Research Article

Economic Impacts of Mobile Telecom in Rural Areas in Low- and Lower-middle-income Countries: Findings of a Systematic Review

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Abstract

Mobile phones have been the most rapidly adopted of all information and communication technologies. Understanding the impact of this technology on economic and productive outcomes in rural areas is of value to governments, international organizations, private companies, and nongovernmental entities. This article presents a comprehensive analysis of their impact from a systematic review of the economic impact of mobile-phone interventions in improving economic, social, and productive outcomes in rural areas in low- and lower-middle-income countries for the period 2000–2014. The evidence of the impact on economic and productive outcomes in rural areas was strongest with regard to infrastructure interventions, wherein mobile network coverage reaches a population that previously lacked connectivity. Studies of access-device interventions, wherein mobile phones or SIM cards are bought by the user or are provided by a third party, and studies of content and application interventions did not yield conclusive findings.

Keywords: mobile phones, economic impacts, systematic review, low-income countries, lower-middle-income countries, rural, livelihoods

Introduction

This article is based on a systematic review of the economic impact of mobile phone interventions[1] in improving economic, social, and productive outcomes in rural areas in low- and lower-middle-income countries for the period 2000–2014. *Economic and productive outcomes* are defined as increases in individual income/savings/wages/expenditures, household income/savings/expenditures, and business profit/productivity as well as reduction in wastage and market price dispersion or volatility.

Under the terms of its funding, our review followed the International Development Coordinating Group guidelines[2] and Campbell[3] and Cochrane Collaboration[4] approaches to systematic reviews (SRs). Our review is limited to quantitative studies that can comprehensively establish impact in the form of effect sizes.

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1. *Interventions in this context include natural experiments, observational studies, and experiences such as randomized controlled trials (RCTs).*
2. *http://www.3ieimpact.org/media/filer_public/2014/09/15/idcg_advisory_group_guidance_final.pdf*
3. *https://www.campbellcollaboration.org/research-resources/writing-a-campbell-systematic-review.html*
4. *http://training.cochrane.org/handbook*

Applying the SR methodology—which was developed for medical science—to social and economic issues is not simple. Attribution and causality are typically more easily established in the natural sciences, where experiments can be repeated and conditions controlled. In the social and economic sciences, the repetition of experiments is not possible and the controlling of conditions is problematic. A further complication stems from the heterogeneity of outcomes, interventions, and methodologies. Applying SR methodology to social and economic impacts requires adjustments to the meta-analysis and combination of effect sizes.

This article approaches the meta-analysis from the perspective of a policymaker wishing to assess the impact of various types of interventions on multiple subjects: households, individuals, businesses, and markets. It should help policymakers prioritize interventions.

Background

The links between economic development and information and communication technology (ICT) has been debated extensively (e.g., Avgerou, 2003; UNDP, 2001). Mobile phones facilitate communication among users. They bridge spatial and information gaps, especially in rural areas. Rural areas are less connected than urban areas and are seen as "information-poor" (Chapman & Slaymaker, 2002). They have a high demand for information (Batchelor, 2002). De Silva and Ratnadiwakara (2008) demonstrated the considerable costs associated with searching for information, including transport costs, and demonstrated that a lack of information leads to economic losses.

ICTs are deeply implicated in multiple sectors, including but not limited to agriculture, health, and education. Donner and Escobari (2010) analyzed 14 studies on the use of mobile telephony by micro and small enterprises in the developing world, detailing findings about changes to internal processes and external relationships of enterprises. Governments use ICTs to communicate with citizens in the form of e-gov or m-gov services. Given the ubiquity and reach of mobiles, it is often seen as an ideal way to reach citizens.

ICTs, particularly mobiles in developing countries, are often seen as "silver bullets" that can improve livelihoods, without necessarily resolving structural problems (Heeks, 2010). Mobile services are heralded for their potential to bridge the urban–rural divide though information and knowledge (Bhavnani, Chiu, Janakiram, Silarszky, & Bhatia, 2008). Both demand and supply factors affect mobile phone adoption in low- and lower-middle-income countries. Liberalization of telecom markets, increased competition leading to lower prices, introduction of prepaid services, and advances in technology are among the factors driving mobile phone adoption (Samarajiva, 2010). However, the telecom sector in low- and lower-middle-income countries is often subject to policy uncertainty (Stork & Gillwald, 2014), which may depress investment, with negative implications for access by the poor.

Mobile phone users do not necessarily have to own the phone. There is evidence of shared mobile use (Zainudeen, 2008). Access to a mobile phone per se will not yield an economic or productive impact. That comes from the ability to use the mobile phone to reduce the spatial disparity between economic agents, the ability to gain access to information and knowledge that would have otherwise been unavailable, the ability to connect to and maintain social and business relationships over distance, and the ability to coordinate with other economic agents at lower transaction costs.

Mobile services, for example, are often subject to higher-than-normal levels of retail and corporate taxes (Katz, Flores-Roux, & Mariscal, 2010). Quantifying the impact of mobiles on rural livelihoods and economic growth may contribute to deciding on appropriate levels of taxation.

Several countries in this review have universal service funds (Hudson, 2010). These funds were created to extend telecom services, particularly to rural areas. Telecom operators must contribute a percentage of their revenue to the fund, which varies from country to country. Because many of the funds have failed to disburse most of what has been collected (Samarajiva & Hurulle, 2017), it is hoped that this review can contribute to how best these resources intended to serve the underserved should be used.

Table 1. PICO Inclusion Criteria.

PICO Framework	Description
Participants	Countries: Low- and lower-middle-income countries
	Individuals: Any age group, gender, ethnicity, or income group, in rural areas
	Households: Rural households
	Businesses: Any size, informal and formal, in rural areas
	Markets: In rural areas
Interventions	Network coverage
	Access to handsets or SIM cards
	Services, content, and applications
Comparisons	Coverage of an area vs. uncovered area by mobile telecommunication services
	Adoption vs. non-adoption of mobile telephony
	Use vs. non-use for services and applications
	Treatment group vs. control group
Outcomes	Individuals: Income or savings
	Households: Household income
	Businesses: Profit, productivity
	Markets: Price dispersion or waste reduction
Study types	Longitudinal
	Panel studies
	Experimental and quasi-experimental designs
	Living labs (creation, prototyping, validating, and testing of new technologies, services, products, and systems in real-life contexts)
Timeframe	2000–2014

Source: Authors.

Methodology

The selected studies are grouped by intervention:

- **Infrastructure intervention:** Where a mobile communication network becomes available in a previously unconnected area or population. The intervention can be by a new operator entering the market or by an existing operator expanding coverage.
- **Access-device intervention:** Where an individual or business purchases a mobile phone or SIM card, is gifted a mobile phone or SIM card, or uses or borrows another's mobile phone or SIM card.
- **Service, content, and application intervention:** Where information about prices, agricultural advisory services, mobile money services, etc., are made available to a population, free or at a cost. Also included are studies that made applications available for downloading and use on a mobile phone.

An extended PICO framework (participants, interventions, comparisons, outcomes)[5] was used to define the inclusion criteria, which is summarized in Table 1.

Studies with participants in rural areas of any age, gender, socioeconomic, and ethnic group classified as low- or lower-middle-income by the World Bank (n.d.) in 2012 were included. The studies had to be conducted at a micro level with individuals, households, businesses, or markets as units of analysis. Macro studies (such as the relationship of GDP growth to mobile adoption on a national level) were excluded.

5. Chapter 5 of http://handbook-5-1.cochrane.org

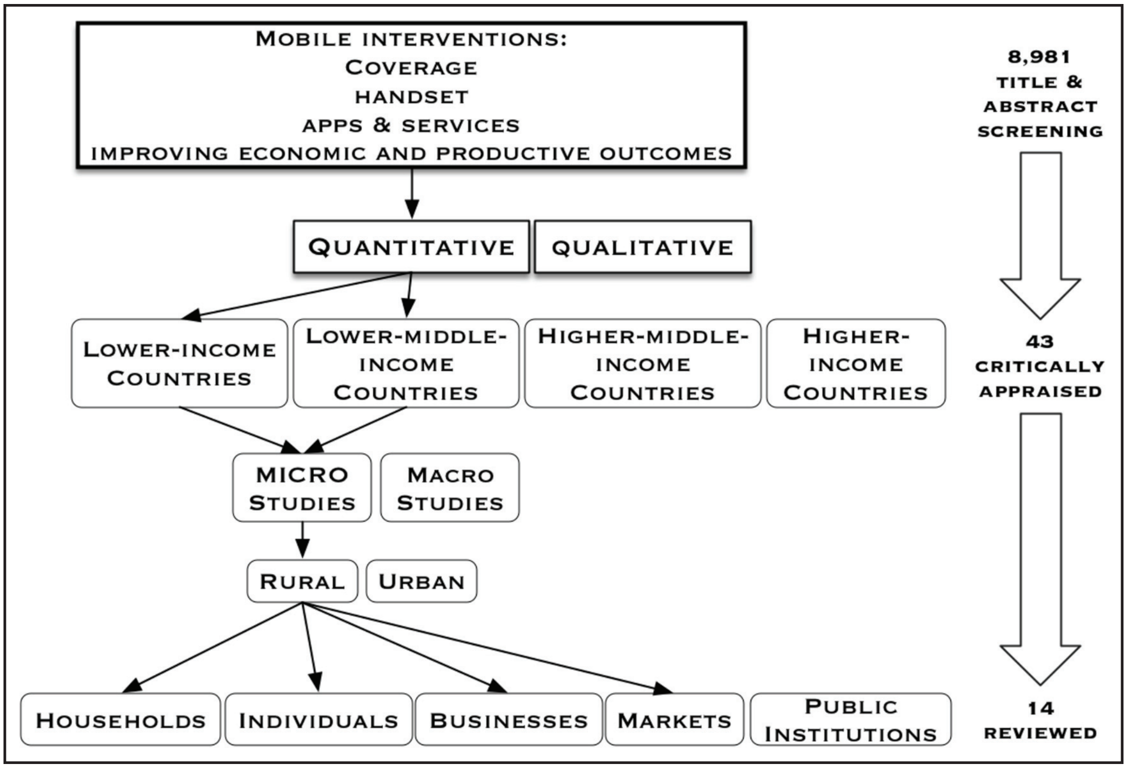

Figure 1. Scope of the review.

Because mobile phones were introduced into most developing countries in the 1990s and achieved substantial penetration by the middle of the next decade, the review only covers studies published after 1999.

The framework informing the inclusion criteria, data extraction, and coding is displayed in Figure 1. The electronic database searches yielded 14,128 hits. Of these, 3,196 studies were published prior to 2000; 1,951 were duplicates and therefore excluded. The remaining 8,981 studies were subjected to an initial title and abstract screening. The search criteria were saved on EPPI Reviewer software. The studies retained after the initial screening were subjected to detailed abstract screening. The remaining 43 articles were subjected to a full-text screening. Data were extracted from the final set of 14 studies. The low number of studies that yielded generalizable effect sizes can be explained by the cost of quantitative studies that deliver effect sizes.

Table 2 classifies the reviewed studies as natural experiments, observational studies (quasi-experiments), and randomized controlled trials (experiments).

The meta-analysis was limited to studies that delivered credible and generalizable results (i.e., were representative of the target population). *Representativeness* derives from random-sampling procedures for surveys, random treatment allocation for randomized control trials (RCTs), and controlling for endogeneity.

Standardizing absolute and relative effect sizes for markets, farmers, and households across different dependent variables and treatments makes little sense. Table 2 depicts the heterogeneity of interventions, outcomes, and participants. The practical implications for policymakers, regulators, and stakeholders were extracted through meta-analysis.

Studies measuring the impact of mobile network coverage are discussed, followed by assessments of studies on handset access and ownership and of mobile services and applications.

Table 2. Classification of Selected Studies.

Treatment	Authors	Dependent Variable	Type of Study
Mobile network coverage	Jensen (2007)	Max-min spread of prices among market, coefficient of variation of price spread, and waste reduction	Natural experiment
	Klonner & Nolen (2008)	Additional likelihood of a person being employed 1 year after coverage	
	Muto & Yamano (2009)	Banana and maize market participation, proportion of production sold, relative price of bananas and maize	
	Aker (2010)	Price dispersion for millet: absolute value of the price differences between market pairs for each month	
	Aker & Fafchamps (2011)	• Price dispersion for cowpea, measured as absolute value of the differences between logs of producer prices of 2 markets • Price dispersion for cowpea, measured as difference in max-min spread of prices between 2 markets • Price dispersion for cowpea, measured as difference in coefficient of variation between 2 markets	
	Beuermann, McKelvey, & Sotelo (2012)	Effect sizes for 6 years of coverage compared to no coverage for wage income, expenditures, and assets	
Mobile phone ownership	Labonne & Chase (2009)	Per capita monthly consumption	Observational study
	Blauw & Franses (2011)	Progress out of Poverty Index (PPI)	
	Lee & Bellemare (2013)	Price for onions	
Receiving information via mobile phone	Zanello, Shankar, & Srinivasan (2012)	• Selling at the farm gate (0) or at the market (1)	
		• Choosing the marketplace: community (C), district (D), or regional market (R)	
Price and weather information using text messages (SMS technology)	Camacho & Conover (2011)	Lower dispersion in sale price, higher sale price, farmers' revenues, household expenditures, crop loss	Experiment—RCT
Free 1-year subscription to Reuters Market Light service, market and weather information delivered via SMS	Fafchamps & Minten (2011)	Price dispersion, price received by farmers, crop loss due to rainstorms, likelihood of changing crop varieties and cultivation practices	
Ban on bulk SMS for 12 days	Parker, Ramdas, & Savva (2012)	Standard deviation of geographic price dispersion for crops for each state	Natural experiment
Having made use of ICT-assisted agricultural extension services	Fu & Akter (2012)	Quality index (QI)	Observational study

Source: Authors.
SMS = Short Message Service

Mobile Coverage

This section reviews articles dealing with mobile infrastructure interventions such as rollout of mobile network coverage. Only a telecom operator can roll out a network. Telecom companies do not build a network for arbitrary reasons, but take into account population density, household income, and the cost of providing services (e.g., availability of electricity, road access, permissions to build), among other reasons. Beuermann et al. (2012) and Aker and Fafchamps (2011) confirm this empirically. Klonner and Nolen (2008) and Aker and Fafchamps (2011) take into account the rollout decisions of mobile operators through an instrumental-variable (IV) approach. Others test alternative explanations for the outcome of their studies (Jensen, 2007; Beuermann et al., 2012).

The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector

Jensen (2007) documented the impact of mobile coverage introduced between 1997 and 2001 in northern Kerala, India on price dispersion and waste in the fishing industry. He found that the adoption of mobile phones by fishers and wholesalers was associated with lower price dispersion and reduced waste, and that both consumer and producer welfare increased. The study constitutes a natural experiment as mobile coverage was unavailable during the first month and in some cases the first years of the experiment. Apart from coverage being gradually introduced, adoption was also gradual after services became available. The parameters of the longitudinal study were these:

- Sample frame for 15 of 35 beach markets in the selected districts. The markets were selected to be evenly spaced along the coast.
- Randomly selected 10 small and 10 large sardine fishing units (could be more than one boat) for each beach market, 300 units in total.
- Interviews of sampled fishing units every Tuesday afternoon for the period September 3, 1996–May 29, 2001.
- Interviews collected information about the morning market sales on amount of fish caught, which market they were sold in, quantity sold, sale price, time of sale, costs, and whether a mobile phone was used.
- Mobile phone service was first rolled out in Kerala on January 1, 1997, but only reached the study districts by May 21, 2000.

For the modelling, the responses are grouped into three regions that received coverage at different times. The data are further grouped into four periods.

- Period 0 (weeks 1–22): No coverage in any of the selected areas
- Period 1 (weeks 23–97): Only Region 1 had coverage (from January 1997)
- Period 2 (weeks 98–197): Regions 1and 2 had coverage (from July 1998)
- Period 3 (weeks 198–249): All three Regions had coverage (from May 2000)

Jensen (2007) pooled the data. The model specifications included dummies for regions, periods (0–3), and whether phone coverage was available for the period and region. The main finding was that mobile phone use allowed fish markets to work better. By asking for current prices from multiple harbors or even agreeing on a sale, fishers could choose which market to sell in while they returned to shore. Jensen (2007) found that the presence of mobile phones also benefited fishers without a mobile due to better demand- and supply-matching across the various markets. He found that price dispersion in terms of min-max spread between markets in the same region dropped by INR 5 (Indian rupees) per kilogram of sardines, on average, from the initial INR 7–8 per kilogram. The price dispersion measured through the coefficient of variation (standard deviation/mean) dropped by 38% between markets. Wastage and unsold fish were reduced by 4.8%. Jensen (2007) examined and excluded alternative explanations and estimated consumer and producer surpluses resulting from mobile phone coverage.

Does ICT Benefit the Poor? Evidence from South Africa

Klonner and Nolen (2008) analyzed the impact of mobile network rollout on household income and employment status in rural South Africa, using household and labor force survey data from the National Statistical Office. The data, which are collected for census enumerator areas, were mapped to Vodacom coverage data. Klonner and Nolen (2008) merged the October Household Survey from 1996, 1997, and 1998 with the September Labor Force Survey for 2000 and 2001, creating a municipal panel over five years. All individuals from the household survey who were in the labor market were included in the data set.

In total, 88 models were tested using OLS and instrumental variables. Fixed effects dummies were used to take into account unobserved factors for placement of base stations, while an instrumental variable was constructed that reflected topographical factors. Klonner and Nolen (2008) ensured that the instrumental variable picked up exogenous factors that predicted rollout, confirming that they had established a suitable instrument.

A potential limitation could be the presence of two mobile operators with slightly different network footprints at the time of the survey. MTN and Vodacom at that time were roughly the same size, yet only Vodacom's network was incorporated into the study. A rural area in a municipality may thus have been classified as not covered (by Vodacom), while it actually was covered by MTN. The lack of data from MTN can be considered a measurement error. The instrumental variable is, however, robust to measurement error as pointed out by Klonner and Nolen (2008).

Klonner and Nolen (2008) found that if a municipality goes from 0% to 100% coverage, employment increases by 33.7% the following year. Applied to this specific case is a 15% increase in employment, on average, for rural areas that had cellular coverage during the period 1997–2001. Ideally, the models would be rerun with MTN coverage included to reduce the measurement error.

Impacts of Mobile Phone Coverage Expansion on Market Participation: Panel Data Evidence from Uganda

Muto and Yamano (2009) analyzed the impact of mobile phone coverage on banana and maize farmers in Uganda. They used data from farm households and communities, unlike Jensen (2007), Aker (2010), and Aker and Fafchamps (2011), who used market prices. Muto and Yamano (2009) used panel data of 856 households in 94 communities over a two-year period, 2003–2005. The communities covered by mobile phone networks increased from 41 to 87 during this period. Muto and Yamano (2009) analyzed the results of mobile coverage on market participation for bananas and maize, the proportion of harvest sold, and changes in prices. Household sampling was done purposefully; therefore, the study is only representative for participating households. The findings cannot be generalized to banana and maize farmers in Uganda. Another potential weakness could be that the distance to the district center was not a relevant proxy for transport costs. The best market for a farmer may not have been the district center, but a market in another district.

Muto and Yamano (2009) concluded that coverage expansion led to greater market participation by farmers in remote areas who produced perishable crops, in this case, *matooke* (cooking bananas). No significant impacts could be determined for maize, which can be stored once dried.

Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger

Aker (2010) measured price dispersion across millet markets in Niger using market and trader surveys. She found that the introduction of mobile phone service between 2001 and 2006 explained a price dispersion reduction of 10–16%. She factored in the impact of transport costs on price dispersion, unlike Jensen (2007).

How Does Mobile Phone Coverage Affect Prices at the Farm Gate? Evidence from West Africa

Aker and Fafchamps (2011) used a data set that was slightly modified from the one used by Aker (2010). They tested three hypotheses about the shift of traders to markets with the highest prices, leveling out price differences between markets covered by mobile networks and reductions in spatial price dispersion. Aker and Fafchamps (2011) used two data sets:

1. Market trader and farmer survey data for the period 2005–2007
2. A 10-year (1999–2008) data set for 37 domestic markets covering millet and cowpea prices

The 10-year data set was enriched by the addition of fuel prices, transport costs, road distances, market latitude and longitude, rainfall, and mobile phone coverage.

In addition to testing price dispersion as an absolute value of the differences between logs of producer prices of two markets, the authors also analyzed max-min spreads and coefficients of variations across all markets, similar to Jensen (2007).

Aker and Fafchamps (2011) found that when comparing market pairs, coverage reduced price dispersion for cowpea by 6.3%. In terms of max-min spread across all markets, coverage led to a reduction of 50% in the spread and 6% in the reduced coefficient of variation. The results are robust, and several factors have been accounted for, including market fixed effects, monthly fixed effects, infrastructure, transport costs, and drought.

The Effects of Mobile Phone Infrastructure: Evidence from Rural Peru

Beuermann et al. (2012) analyzed the impact of mobile coverage rollout in rural Peru on household assets, income, and expenditures. They constructed a data set based on coverage data and national household surveys from 2001–2007. Beuermann et al. (2012) ran several models to test for the impact of mobile coverage on household characteristics, controlling for rollout bias toward more populated and higher-income areas by mobile operators, for varying time effects to account for growth areas and for migration.

Beuermann et al. (2012) found that mobile phone coverage increased the income, assets, and expenditures of rural consumers. However, the authors did not find a statistically significant impact on the profits of home businesses or home farms. Generally, one would not have expected an immediate effect of coverage on household income, assets, etc. The third model used by Beuermann et al. (2012) used dummies for the years of coverage and found that the impacts were stronger the longer a village had coverage. There was an increase in wage income of 15% after two years of coverage and 34% after six years of coverage. The value of household assets increased by 23% after two years of coverage and 54% after six years.

Discussion

The six studies yielded valuable insights into the impact of mobile coverage on markets and on households. They benefited from the advantages of natural experiments, measuring an outcome variable before, during, and after network rollout. For natural experiments several potential biases encountered in RCTs fell away such as spillover, Hawthorne effects, and motivation bias. However, causality becomes more complex to establish. Confounding variables are usually dealt with by using instrumental-variable and fixed-effect regression models. The risk of findings biased by the choice of where operators build the next base station was addressed by all authors, except Muto and Yamano (2009). Mobile coverage enhances economic activities, leads to more price transparency and more efficient markets, and benefits businesses, households, and individuals.

Mobile Device Access and Use

This section reviews studies based on access-device interventions. This can be based on mobile phones or SIM cards gifted to someone as an intervention or self-selection, that is, the impact of mobile adoption.

The Power of Information: The Impact of Mobile Phones on Farmers' Welfare in the Philippines

Labonne and Chase (2009) analyzed the impact of mobile phone adoption on income, approximated by expenditure of a panel of farmers over three years. By constructing a panel of households and visiting them in the Philippines in 2003 and 2006, the authors explored the impact on poor farmers' consumption through access to information via mobile phones. The panel data set was combined with spatially coded mobile-coverage data. In 2003 the authors interviewed 2,400 households, with a follow-up survey in 2006 in which they reinterviewed 2,092 households. The households were selected from 135 villages in 16 of the poorest municipalities.

The impact of information is measured through mobile phone ownership, based on the assumption that ownership will allow better access to information. The outcome is per-capita income (household income divided by household size), with per-capita expenditure as a proxy. Higher income should be reflected in higher expenditures, particularly for poor households.

Labonne and Chase (2009) constructed an instrumental variable based on mobile phone availability in the village and the highest level of education achieved by children in school in 2003. This was thought to be correlated with the decision to buy a mobile phone through network effects and with education driving adoption. Labonne and Chase (2009) tested for IV weakness and were able to reject it. They found that mobile phone adoption led to an 11–17% higher growth rate of per-capita consumption, depending on the sample and the specification chosen.

The Impact of Mobile Telephone Use on Economic Development of Households in Uganda

Blauw and Franses (2011) analyzed the impact of phone use on the poverty status of households and individuals, using the PPI developed by the Grameen Foundation. The index ranges from 1–100, with lower values indicating a high probability of poverty. Telephone use was classified as public phone use, mobile phone use by head of household, mobile phone use by other household members, advanced telephone use, mobile banking, and mobile search.

Interviews were conducted with 196 household heads in three interview locations in Uganda. Responses from 167 households were used in the empirical model. The selection was not random. The results cannot be generalized. Blauw and Franses (2011) use IV estimations to deal with endogeneity, but the article does not state how IV was constructed. The sampling methodology and sample size make this, at best, an indicative study. The number of respondents using mobile banking services and mobile search was low (12% and 5%, respectively). No statistical analysis was conducted on advanced telephone use. Therefore, the study has only been categorized in "mobile device access and use."

Look Who's Talking: The Impacts of the Intrahousehold Allocation of Mobile Phones on Agricultural Prices

Lee and Bellemare (2013) analyzed the impact of mobile phone ownership by farmers and family members on the price of yellow onions for 95 farm families. The data were collected May–June 2010, two or three months after farmers had sold their onion harvest. The farm families were located in three districts surrounding San Jose in the Nueva Ecija province of the Philippines.

Lee and Bellemare (2013) found that when the farmer or spouse owned a mobile phone, they obtained 5–7% higher prices for their crops, compared to farmers and spouses who did not own a mobile phone. The sample size was small, and the sampling was not random. The results cannot be generalized. The authors stated that they could not establish the causal impact of mobile phones on the prices received by farmers in this context.

Transaction Costs, Information Technologies, and the Choice of Marketplace Among Farmers in Northern Ghana

Zanello et al. (2012) analyzed determinants of a farm household's choice of marketplace. They used data collected from Ghanaian farmers in five communities from three rural districts, 30 per community, totaling 447 farm households. The final data set included data from only 197 farm households. Zanello et al. (2012) tested for whether the decision to sell at a market or at the farm gate was influenced by various factors, including receiving information via mobile phone. Receiving information via mobile phone was not a treatment, but a self-reported response from household heads during the survey. The second decision tested was that of choosing a market from among community, district, and regional options if the farmer decided to sell at a market.

The two decisions were analyzed for crops, including millet, sorghum, maize, rice, cowpea, and groundnut. Zanello et al. (2012) used an instrumental variable to control for endogeneity. However, this was not linked to receiving information via the mobile phone. Several concerns arise:

- **The main concern is survey reliability.** It is unclear how the districts and communities were selected. The authors state that the 30 households per community were randomly selected, but provide no details about the sample protocol.

- **Sample size is a concern.** 197 households for multiple agricultural products seems too low. Sample size was not determined by any of the usual formulae (see, e.g., Rea and Parker [2014]).
- **It is unclear whether the selected respondents received any relevant information on selling choices.**

Zanello et al. (2012) found that, for larger transactions, farm-gate buyers were prepared to pay a premium to lower search costs, thus strengthening the producer cooperative business model. They found only weak evidence of mobile phone use to reduce search costs and attract farm-gate buyers. The findings cannot, however, be generalized due to the small sample size and absence of representative sampling.

Discussion

Only the study by Labonne and Chase (2009) provided credible results. While Labonne and Chase (2009) used panel data, Blauw and Franses (2011), Zanello et al. (2012), and Lee and Bellemare (2013) used small-sample, nonrepresentative, cross-section survey data, which meant the results could not be generalized.

Labonne and Chase (2009) found that purchasing a mobile phone led to an increased growth rate of per-capita consumption of 11–17%, depending on the sample and the specification chosen. This indicated that the mobile phone indeed created more productive opportunities that led to higher incomes and, thus, higher consumption. Labonne and Chase (2009) studied poor farm households in the Philippines, and while the direction of impact was similar across the globe and various population segments, the magnitude was likely to be different.

Applications and Services

This section discusses the impact of interventions such as price information, agricultural advisory services, and mobile money services that are made available to a population for free or for a fee.

The Impact of Receiving Price and Climate Information in the Agricultural Sector

Camacho and Conover (2011) used a randomized controlled trial methodology to analyze whether the recipients of price and weather information via SMS would change what they planted and whether they got a higher price in regional markets. Camacho and Conover (2011) randomly sampled 500 farmers from two irrigation associations in Colombia. The farmers were randomly divided into control and treatment groups. They were surveyed in March–April 2009 and in December 2009. During the July–December 2009 period, each farmer in the treatment group received, on average, 144 price messages, 34 weather messages, and four administrative messages.

Camacho and Conover (2011) found that famers from the treatment group were more likely to know market prices and had a narrower dispersion in the expected price of their crops from the SMS-reported prices. This is hardly surprising, given that they received 144 price SMSs during a six-month period. Testing knowledge about the content of the SMSs and expectations based on this knowledge cannot have been the objective of this intervention. The authors also found that farmers appreciated the SMS information and valued it at least as an additional information source.

Camacho and Conover (2011) found sales prices obtained by treated farmers not significantly different compared to those in the control group. However, they recorded a significant increase in the sale prices of the products included in the intervention, which is likely a spillover effect of the program. The prices reported via SMS were average prices from central markets. Informed buyers entering the market would have impacted the average price, from which the uninformed buyers may also have benefited, even in the absence of a spillover. Camacho and Conover (2011) did not find significant differences for crop loss.

The Impact of SMS-based Agricultural Information on Indian Farmers

Fafchamps and Minten (2011) investigated the benefits of the Reuters Market Light (RML) information service for Indian farmers through RCTs in 100 villages in Maharashtra. The authors did not find significant treatment effects for prices received by farmers, crop value added, crop losses resulting from rainstorms, or the likelihood of changing crop varieties and cultivation practices.

Fafchamps and Minten (2011) focused their study on five crops sold by small Maharashtra farmers. These crops were selected for different characteristics. Wheat and soybean are storable. Pomegranate is sensitive to weather. Tomato and onions cannot be stored for long.

- One district was chosen for each crop where small farmers grew and sold that crop.
- In each of the five districts, 20 villages were chosen, 100 in total. They were selected purposefully in close consultation with Thomson-Reuters to ensure they had not been previously targeted by marketing campaigns.
- Ten farmers were randomly selected from each village, 1,000 farmers in total. Only farmers who grew the respective crop, who had not previously used RML, and who owned a mobile phone were entered into the sample frame for the village.
- The 20 villages were grouped into six triplets and one pair based on similar characteristics.
- In Treatment 1 villages all 10 farmers got access to the RML service. In Treatment 2 villages only three of 10 got access, and none in the Control villages.
- A baseline survey in June–July 2009 confirmed that all 100 villages had electricity and mobile phone coverage.
- The ex-post survey, after a one-year free RML subscription, was conducted in June–July 2010.

Fafchamps and Minten (2011) controlled for various potential or actual spillover effects. A potential spillover for Treatment 2 villages was examined by analyzing Treatment 1 villages separately. The information received through the free RML service for a year could have spilled from the three subscribed farmers to the other seven farmers in the village who did not get RML services. Running the analysis separately for only Treatment 1 villages did not yield significant results.

Farmers from the control villages could have received RML services on their own account. The article states that this contamination was limited to 10 of 272 farmers in the Control villages. Noncompliance (not using the free service) was common, but also controlled for by running the analysis for RML users only. The authors could not rule out that supply factors could have played a role.

Is Information Technology Enough? Evidence from a Natural Experiment in India's Agriculture Markets

Using a data set of RML, Parker et al. (2012) analyzed the impact of access to information on geographic price dispersion within state boundaries for two crops in rural India. During the period of investigation, bulk text messages were banned unexpectedly for 12 days across India, allowing the authors to identify the difference information availability made to the analyzed crop prices.

Thomson Reuters provided subscriber and market information databases. The subscriber database contained start and end dates of the subscription and up to three markets chosen by subscribers. The market information database contained daily data for all markets in India where the crop was being traded, with volumes and with high and low prices. Price data covered the period August 22–November 8, 2010 and were corrected for inflation. Prices for Sundays and public holidays were removed from the data set as well as from markets where certain crops were traded infrequently.

Parker et al. (2012) found the impact was positively related to the number of users and crop perishability, which is unsurprising given that the bulk SMS ban was only in place for 12 days. They found the average spatial price dispersion for 170 crops across 13 states increased by 5.2% during the time of the ban. Price dispersion was measured as standard deviations of high prices recorded across market clusters for each day.

Impact of Mobile Telephone on the Quality and Speed of Agricultural Extension Services Delivery: Evidence from the Rural E-services Project in India

Fu and Akter (2012) examined the impact of a mobile agricultural extension service provided by a project called KHETI in India. The agricultural extension services are being improved through assistants to agriculture specialists, called *munnas,* carrying a mobile phone to record local agricultural problems with pictures and voice recordings. Munnas function as intermediaries, removing the need for face-to-face interactions between specialists and farmers. The deployment of mobiles via munnas was the result of qualitative research. Fu and Akter (2012) set out to measure the change in service delivery through intermediation by the munnas. They conducted two surveys: a baseline survey in July 2008 and a follow-up survey in March 2009.

The treatment group contained all KHETI beneficiaries from 30 villages, 698 farmers in total. The comparison group comprised 507 farmers randomly selected from 26 villages where KHETI agricultural extension services were not provided.

Most farmers agreed that the ICT-supported agricultural extension services were better, that the process was quicker, and that they used extension services more often as a result. The authors constructed a quality index (QI) based on an evaluation of service quality. They used Tobit and OLS models to test for the perceived utility of the new services. The treatment variable is 1 for the treatment group for the follow-up survey and 0 for the baseline survey. For the comparison group, it was set to 0 for both surveys. Fu and Akter (2012) interpreted the results from the Tobit model in the same way as the OLS coefficient, which is a common mistake.

The study cannot be considered an impact evaluation since it is solely based on the perceived utility of the enhanced service. The utility of the new service would only transpire at a later point when farmers must pay for the service. Additionally, impact would have to capture more than perceived utility. Overall, an entirely qualitative approach may have been more insightful.

Discussion

Parker et al. (2012) demonstrated the effects of an electronic price system on price dispersion. They used a natural experiment for their study.

The evidence from other studies has either been insignificant or unconvincing. Not having found significant differences between the control and treatment groups does not mean, however, that there were no benefits. The spillover from SMS intervention in Columbia (Camacho and Conover, 2011) that resulted in higher sales prices for all farmers is an example.

Another reason why RCT studies of services delivered by mobile phone may not discover significant differences between control and treatment group could be in the value of the services provided to the treatment group. It is not possible to assess the intervention’s value based on the article alone. One example could be SMS-based weather services. For example, farmers in the control group may have received the required weather information from other sources. At the same time, farmers from the treatment group may not rely on the information provided by SMS and may rely on traditional sources instead. Farmers in the treatment group could also lack the ability to use the weather information effectively or not trust it enough to make changes that may adversely impact their livelihoods. An SMS weather service would need to prove itself over many years before it could replace traditional means and farmers’ instincts learned over generations.

Meta-Analysis

The meta-analysis is limited to studies that delivered credible and generalizable results. Instead of attempting to standardize absolute and relative effect sizes for markets, for farmers and households across different dependent variables, the practical implications for policymakers, regulators and stakeholders are highlighted in this section.

Mobile Coverage

The coverage studies worked well since there could not have been any spillovers. The studies were based on panel data and addressed endogeneity issues. The six studies included in this review deal with the impact of mobile phone coverage, five of which produced credible results that can be generalized. Jensen (2007), Aker (2010), and Aker and Fafchamps (2011) demonstrated how agricultural markets worked more efficiently and price volatility decreased with the extension of mobile phone coverage to rural areas.

Klonner and Nolen (2008) and Beuermann et al. (2012) demonstrate the positive impact of mobile coverage on income and employability.

Each of the five studies measured something different and at a different time. The results of an initial mobile network roll-out would be different than an upgrade of base stations, for example. Also, fish markets

Table 3. Treatment Variable: Mobile Coverage.

Authors	Dependent Variable		Observations	Effect Size	Standard Error
Jensen (2007)	Max-min spread of prices between markets		74,700	−5Rs	0.27
	Coefficient of variation price spread			−0.38	0.03
	Waste reduction			−0.048	0.0004
Klonner & Nolen (2008)	Additional likelihood of a person being employed 1 year after coverage		57,486	33.7%	0.102
Aker (2010)	Price dispersion for millet: absolute value of the price differences between market pairs for each month		53,820	16% −3.51CFA/kg	0.645
Aker & Fafchamps (2011)	Price dispersion for cowpea measured as absolute value of the differences in logs of producer prices of 2 markets		39,120	6.3%	−0.007
	Price dispersion for cowpea measured as difference in max-min spread of prices between 2 markets		2,503	50%	0.105
	Price dispersion for cowpea measured as difference in coefficient of variation between 2 markets		39,120	6%	0.14
Beuermann et al. (2012)	Effect sizes for 6 years of coverage compared to no coverage	Wage income (log)	40,000	0.34	0.043
		Expenditure (log)		0.446	0.043
		Assets (log)		0.538	0.168

Source: Authors.

in India, where the fish must be sold the day they are caught, will benefit differently from mobile coverage than cattle auctions and grain markets in Niger.

The evidence relevant to policymakers and regulators from these studies are:

- Mobile coverage in rural areas makes markets more efficient by leading to a more efficient matching of demand and supply, leading to both consumer and producer welfare gains by moving closer to the one-price ideal. Efficiency is also expressed in terms of reduced waste for highly perishable agricultural produce such as fish.
- Mobile coverage in rural areas provides direct and indirect jobs. The case of South Africa demonstrates how mobile coverage leads to an increased likelihood of someone being employed by 33.7% (e.g., if 50% of the labor force were employed prior to coverage, then 66.9% of the labor force may be expected to be employed one year after full coverage is established).
- Mobile coverage in rural areas provides economic development that is reflected in disposable income and, thus, in expenditures. Expenditures increased by nearly 44.6% six years after coverage was established in Peru.

These findings may be used as a basis for calculating expected returns from subsidizing rural network coverage.

Device Access and Use

Only the study by Labonne and Chase (2009) provided credible results for the impacts of mobile adoption. The authors found that purchasing a mobile phone led to an increased growth of per-capita consumption of between 11% and 17%, depending on the sample and the specification chosen.

The implications for policymakers are that mobile adoption is desirable and that policies should be geared

Table 4. Treatment Variable: Device Access and Use.

Authors	Treatment Variable	Dependent Variable	Observations	Effect Size	Standard Error
Labonne & Chase (2009)	Mobile phone purchase	Per-capita monthly consumption	2,092 households	Increase in growth rate of capital consumption: 15%	0.032

Source: Authors.

toward allowing wide access to mobiles. Low prices would further stimulate use. Lower access and usage prices can best be established through fair competition. The findings can be taken further to argue for lower or no taxes on hardware and services to stimulate economic growth. The tax base for the state would increase with increased income.

Mobile Services and Applications

The only randomized controlled trial studies in this review are by Fafchamps and Minten (2011) and Camacho and Conover (2011). Neither study yielded significant results, which is a finding in itself.

A reason why RCT studies for services via a mobile phone may not show significant differences between control and treatment groups could be in the value of the services provided to the treatment group. An information service provided for free for a year does not mean the service is of actual value to farmers. Neither does it mean that farmers who do not get the treatment service do not have access to this service indirectly or lack alternative sources of information. It is not possible to assess the value of the intervention based on the study alone.

Table 5. Treatment Variable: Mobile Services and Applications.

Authors	Treatment Variable	Dependent Variable	Observations	Effect Size	Standard Error
Fafchamps & Minten (2011)	1 year free subscription to RML and market and weather information delivered via SMS	Price dispersion	1,000 farmers; 272 in control group	Not significant	
		Price received by farmers		Not significant	
		Crop loss due to rainstorms		Not significant	
		Likelihood of changing crop varieties and cultivation practices		Not significant	
Parker et al. (2012)	Ban on bulk SMS for 12 days	Standard deviation of geographic price dispersion for crops for each state	14,349	5.2% higher spatial price dispersion during ban	0.026
Camacho & Conover (2011)	SMS information service on weather and prices	Sale price	1,107	Not significant	
		Farmers' revenues	1,107	Not significant	
		Household expenditures	1,107	Not significant	
		Crop loss	1,107	Not significant	

Source: Authors.

The lack of significant differences between the control and treatment groups does not mean there were no benefits from the intervention. The spillover from SMS intervention in Colombia (Camacho and Conover, 2011) in the form of higher sales prices for all farmers is an example of a benefit.

The results from Parker et al. (2012) demonstrate the negative impact for farmers in the absence of price information services. This provides enough evidence for policymakers and regulators to intervene when mobile operators charge excessive rates for wholesale access to their network (premium SMS or USSD [Unstructured Supplementary Service Data] access, for example).

Conclusion

The studies that remained after the various screens were applied were heterogeneous and did not allow aggregation of effect sizes. As a result, meta-analysis was only possible in narrative form for specific subgroups anchored to different kinds of actions or interventions. Heterogeneity exists within the subgroups, but is less than if the studies were taken as one group.

Mobile phone interventions may be broadly defined as those that promote mobile network coverage, handsets and SIM cards, and services, content, and mobile applications.

From the six studies in the infrastructure interventions category, five yielded valuable and credible insights on the impact of mobile coverage on markets and households. They were natural experiments, measuring an outcome variable before, during, and after network rollout. The risk of findings biased by the choice of where operators built base stations was addressed by all authors, except Muto and Yamano (2009). Therefore, it may be concluded that five well-designed and -executed studies provided support for claims of significant positive outcomes from the availability of mobile network infrastructure.

Among the access-device intervention studies, only Labonne and Chase (2009) provided credible results for the impact of mobile adoption. They found that purchasing a mobile phone led to an increased growth rate of per-capita consumption of 11–17%, depending on the sample and the specifications.

The evidence from the content-and-application interventions category is weak, with findings that are either insignificant or unconvincing. Parker et al. (2012) is the exception, benefiting from a serendipitous opportunity to gather data before, during, and after a ban of services. They were able to demonstrate that an electronic price system reduces price dispersion.

The only studies using RCTs in this review yielded no significant results, which indicates the need for further research on whether RCTs are appropriate for social and economic impact studies.

A mobile phone or content-and-application service may not be an ideal treatment with which to design rigorous RCTs. We were unable to exclude the possibility that study participants who did not receive the treatment lacked access to a mobile phone, the content, or the application indirectly. Information service may spill over, it may not be useful, or information can be accessed through other means by the control group.

The policy-relevant evidence generated by this systematic review includes:

- Mobile coverage in rural areas makes markets more efficient by matching demand and supply better, leading to both consumer and producer welfare gains and bringing prices closer to the law of one price. The superior matching of supply and demand is manifested by reduced waste of perishable agricultural produce and fish.
- Mobile coverage in rural areas contributes to the creation of direct and indirect employment, primarily by making labor markets more efficient. The case of South Africa demonstrates how mobile coverage leads to 33.7% increased likelihood of someone being employed.
- Mobile coverage in rural areas provides economic development that is reflected in disposable income and, thus, expenditures. Expenditures increased by nearly 44.6% six years after coverage was established in Peru.

The above findings may be used as a basis for calculating expected returns of subsidizing rural network coverage.

The review also looked at gender and socioeconomic classifications as secondary outcomes. A gender-differentiated analysis in Klonner and Nolen (2008) showed that with wider mobile coverage comes increased employment by women, in particular those who are not burdened with childcare responsibilities in the home. However, the other studies were not amenable to drawing such conclusions. While there is no particular focus on socioeconomic classifications, all studies focus on low-income earners in low- and lower-middle-income countries.

Only a few quantitative studies were available across the three treatment categories covered in this report (coverage, device ownership, mobile-based services). Another review, specific to only one treatment and inclusive of urban areas and high-income countries, may provide more opportunity for a detailed meta-analysis. ■

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