that once a country issues its fourth mobile license, penetration rates increase by an average of about four percentage points per year. The authors argue that the most important factor for increasing universal access will be maintaining competition between network providers.

Two studies explore the effects on mobile coverage of more general market liberalization. Bhavnani et al. (2008) report that the main driver of mobile coverage growth is private sector investment, assisted by favorable enabling legal and regulatory environments. However, they find that in many developing countries, regulatory policies and a lack of functioning institutional mechanisms hinder competition and private sector involvement in the provision of ICT infrastructure and services, especially to rural communities. Buys et al. (2009) investigate the determinants of disparities in mobile coverage in sub-Saharan Africa and report that improvements in a general market competitiveness index are strongly related to increased mobile coverage.

Several studies contend that market liberalization alone is not sufficient to achieve universal mobile coverage. This line of research separates the market inefficiency gap, which can be addressed through market liberalization, and the "true access gap" in coverage for populations that will not be served "even with the most optimal, efficient and liberalized market conditions" (Dymond & Oestmann, 2003, p. 58). The World Bank's approach to financing telecommunications infrastructure in the developing world follows this logic, prioritizing market liberalization and recommending targeted intervention only when necessary (World Bank, 2006). The GSMA (2015) argues that while coverage has expanded further and faster in markets with network competition, governments should undertake complementary measures to incentivize

expansion to rural areas where private MNOs may not see an opportunity for profit. Buys et al. (2009) argue that the market will not expand coverage to certain populations and regions without specific mandates or incentives by the government or other stakeholders. While the authors find that a generalized improvement in competition policy could lead to huge improvements in cell phone area coverage in sub-Saharan Africa, their simulation suggests that coverage expansion would be concentrated in areas with relatively dense populations, leaving a coverage gap for low-density rural populations.

Williams et al. (2011) estimate that eight percent of Africa's population lives in areas that would be unprofitable to service. They find that a total expenditure of $15.5 billion would be required over the course of eight years to expand basic GSM network coverage to Africa's entire population. Of this $15.5 billion, nearly half, $6.9 billion, would cover areas that are rated as potentially commercially viable, but the authors argue that "even in the most favorable policy and incentive environment, in most countries in Africa a small but significant proportion of the population will be found in areas that are not commercially viable" (p. 194), requiring some form of direct financial subsidy as an incentive for MNOs to expand into these areas. They maintain that competition between MNOs should be supported by providing commercial incentives for operators through tax policies, such as reducing taxes on equipment and on ICT services for remote or rural areas. They also advocate for subsidizing emerging technologies such as low-capacity coverage extenders, lower-frequency bands, extended coverage base stations, and solar power supplies for base stations. Furthermore, they argue for implementing cost-reduction strategies for operators such as implementing regulatory measures for infrastructure sharing between operators, power sharing, contractual agreements between operators to sell power into local or national grids, and lifting restrictions on skilled staff mobility.

In this paper, we review trends in mobile coverage to analyze the gap between urban and rural coverage. Next, we test the hypotheses that mobile-specific or general market liberalization are associated with higher levels of mobile coverage by evaluating the relationship between mobile coverage and three indicators of market liberalization: the number of MNOs, the Herfindahl-Hirschman Index (HHI) for the mobile industry, and the CPIA Business Regulatory Environment Rating.

Mobile Coverage Estimates Methodology

We determine the spatial extent of mobile coverage using 2012 data from Collins Bartholomew in ESRI shapefile format and WGS84 datum, provided by the data visualization organization SpatialDev. Collins Bartholomew is a private research firm that uses industry-reported coverage data primarily from the GSMA. These data are self-reported by mobile network providers and include metrics on the performance of 1,140 operators and 1,153 MNOs across 3,505 networks, 65 groups, and 236 countries worldwide. The GSMA data only includes providers who choose to submit their data, so Collins Bartholomew supplements these with data obtained directly from telecommunications companies and national telecommunications regulatory providers. Although all the coverage estimates remain self-reported, the Collins Bartholomew data are the most recent and accurate data available.

We use the LandScan 2012 High Resolution Global Population Data Set to layer population density over the coverage data, which allows us to estimate the number of people living outside of mobile coverage areas, accurate to within one square kilometer. Our analysis also uses data from the Global Rural-Urban Mapping Project, Version 1 (GRUMPv1) to analyze rural and urban populations living inside and outside of mobile coverage. Urban and rural areas

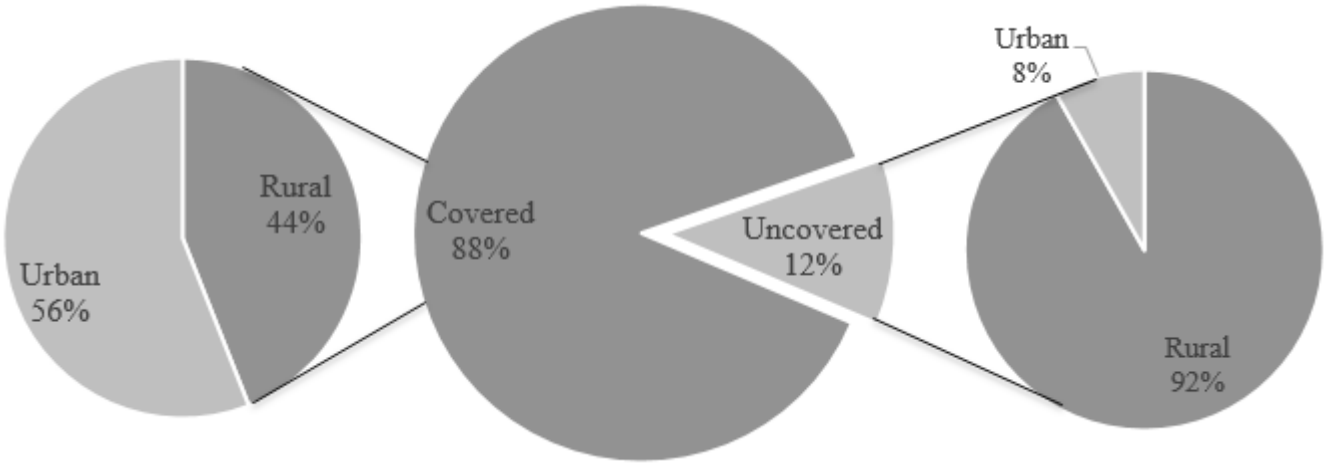
are estimated at a 30 arc-second resolution, producing 1 km grids that define designations using a combination of variables: population counts, settlement points, and the presence of nighttime lights. Urban refers to contiguous lighted cells or approximate urban extents based on buffered settlement points for which the total population is greater than 5,000.

Using these data, we assess the current state of mobile coverage globally and in selected regions. Where the data are available, we also compare current levels of coverage with earlier estimates from the GSMA or from previous studies. This analysis answers questions about the current extent of mobile coverage, where populations lacking mobile coverage are located geographically, and how coverage has expanded in developing countries. "Original estimates" in the tables that follow refer to those either provided directly by SpatialDev using Collins Bartholomew coverage data, or our adaptations additionally using GRUMPv1 and LandScan population data.

Global and Regional Mobile Coverage Estimates

Our analysis of 2012 data on population density from LandScan and mobile coverage from Collins Bartholomew indicates that 11.7% of the world's population, a total of just under 821 million people, live in areas without mobile coverage. Using GRUMPv1 data we find that of that 11.7% without mobile coverage, 91.8% are located in rural areas. In contrast, just 44% of the population with mobile coverage live in rural areas. Since 49.6% of the world's population are located in rural areas, it is clear that the main coverage gap exists for rural populations.

Figure 1. *Percentages of world population with and without mobile coverage.*



Source: Original estimates.

We compare the mobile coverage figures from our analysis to estimates from the literature of coverage in previous years. Since much of the literature focuses on mobile coverage in sub-Saharan Africa, we also include estimates of coverage in this region. These estimates are presented along with our original estimates in Table 1.

Table 1. *Estimates of the percentage of the population with mobile coverage, 1999-2012*

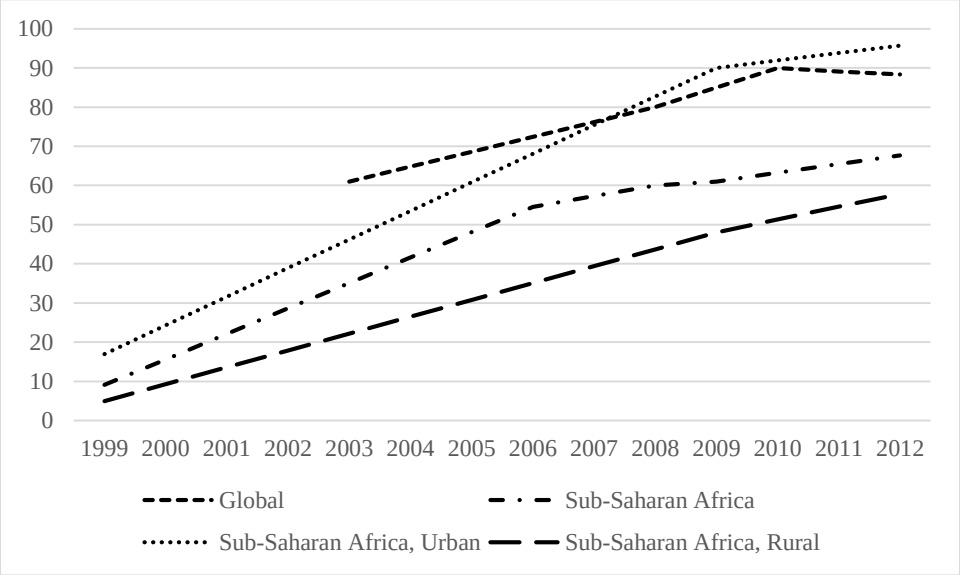
Year	1999	2003	2006	2008	2009	2010	2012
Global		61 [c]		80 [d]		90 [c]	88.3 [f]
Sub-Saharan Africa	9.1 [a,b]		54.5 [a]	60 [e]	61 [b]		67.7 [f]
Sub-Saharan Africa, Urban	17 [b]				90 [b]		95.7 [f]
Sub-Saharan Africa, Rural	5 [b]				48 [b]		57.8 [f]

[a] Buys et al., 2009
[b] Williams et al., 2010
[c] World Bank, 2012
[d] Bhavnani et al., 2008
[e] Aker & Mbiti, 2010
[f] Original estimates

Figure 2 illustrates the changes in mobile coverage using the estimates from Table 1. The global population that lives in areas with mobile coverage increased by over 27 percentage points between 2003 and 2012. This change in coverage represents a three percentage point average increase per year during this time period. If we divide the period in two relatively equal parts, we find a 3.8 percentage point average annual increase between 2003 and 2008, and a 2.1 percentage

point average annual increase between 2008 and 2012. The rate of coverage expansion in this period is brought down by the decrease in the estimate of the percentage of the world population with mobile coverage between 2010 and 2012[1].

Figure 2*. Trends in percentage of the population with mobile coverage, 1999-2012*



Source: This figure was developed using the coverage estimates from Table 1. Values for years with no coverage data were estimated using the average change in mobile coverage between the years where coverage data estimates were available.

In sub-Saharan Africa, 9.1 percent of the population had mobile coverage in 1999 compared to 67.7 percent in 2012, a 58.6 percentage point increase over 13 years. If we again divide this period into two parts, we find that mobile coverage increased by an average of 6.5 percentage points per year between 1999 and 2006, but by just 2.2 percentage points per year between 2006 and 2012. An analysis of the trends in mobile coverage in urban and rural areas in sub-Saharan Africa reinforces our finding that most of the remaining coverage expansion will

[1] The 2010 estimate that 90% of the world's population had mobile coverage was taken from the International Telecommunication Union (ITU). The fall in estimated coverage between 2010 and 2012 may be due to the use of different coverage data between the ITU and Collins Bartholomew, our data source. However, it is possible that coverage did fall. For example, population growth rates in areas without mobile coverage may have exceeded population growth in areas with mobile coverage, which is likely since most areas without mobile coverage are in developing countries with higher fertility rates. We cannot confirm the actual reason for the fall in reported mobile coverage with the data available.

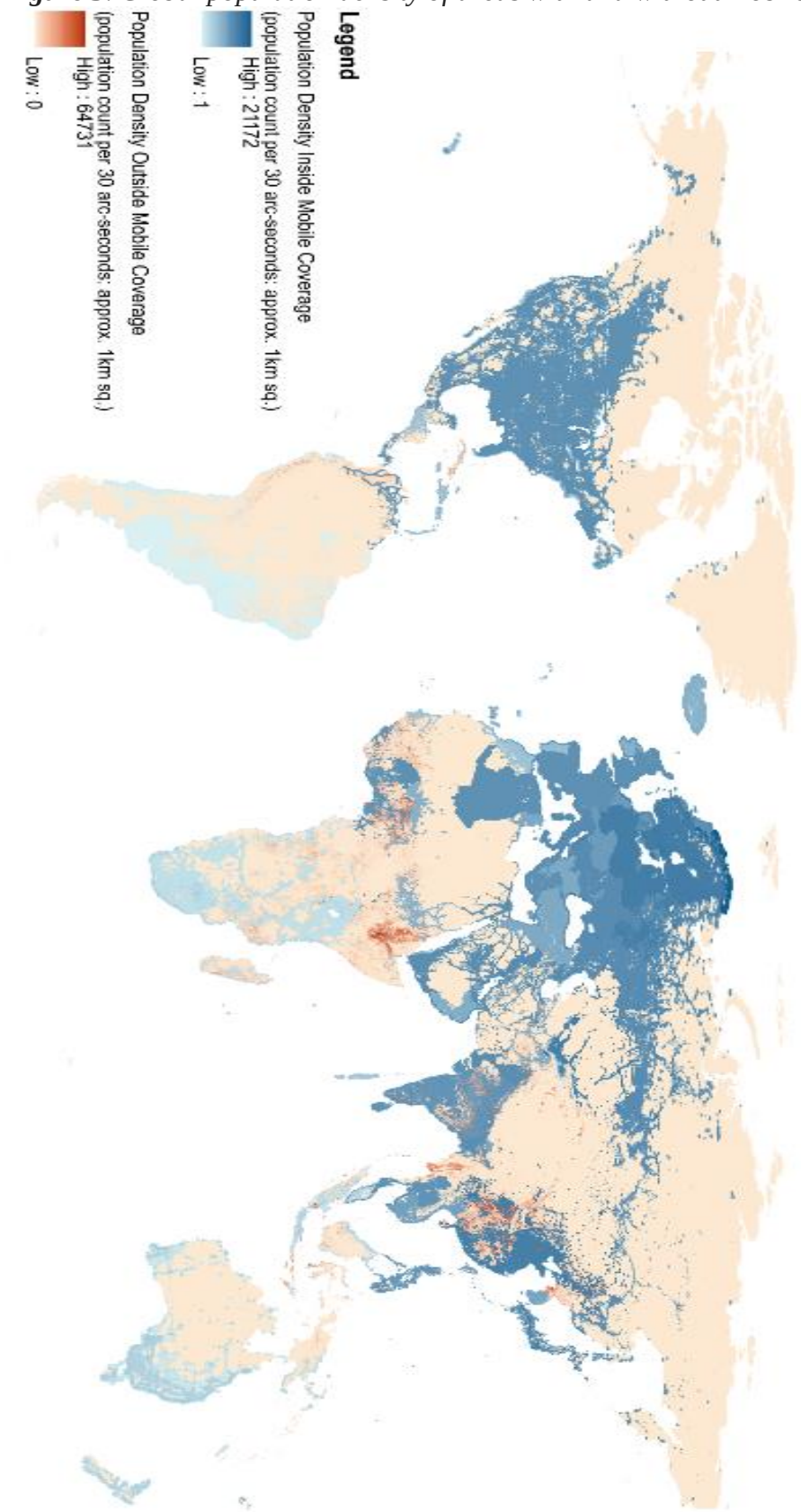
need to take place in rural areas. While rural mobile coverage has greatly increased, the majority of the expansion of coverage to date has taken place in urban areas. The percentage of the urban population in sub-Saharan Africa with mobile coverage increased from 17 in 1999 to 95.7 in 2012, an increase of 78.7 percentage points over 13 years. For rural populations, the percentage with mobile coverage increased by 52.8 percentage points over this time period. As more of the urban population has gained mobile coverage, the overall rate of coverage expansion has slowed, to just 1.9 percentage points per year between 2009 and 2012. While the rate of coverage expansion to rural populations is higher, it is still relatively low at 3.3 percentage points per year.

If the rate of global coverage expansion from 2008 to 2012 continued, global mobile coverage would reach 100 percent by 2018. However, extrapolating the rate of coverage expansion in sub-Saharan Africa indicates that this is unlikely to happen. If coverage expansion continued at the same rate as the average from 2006 to 2012, mobile coverage in sub-Saharan Africa would not reach 100 percent of the population until 2027. Moreover, it is unlikely that coverage will continue to expand at historical rates, as seen by the decreasing rate of coverage expansion in more recent years as easier to reach and more densely populated areas are increasingly covered.

The populations living without mobile coverage are not spread evenly in rural areas, and future rates of coverage expansion will depend on the characteristics of where these populations are located. Figure 3 presents a map of global population density in areas with and without mobile coverage. Populations with mobile coverage are shaded in blue, with more densely populated areas represented by darker shadings. Populations without mobile coverage are shaded in orange. The figure shows that the majority of the populations in North America, Europe, Australia, and the Middle East and North Africa live in areas with mobile coverage. There are

some small concentrations of populations without mobile coverage in South America, Southern Africa, and Central Asia, but the majority of the global population without mobile coverage is concentrated in East, West, and Central Africa and in South, East and Southeast Asia.

Figure 3. *Global population density of areas with and without mobile coverage.*



Source: SpatialDev, 2014.

Table 2 presents 2012 estimates of mobile coverage in selected global regions representing 69.6% of the world's population living outside of coverage[2]. The majority of the uncovered populations in these regions are located in rural areas. In all regions except for East Africa, less than 5% of the urban population lacks mobile coverage[3]. On the other hand, a much larger percentage of the rural populations do not have coverage. These patterns indicate that continued coverage expansion in these regions will become more difficult and costly as MNOs move from covering the densely-concentrated urban populations with relatively good infrastructure to more dispersed rural populations.

Table 2. *Regional mobile coverage estimates (2012)*

Region	Percent of World's Population Living Outside Coverage	Number of People in Region Living Outside of Coverage (Millions)	Percent of Population in Region Outside Coverage	Percent of Rural Population in Region Outside Coverage	Percent of Urban Population in Region Outside Coverage
West Africa	9.7%	79.2	24.6%	34.2%	1.4%
Southern Africa	1.7%	13.7	14.7%	26.7%	0.5%
Central Africa	8.1%	66.2	45.6%	61.7%	4.7%
East Africa	14.6%	119.4	39.5%	44.5%	13.2%
North Africa	1.1%	8.9	4.4%	11.3%	0.4%
Central America & Caribbean	1.1%	9.4	11.1%	20.0%	4.0%
South America	5.4%	44.4	11.2%	33.5%	2.4%
South Asia	17.0%	139.3	8.0%	12.0%	1.4%
Southeast Asia	11.1%	90.8	14.7%	22.0%	3.7%
Total, Selected Regions	69.6%	571.3	-	-	-

Source: Original estimates.

[2] The majority of the remaining 30.4% are located in East Asia and particularly in China

[3] Ethiopia alone accounts for nearly 10% of the world's uncovered population, and over 68% of the population living outside of coverage in East Africa, and is characterized by a large proportion of the urban population without mobile coverage. According to Williams et al. (2011), a key contributing factor to the low rate of coverage in Ethiopia is the communications monopoly enjoyed by Ethio Telecom, the state-owned telecommunications company. The network has announced plans to partner with Ericsson, Huawei, and ZTE to expand coverage in Ethiopia to 85% of the population (Geeska Afrika Online, 2014), but we do not have access to data on coverage levels more recent than 2012.

The rural areas into which mobile networks are now expanding are generally characterized by low population density, low road density, difficult geography, and lack of proximate electricity grids (Williams et al., 2011; Bhavnani et al., 2008). These factors could all combine to continue to decrease the rate of coverage expansion, as market forces no longer provide a sufficient incentive for MNOs to expand. Several studies argue that some form of government intervention may therefore be required to reach the remaining populations without mobile coverage (Dymond & Oestmann, 2003; Buys et al., 2009; Williams et al., 2011).

Mobile Coverage and Market Liberalization Methodology

A recurring argument in the literature is that mobile network liberalization would lead to higher levels of mobile coverage. Buys et al. (2009) use a competitiveness index from the World Bank's Country Policy and Institutional Assessment (CPIA) database as their indicator of market liberalization, and find that spatial modeling in 41 sub-Saharan African countries indicates that improvements in competitiveness were strongly associated with the likelihood of mobile coverage in a given area. The authors test the robustness of their findings using the Herfindahl-Hirschman Index (HHI) of mobile market concentration instead of the CPIA competitiveness index in a subset of 24 countries for which the HHI was available, and the results support their findings.

Our analysis builds on the Buys et al. (2009) study, using 2010 data on mobile coverage, mobile network liberalization, and market size from the World Bank's 2012 "Maximizing Mobile" report. Our interest is in whether different measures of competitiveness are similarly associated with mobile coverage. The mobile coverage data in the report measure "the percentage of people within range of a mobile cellular signal regardless of whether they are

subscribers" and are from the International Telecommunication Union (ITU)[4]. We use these data on mobile coverage rather than 2012 data from Collins Bartholomew in order to ensure that the data from all variables used in our analyses are from the same year: 2010.

The "Maximizing Mobile" report includes data on two indicators of mobile network liberalization, the number of mobile network operators (MNOs) and the Herfindahl-Hirschman Index for the mobile industry. The number of mobile operators refers to nationwide "licensed mobile cellular service providers that have their own network infrastructure as opposed to other mobile service providers who lease it" (World Bank, 2012). This distinction is relevant as some MNOs lease mobile towers from private companies rather than owning their own. In this situation, MNOs would not directly drive coverage expansion, as they depend on the companies providing the infrastructure. Limiting the measure of the number of mobile operators to just those with their own network infrastructure makes it more likely that a greater number of MNOs would be associated with greater mobile network coverage.

Although we hypothesize that additional MNOs may support increased mobile coverage, there are several reasons why this might not be the case. The areas covered by different MNOs are likely to overlap as they compete over the same customers in less costly areas, rather than expanding to uncovered but costly to reach areas. In addition, it is possible that countries with a higher level of mobile coverage could be able to accommodate a greater number of MNOs, making it difficult to determine the direction of causation between the number of MNOs and mobile coverage. It is also not clear that more MNOs increase competition relative to two competitive MNOs. In other words, we should not expect competition to necessarily be increasing after the entry of a second MNO.

[4] We are not able to locate any additional data on mobile coverage on the ITU website.

Our second indicator of mobile network liberalization is the Herfindahl-Hirschman Index (HHI). The HHI measures the size of firms in relation to a particular industry, and is a commonly accepted measure of market concentration. The HHI is computed as the sum of squares of the market share of each firm competing in the market and is measured on a scale from 1-10,000. For the mobile market, market share is calculated based on the number of mobile subscribers. An HHI rating of 10,000 indicates no competition, or a monopoly, and a rating of 5,000 indicates a duopoly with each operator having half of the market share. The data on mobile operators and the HHI are from ictDATA.org.

The HHI is likely a better proxy of mobile market liberalization as it measures market concentration and competition in the mobile industry and therefore incorporates the number of MNOs. However, the HHI does not reflect the full policy environment around mobile telecommunications, which could include subsidies to domestic MNOs, barriers to foreign investment, mobile tariffs, limitations on spectrum availability, restrictions on skilled staff mobility, and regulations for developing or sharing infrastructure. Such policies could restrict coverage expansion even in countries with a high level of competition among existing MNOs in the areas already covered. In addition, regulations for developing or sharing infrastructure could impact the extent to which MNOs are responsible for coverage expansion, as in some countries it may be the government or other private companies that build mobile towers and then lease them to MNOs.

Our sample is too small and the distribution of mobile coverage too skewed to confidently conduct any regression analysis, but we can confirm some expected associations. We expect that mobile coverage should increase as the number of MNOs increases, as countries with a monopoly may have less incentive to expand coverage to less profitable areas, while countries

with more MNOs may seek market share through expanding coverage. For the same reasons, we expect that an increase in the mobile HHI, which implies less competition within the mobile industry, would be associated with a decrease in the level of mobile coverage. However, it is possible that causation could flow in both directions as countries with a higher level of mobile coverage may be able to accommodate a larger number of MNOs and foster a more competitive mobile industry.

Buys et al. (2009) use ratings of "Competitive Environment for the Private Sector" from the 2003-2004 World Bank CPIA as their indicator of market liberalization. The CPIA no longer collects data on this particular measure, so we use 2010 data for the "Business Regulatory Environment Rating" (BRE rating), the closest current CPIA rating to that used by Buys et al., as a third indicator of market liberalization. This rating assesses "the extent to which the legal, regulatory, and policy environments help or hinder private businesses in investing, creating jobs, and becoming more productive." Countries are rated on a scale from one to six, with a six indicating a highly supportive regulatory environment for business activity (World DataBank, 2010). A country's BRE rating is based on regulation affecting entry, exit, and competition, regulation of ongoing business operations, and regulation of factor markets (labor and land). Appendix A includes additional specific information on how the BRE rating is calculated. Although the BRE rating is not specific to the mobile industry, we would predict that countries with a higher BRE rating would have higher levels of mobile coverage, as mobile operators would be supported in expanding coverage wherever it was profitable.

Buys et al. (2009) include the natural log of GNI per capita as an indicator of demand for mobile coverage. The "Maximizing Mobile" report includes 2010 figures for GNI per capita using data from the World Bank. We expect that higher GNI per capita would be associated with

increased mobile coverage, as the MNOs could obtain higher profits by expanding coverage to populations with high average incomes. Further, countries with higher GNI per capita are likely to have more supporting infrastructure, such as roads and electricity grids, to enable mobile coverage expansion.

The Buys et al. (2009) study also includes total population as a measure of demand influencing the likelihood of mobile coverage in a given area. Since our dependent variable is the percentage of the population with mobile coverage rather than coverage in a given area, this measure is not appropriate in our analysis. We cannot hypothesize that an increase in population size would increase or decrease the percentage of the population with coverage, as the market response would depend on how spread out the demand for coverage is. As a result, we use the rural proportion of the population as our measure of population that influences mobile coverage. The "Maximizing Mobile" report includes 2010 data for the rural proportion of the population, as defined by national statistical offices, from the United Nations. We anticipate that a larger rural population as a percentage of the total would be associated with a lower level of mobile coverage, as the costs of expanding coverage in rural areas is greater and a smaller proportion of the population is covered by each increase in geographic area covered.

Our analysis serves as a macro-level test of the findings from Buys et al. (2009), looking at country-level rather than sub-national mobile coverage. The World Bank's "Maximizing Mobile" (2012) dataset includes 155 countries, of which 112 have data on mobile coverage. This sample includes 39 of the 41 sub-Saharan African countries analyzed by Buys et al. (2009)[5], but also includes middle- and high-income countries. Data for the 2010 CPIA Business Regulatory Environment rating are available for 80 developing countries, but just 36 of these countries have

[5] The report does not include mobile coverage data for Gabon and Namibia.

mobile coverage data in the "Maximizing Mobile" report. The data for all 112 countries in our sample are included in Appendix B. Table 5 reports summary statistics for this sample. All data are from 2010.

***Table 5**. Summary statistics*

Variable	N	Mean	Std. Dev.	Min.	Max.
CPIA BRE Rating [a]	36	3.32	0.81	1.5	5.5
GNI per capita (2010 US$) [b]	109	14,043	17,601	170	87,350
Rural Population (% of Total) [b]	109	40.19	22.48	0	89
Number of Mobile Operators [b]	109	3.42	1.17	1	8
Herfindahl-Hirschman Index (HHI) [b]	103	4,114.69	1,409.19	1,393	10,000
Mobile Coverage (% of the Total Population) [b]	112	93.09	12.35	32	100

[a] World DataBank, 2012
[b] World Bank, 2012

To evaluate the relationship between mobile market liberalization and mobile coverage, we first conduct pairwise correlations between mobile coverage, our three indicators of mobile market liberalization, GNI per capita, and the rural proportion of the population. Next, we qualitatively analyze the relationship between mobile coverage and each of our indicators of market liberalization individually by looking at trends in our sample. Finally, we conduct one-way analyses of variance (ANOVA) to determine whether levels of mobile coverage significantly change at different levels of market liberalization, for each of our three indicators as well as for GNI per capita and the rural proportion of the population.

Results

Table 6 presents the pairwise correlations[6] between mobile coverage, our three indicators of mobile market liberalization, GNI per capita, and the rural proportion of the population.

[6] Listwise deletion eliminates from all correlations any observations with a missing value for any of the variables. This process would result in a sample of just 33 countries with data for all variables. We therefore use pairwise

Unexpectedly, the number of MNOs has a negative correlation with mobile coverage, but the correlation is weak. The HHI has the expected sign and has a stronger correlation with mobile coverage, indicating that concentration of mobile market share has a greater influence than just the number of operators. However, the more general indicator of market liberalization, the CPIA BRE rating, is more strongly correlated with mobile coverage than both indicators that are specific to mobile network liberalization. We also find that GNI per capita has a strong positive correlation with mobile coverage, while the rural proportion of the population has a strong negative correlation, as hypothesized. These variables are, however, strongly correlated with each other, and with the CPIA BRE rating. Overall, these results suggest that wealthier, more urban countries with more liberalized markets are associated with higher levels of mobile coverage.

***Table 6**. Pairwise correlation matrix (number of observations in parentheses)*

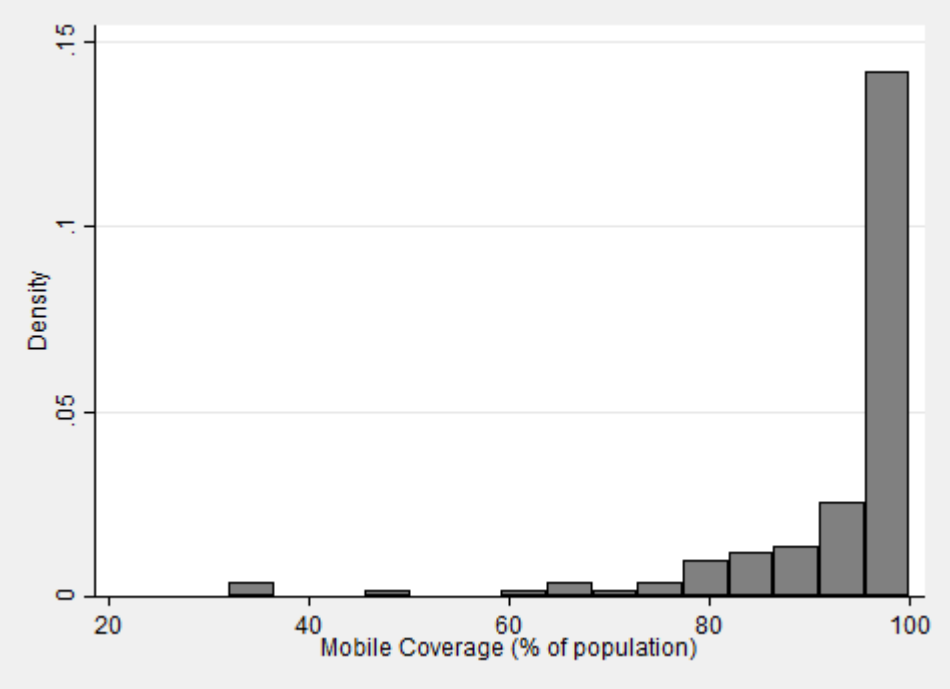
Variables	Mobile Coverage (% of the total population)	Number of MNOs	Herfindahl-Hirschman Index (HHI)	CPIA BRE Rating	GNI per capita	Rural Population (% of Total
Mobile Coverage (% of the Total Population)	1					
Number of MNOs	-0.0509 (109)	1				
Herfindahl-Hirschman Index (HHI)	-0.1565 (103)	-0.6919 (103)	1			
CPIA BRE Rating	0.4671 (36)	0.1860 (35)	-0.2804 (33)	1		
GNI per capita	0.3781 (109)	-0.1210 (106)	-0.1657 (100)	0.4769 (36)	1	
Rural Population (% of Total)	-0.4558 (109)	0.2220 (106)	0.1605 (103)	-0.3278 (34)	-0.5753 (106)	1

Our finding that the correlation is stronger between mobile coverage and the CPIA BRE rating than with our mobile-specific indicators of market liberalization is perhaps not surprising,

deletion, where a pair of data points are deleted from the calculation of the correlation only if one (or both) of the data points in that pair is missing.

as national regulations affecting entry, exit, and competition and regulations of business operations likely influence the number of MNOs and the distribution of mobile market share. Table 6 shows that there is a correlation between a more liberalized business regulatory environment and both a greater number of MNOs and more competition in mobile market share (lower HHI). This result is consistent with the argument that removal of restrictions on entry into the mobile market is related to higher levels of mobile coverage (Aker & Mbiti, 2010; Williams, Mayer, & Minges, 2011). However, it is surprising that the mobile-specific indicators of market liberalization do not seem to be strongly related to mobile coverage.

Figure 5. *Distribution of mobile coverage in sample of 112 countries*



To more closely evaluate the relationship between mobile coverage and our three indicators of mobile market liberalization, we explore whether different levels of mobile coverage appear to be associated with different levels of market liberalization. As shown in Figure 5, the level of mobile coverage is not evenly distributed in our sample. We therefore divide our sample into countries with full mobile coverage (100% of the population), countries

approaching full coverage (95-99%), countries with high coverage (90-94%), countries with medium coverage (80-89%), and countries with lower coverage (below 80%). Tables 7, 8, and 9 present summary statistics at each of these levels of mobile coverage for the number of MNOs, the HHI, and the CPIA BRE rating, respectively.

Table 7. *Number of MNOs at different levels of mobile coverage (n=109)*

Level of Mobile Coverage	Number of Countries	Average Mobile Coverage	Number of MNOs			
			Minimum	Maximum	Median	Mean
100 %	40	100	1	5	3	3.2
95-99 %	35	97.9	2	7	3	3.5
90-94 %	14	91.4	1	5	3	3.4
80-89 %	11	83.2	2	8	4	4.2
<80 %	9	60.0	1	5	3	3.2

We do not find any significant variation in the median or mean number of MNOs as the level of mobile coverage goes down (Table 7). In fact, the mean number of MNOs is the same both for countries with full mobile coverage and for countries with less than 80% mobile coverage. One exception is that we see a higher mean number of MNOs for countries with 80-89% mobile coverage, likely explained by including India, which has eight MNOs (the highest number in our sample) and 83% mobile coverage. If India is removed from the group of countries with 80-89% coverage, the mean number of MNOs in that group falls to 3.8. These results suggest that there is no relationship between the number of MNOs and mobile coverage.

Table 8. *Herfindahl-Hirschman Index (HHI) at different levels of mobile coverage (n=103)*

Level of Mobile Coverage	Number of Countries	Average Mobile Coverage	Herfindahl-Hirschman Index (HHI)			
			Minimum	Maximum	Median	Mean
100 %	39	100	2,495	6,429	3,780	3,921
95-99 %	34	97.9	2,354	6,800	3,718	3,907
90-94 %	12	91.5	2,282	10,000	3,655	4,955
80-89 %	11	83.2	1,393	5,625	3,871	2,899
<80 %	7	57.1	3,242	10,000	4,826	5,141

Using a share rather than count measure in Table 8, we find somewhat more variation in the median and mean HHI as mobile coverage goes down, but this variation remains limited. We unexpectedly see a lower HHI (indicating greater mobile market competition) for countries with 80-89% mobile coverage, but this can again be explained by including India, which has an HHI of 1,393 and 83% coverage. With India removed, the mean HHI in that group of countries rises to 4,120. We do observe a higher HHI in the group with the lowest levels of coverage, but it is not significantly different from the group with 90-94% coverage. The higher mean HHIs in these groups of countries are largely explained by several countries with an HHI of 10,000, meaning there is just one MNO with a monopoly on the mobile market. These results indicate at most a weak relationship between the HHI and mobile coverage.

Table 9. *CPIA Business Regulatory Environment (BRE) rating at different levels of mobile coverage (n=36)*

Level of Mobile Coverage	Number of Countries	Average Mobile Coverage	CPIA BRE Rating			
			Minimum	Maximum	Median	Mean
100 %	2	100	4	4	4	4
95-99 %	6	98.2	3.5	5.5	4	4.2
90-94 %	9	91.3	2	4	3.5	3.3
80-89 %	11	83.2	2	4.5	3.5	3.2
<80 %	8	58.3	1.5	4.5	3	2.8

Table 9 shows a steady trend of lower median and mean BRE ratings as the level of mobile coverage goes down. This finding suggests a strong relationship between mobile coverage and a more liberalized business regulatory environment, in contrast with the previous two indicators of mobile-specific market liberalization.

To test whether levels of mobile coverage significantly change at different levels of market liberalization, we conduct one-way analyses of variance (ANOVA). For comparison, we also conduct ANOVA tests with GNI per capita and the rural proportion of the population. For

each ANOVA test, we divide our sample into quintiles using the *egen* command in Stata, specifying the division of our sample into five groups by percentile for the independent variable. The results of the ANOVA tests are summarized in Table 10.

***Table 10**. Results of one-way ANOVA for mobile coverage and indicators of market liberalization*

Variable	SS	df	MS	F	Prob > F
Number of MNOs	1072.69	4	268.17	1.83	0.128
HHI	1274.87	4	318.72	2.27	0.068
CPIA BRE Rating	3778.77	4	944.69	5.06	0.003
GNI per capita	5715.82	4	1428.96	13.37	0.000
Rural Population (% of Total)	3695.87	4	923.97	7.95	0.000

We find that there is not a statistically significant difference in mobile coverage between groups with different numbers of MNOs ($p = 0.128$), supporting the simple correlations above. There is a significant difference (at the 90% confidence level, $p = 0.068$) in mobile coverage between groups with different HHI levels. Again, we find that the relationship is strongest between mobile coverage and the CPIA BRE rating, with a statistically significant difference between groups at the 99% confidence level ($p = 0.003$).

We also find statistically significant differences between groups for GNI per capita and the rural proportion of the population ($p < 0.001$). These results align with our initial pairwise correlations, though the ANOVA tests indicate that differences in GNI per capita are most closely related to differences in mobile coverage, followed by differences in the rural proportion of the population and the CPIA BRE rating, contrary to the pairwise correlation which suggested that the relationship was strongest between mobile coverage and CPIA BRE rating.

Discussion

We find that of the 11.7% of the world's population without mobile coverage, 91.8% are located in rural areas. Mobile coverage expansion rates are slowing as MNOs move from covering the densely-concentrated urban populations with relatively good infrastructure to more dispersed rural populations that are more difficult and costly to reach. For example, sub-Saharan Africa experienced a 58.6 percentage point increase in mobile coverage between 1999 and 2012. However, if we divide this period into two parts, we find that mobile coverage increased by an average of 6.5 percentage points per year between 1999 and 2006, but by just 2.2 percentage points per year between 2006 and 2012, as coverage in urban areas reached 95.7% in 2012 compared to 57.8% in rural areas. In our analyses of the global regions with the majority of the world's uncovered populations, we find that in all regions except for East Africa (due to the very low rates of coverage in Ethiopia), less than 5% of the urban population lacks mobile coverage.

Several studies have argued that mobile network liberalization, or allowing greater competition between MNOs, would lead to higher levels of mobile coverage (Aker & Mbiti, 2010; Bhavanani et al., 2008; Buys et al., 2009; Donner, 2008; Ibarguen, 2003; Varoudakis & Rossotto, 2004; World Bank, 2012). The extent to which this relationship holds would significantly influence the policy recommendations for how to promote universal mobile coverage, from taking a more active role in promoting and subsidizing coverage expansion to allowing market forces to push expansion.

Using data for 112 countries from the World Bank's 2012 "Maximizing Mobile" report, we find that two indicators of mobile network liberalization, the number of mobile network operators and the Herfindahl-Hirschman Index (HHI) of mobile market concentration, are not significantly associated with the proportion of a country's population with mobile coverage.

Pairwise correlation shows limited relationships between mobile coverage and the number of MNOs and the HHI, and ANOVA tests show that differences in the number of MNOs and the HHI are not significantly related to differences in mobile coverage. On the other hand, we find a strong and significant relationship between mobile coverage and the CPIA Business Regulatory Environment rating, an indicator of general market liberalization, from both pairwise correlation and ANOVA. This result indicates that mobile-specific market liberalization will likely not be sufficient to expand mobile coverage to all of the populations that currently lack it, and that more general market liberalization to promote competitiveness in both the mobile industry and in complementary industries may be required.

A limitation of our analyses is that our sample may not be representative of all developing countries, where the issue of increasing mobile coverage is more relevant. The World Bank's "Maximizing Mobile" (2012) dataset includes many middle- and high-income countries, and coverage data are more readily available for these countries than for developing countries. Appendix C compares summary statistics for our sample and the countries that did not have coverage data. We find that the countries in our sample on average have significantly more MNOs, lower HHI scores, higher CPIA BRE ratings, higher GNI per capita, and less rural populations. The World Bank's "Maximizing Mobile" (2012) report estimates that global mobile coverage in 2010 was 90% of the population, while the mean level of coverage in our sample is 93%. This difference indicates that the countries not included in our sample have lower levels of mobile coverage, on average. As our findings indicate that lower levels of mobile coverage are associated with lower CPIA BRE ratings, lower GNI per capita, and more rural populations, and as we observe these characteristics in the countries not included in our sample, we expect that

including the 43 countries without mobile coverage in our analysis would likely further support our findings.

Our results support those of Buys et al. (2009) who contend that market liberalization can be expected to support mobile coverage expansion. Our analysis cannot, however, evaluate the arguments of Dymond & Oestmann (2003), Buys et al. (2009), and Williams et al. (2011) that market liberalization alone may not be sufficient to expand mobile coverage to the "final frontier." Our findings suggest that improving the business regulatory environment will likely increase mobile coverage, but we cannot assess whether market liberalization alone will be sufficient to reach universal mobile coverage without also increasing GNI per capita, which is positively and significantly associated with mobile coverage. The most current data on mobile coverage shows that the remaining populations outside of mobile coverage are largely rural, and the literature indicates that these populations are more costly to reach due to low population density, difficult geography, and lack of supporting infrastructure (Williams et al., 2011; Bhavnani et al., 2008). As Williams et al. (2011) and others contend, in the absence of significant increases in rural income or decreases in the costs of reaching rural populations, some form of government support or subsidy may be required in order to achieve universal mobile coverage.

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Appendix A. Calculation of CPIA Business Regulatory Environment Rating[7]

The Country Policy and Institutional Assessment (CPIA) is an annual rating of countries against a set of 16 criteria grouped in four clusters: economic management, structural policies, policies for social inclusion and equity, and public sector management and institutions. The CPIA covers 95 countries in the following regions: East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, South Asia, and Sub-Saharan Africa. The CPIA was significantly revised in 2004, reducing the number of criteria from 20 to 16 and changing the ratings from a 5 to a 6 point scale, and introducing an equal weighting procedure for calculating the CPIA. One of the criteria that was eliminated was the Competitive Environment for the Private Sector used by Buys et al. (2009) as their indicator of market liberalization.

The CPIA "ratings process ratings process involves two key phases. In the benchmarking phase a small, representative sample of countries drawn from all Regions is rated; in the second phase, staff rate the remaining countries using benchmark countries' scores as guideposts." According to the World Bank Operations Policy and Country Services department, "The benchmarking phase helps ensure that, given the criteria, the ratings are set at the right level and are consistent across countries and Regions." Following the benchmarking phase, "Country teams prepare ratings proposals that are accompanied by a written justification. These proposals are reviewed within the respective Region by the Chief Economist and then submitted to a Bankwide review by the Networks and Central Departments."

The 16 CPIA criteria are grouped into four clusters: Economic Management, Structural Policies, Policies for Social Inclusion and Equity, and Public Sector Management and Institutions. The Business Regulatory Environment criterion is included under Structural Policies. For each criterion, countries are rated on a scale of 1 (low) to 6 (high), and "a 1 rating corresponds to a very weak performance, and a 6

[7] Derived from the World Bank Operations Policy and Country Services' 2010 CPIA Assessment Questionnaire.

rating to a very strong performance. Intermediate scores of 1.5, 2.5, 3.5, 4.5 and 5.5 may also be given." The World Bank stipulates that "Country scores should reflect a variety of indicators, observations, and judgments that are based on country knowledge originated in the Bank, analytic work or policy dialogue, or work done by partners, and relevant publicly available indicators."

The 2010 CPIA Assessment Questionnaire includes the following instructions for calculating the Business Regulatory Environment criterion:

> "This criterion assesses the extent to which the legal, regulatory, and policy environment helps or hinders private business in investing, creating jobs, and becoming more productive. The emphasis is on direct regulations of business activity and regulation of goods and factor markets. Three subcomponents are measured: (a) regulations affecting entry, exit, and competition; (b) regulations of ongoing business operations; and (c) regulations of factor markets (labor and land). These three components should be considered separately and equally weighted. Macroeconomic aspects are covered in criteria 1 to 3; trade factors are assessed in criterion 4. Some business environment related issues are covered in criterion 12, namely discretion and lack of transparency in obtaining business licenses. Issues related to access to credit are assessed in criterion 5."

The 2010 CPIA Assessment Questionnaire includes details of the criteria to use in rating the Business Regulatory Environment. These criteria are included below for reference.

1. a) Extensive bans on, or complex licensing of, investment. Procedures to enter and exit are extremely difficult and costly. No legal framework to address anti-competitive conduct by firms in naturally competitive markets. Public sector entities are required to purchase only from state firms.
   b) Extremely burdensome operational licensing, permits, inspections, and other compliance systems, including taxes and customs. Goods markets are highly restricted, e.g. through extensive state ownership in competitive sectors, widespread price controls, or the state makes administrative allocation/decisions about production. No, or weak requirements on ownership and financial disclosure, few or no shareholder protections; those that exist are not enforced.
   c) Extensive labor market controls and rigidity of labor regulation. Private land ownership is illegal or severely curtailed. Very few businesses have formal title or use rights to land. Process to register property extremely costly.

2. a) Many bans on, or complex licensing of, investment. Procedures to enter and exit economic activities are very costly. Very limited legal framework to address anti-competitive conduct by firms in naturally competitive markets. Public entities are required to purchase many goods and services only from state firms.

b) Burdensome operational licensing, permits, inspections and other compliance systems, including taxes and customs. A market for goods exists, but there is significant state intervention, e.g. a significant presence of regulated parastatals in product markets and/or significant subsidies on major commodities. Weak regulations on ownership and financial disclosure, few shareholder protections; those that exist are not effectively enforced.
c) Very rigid employment regulations and other labor institutions that significantly depress formal employment. Private land ownership curtailed by restrictive land use rights and distortions from property market controls. Many businesses do not have formal title or use rights to land. Process to register property is very costly.

3. a) Few bans on investment, but there are complex licensing requirements for many activities. Procedures to enter and exit many economic activities are costly. Legal framework to address anti-competitive conduct by firms exists, but there is no effective enforcement. Public sector entities are not formally required to purchase exclusively from state firms, but there is widespread implicit pressure to do so.
   b) Operational licensing, permits, inspections and other compliance systems, including those related to taxes and customs, are moderately burdensome in some sectors. A market for goods exists, but there is some state intervention through controls and/or subsidies/taxes. Inadequate regulations on ownership and financial disclosure; those that exist are sometimes not enforced effectively.
   c) Rigid employment regulations and other labor institutions depress formal employment. Private land ownership permitted with very few restrictions or distortions from property market controls, but in practice some businesses do not have formal title or use rights to land. Process to register property is costly.

4. a) Licensing requirements for most activities eliminated or streamlined, but remain problematic in some cases. Few barriers to entry and exit for most activities, but barriers remain for some. Good legal framework to address anticompetitive conduct by firms exists, and enforcement is often, but not always, effective. Public entities are free to procure from any source, but there is occasional interference.
   b) Operational licensing, permits, compliance and inspection requirements, including those related to taxes and customs, impose few burdens on business. Little direct state intervention in goods markets through controls and/or subsidies, but there some market imperfections are not addressed, e.g. high concentration ratios in industries enjoying some trade protection or producing non-tradable goods. No significant parastatals in product markets. Corporate governance laws generally encourage disclosure and protect shareholder rights, although enforcement requires improvement.
   c) Employment law is reasonably flexible, but there are some labor market institutions that depress formal employment in some sectors. No legal/institutional barriers to land ownership, but land markets could be distorted by significant monopolistic elements. Registering property is

reasonably easy

5. a) Very few bans or investment licensing requirements. Few barriers to entry and exit of business. Good legal framework to address anti-competitive conduct by firms exists and is generally enforced. All public sector entities are free to procure from any source.
   b) Operational licensing, permits, inspections and other compliance requirements, including those related to taxes and customs, impose only minimal burdens on business. State intervention in the goods market is generally limited to regulation and/or legislation to smooth out market imperfections. Corporate governance laws encourage ownership and financial disclosure and protect shareholder rights and are generally enforced.
   c) Employment law provides for flexibility in hiring and firing. State intervention in the labor and land markets is limited to regulation and/or legislation to smooth out market imperfections. Procedures to register property are simple and low-cost.

6. a) Almost no bans or investment licensing requirements. Regulations facilitate efficient entry and exit of business. Good legal framework to address anti-competitive conduct by firms exists, and is consistently enforced. All public sector entities are free to procure from any source.
   b) Streamlined industry licensing, permits, and inspections requirements facilitate business activity. State intervention in the goods market is limited to regulation and/or legislation to smooth out market imperfections. Corporate governance laws encourage disclosure and protect shareholder rights and are enforced effectively.
   c) Employment law provides a high degree of flexibility to hire and fire at low cost. Other labor market institutions facilitate doing business. State intervention in the labor and land markets is limited to regulation and/or legislation to smooth out market imperfections. Procedures to register property are simple, low cost, and fast.

Appendix B. Country Data, Sorted by Mobile Coverage and CPIA Business Regulatory Environment Rating

Country	GNI per capita (2010 US$)	Rural population (% of total)	Number of Mobile Operators	Herfindahl-Hirschman Index (0-10,000)	CPIA Business Regulatory Environment rating (1-6)	Mobile Coverage (% of population)
Bosnia and Herzegovina	4770	51	3	4013	4	100
Uganda	500	87	5	4384	4	100
Qatar		4	2	6250		100
Azerbaijan	5330	48	3	3780		100
Bahrain	18730	11	3	3354		100
Belarus	5950	26	3	3889		100
Belgium	45840	3	3	3457		100
Brazil	9390	14	4	2537		100
Kuwait		2	3	3746		100
Bulgaria	6280	28	3	3866		100
Chile	10120	11	4	3509		100
Croatia	13890	42	3	4046		100
Cyprus	29430	30	2	6429		100
Czech Republic	17890	27	3	3489		100
Egypt, Arab Rep	2420	57	3	4003		100
Estonia	14460	31	3	3674		100
Finland	47570	36	3	3350		100
Greece	26950	39	3	3747		100
Hong Kong	32780	0	5			100
Israel	27180	8				100
Italy	35700	32	4	3011		100
Japan	41850	33	4	3601		100
Korea, Rep	19890	18	3	3876		100
Lithuania	11510	33	3	3396		100
Macedonia	4570	32	3	4315		100
Netherlands	49030	17	2	3789		100
Norway	87350	22	3	4478		100
Romania	7850	45	4	3130		100
Singapore	40070	0	3	3520		100
Slovakia	16840	43	3	3918		100
Slovenia	23900	52	4	4100		100

Spain	31750	23	4	3340		100
Switzerland	71520	26	3	4371		100
Trinidad and Tobago	15380	86	1	5003		100
Tunisia	4160	33	3	4497		100
Turkey	9890	30	3	4020		100
Ukraine	3000	32	4	4063		100
United Arab Emirates	41930	22	2	5887		100
United Kingdom	38200	10	4	2495		100
United States	47340	18	4	2848		100
Uruguay	10230	8	3	3746		100
Georgia	2690	47	5	3465	5.5	99
Armenia	3200	36	3	4493	4	99
Cambodia	750	77	7	2354	3.5	99
Australia	46200	11	3	3433		99
Austria	47030	32	4	3339		99
Botswana	6740	39	3	4079		99
Canada	43250	19	3	3019		99
China	4270	55	3	5323		99
France	45370	22	3	3223		99
Germany	43070	26	4	2749		99
Hungary	12860	32	3	3555		99
Ireland	41820	38	4	3357		99
Jordan	4340	22	3	3402		99
Mauritius	7850	57	3	4366		99
Philippines	2060	34	3	3931		99
Poland	12440	39	5	2692		99
Portugal	21870	39	3	3718		99
Saudi Arabia	16190	16	3	3802		99
Sweden	50100	15	4	2990		99
Sri Lanka	2240	85	5	2810	4	98
Albania	3960	52	4	3661		98
Libya	12320	22	2			98
Morocco	2850	43	3	4108		98
Oman	18260	28	2	5072		98
Syria	2750	45	2	5050		98
New Zealand	28770	13	3	4229		97
Peru	4700	28	3	5115		97
Serbia	5630	48				97
Rwanda	520	81	3	5609	4	96

Kyrgyzstan	830	63	4	4253	3.5	96
South Africa	6090	38	4	3580		96
Kazakhstan	7580	42	4	4236		95
Lebanon	8880	13	2	5015		95
Malaysia	7760	28	4	3451		95
West Bank and Gaza		28	2	6800		95
Russia	9900	27	6	2570		95
Paraguay	2720	39	4	3655		94
Uzbekistan	1280	63	5	3339	3	93
Ecuador	3850	33	3	5625		93
Mexico	8930	22	3	5500		93
Pakistan	1050	63	5	2282	3.5	92
Cote d'Ivoire	1160	50	5	2849	3	92
Panama	6970	25	4			91
Swaziland	2930	75	1	10000		91
Senegal	1080	57	3	4893	4	90
Benin	780	58	5	2536	3.5	90
Djibouti	1270		1		3.5	90
Nigeria	1230	50	5	3305	3.5	90
Zambia	1070	64	3	5478	3.5	90
Eritrea	340	78	1	10000	2	90
Kenya	810	78	4	5229	4	89
Mongolia	1870	43	4	3102	3.5	85
Tanzania	540	74	4	3082	3.5	85
Malawi	330	80	2	5626	3	85
Yemen	1170	68	3	3450	3.5	84
India	1270	70	8	1393	3.5	83
Burundi	170	89	5	5276	2.5	83
Dominican Republic	5030	30	4	4085	4.5	81
Laos	1040	67	4	3670	3	80
Guinea	400	65	5	2699	2.5	80
Zimbabwe	460	62	3	4977	2	80
Cuba	5460	24	1	10000		78
Ghana	1250	49	5	3374	4.5	77
Afghanistan	410		4		2.5	75
Timor-Leste	2220	72			1.5	69
Sudan	1270	55	3	4402	2.5	66
Fiji	3630		2			65
Mauritania	1000	59	3	5092	3	62

Congo Dem Rep	180	65	5	3242	2	50
Nepal	490	82	4	4826	3	35
Mozambique	440	62	2	5050	3	32

Source: All data from World Bank's "Maximizing Mobile" report (2012), except CPIA Business Regulatory Environment rating from World Bank CPIA (World DataBank, 2010).

Appendix C. Comparison of "Maximizing Mobile" Dataset Countries With and Without Mobile Coverage Data

Our sample includes 112 countries from the World Bank's "Maximizing Mobile" (2012) dataset with mobile coverage data. The 43 countries without mobile coverage data are not included in our analyses. The table below presents summary statistics for these two groups of countries, along with t-values for one-sided t-tests of the difference between the means for each variable

Variable	Countries included in sample (n=112)			Countries not included in sample (n=43)			t-value
	N	Mean	Std. Dev.	N	Mean	Std. Dev.	
Number of MNOs	109	3.42	1.17	41	3.10	1.30	-1.4721*
HHI	103	4,114	1,409	35	4,981	1,963	2.8290***
CPIA BRE Rating	36	3.32	0.81	24	2.98	0.52	-1.8163**
GNI per capita	109	14,043	17,601	42	4,497	9,352	-3.3337***
Rural Population (% of total)	109	40.19	22.48	43	49.86	22.20	2.3963***

*** $p < 0.01$
** $p < 0.05$
* $p < 0.1$