Systematic Review

Mobile-phone interventions for improving economic and productive outcomes for farm and non-farm rural enterprises and households in low and middle-income countries

Christoph Stork
Nilusha Kapugama
Rohan Samarajiva

Final report submitted to 3ie

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List of Acronyms

AMIS	Agriculture Marketing Information System
AgMIS	Agriculture Marketing Information System
DFID	Department for International Development
DIME	Development Impact Evaluation
EA	Enumerator Areas
EPPI	Evidence for Policy and Practice Information
FAO	Food and Agricultural Organisation
FGD	Focus Group Discussion
ICA	Information Communication Association
ICT	Information and Communication Technology
ICTD	Information and Communication for Development
IDCG	International Development Coordinating Group
IDRC	International Development Research Centre
INR	Indian Rupees
IV	Instrumental Variable
LMIC	Low and Middle Income Countries
M- banking	Mobile Banking
M- health	Mobile health
M- money	Mobile Money
MSE	Micro and Small Enterprises
MTN	Mobile Telephone Network
NGO	Non- Governmental Organisation
OHS	October Household Survey
OLS	Ordinary Least Squares
PPI	Progress out of Poverty Index
	Progress in terms of Poverty Index
QI	Quality Index
RCT	Randomized Control Trials
RML	Reuters Market Light
SIM	Subscriber Identity Module
SMS	Short Message Service
SSRN	Social Science Research Network
StatsSA	National Statistical Offices, South Africa
UNDP	United Nations Development Programme
UNSD	United Nations Statistical Division
USAID	United States Agency for International Development
USO	Universal Service Obligation
VAS	Value Added Services

Acknowledgements

The authors wish to thank Shazna Zuhyle, Ranjula Seneratne Perera and Ranmalee Gamage for the diligent work done throughout the protocol writing and study selection stages.

The authors would also like to thank 3ie for providing the training for the review team members as well as Tracey Koehlmoos, PhD, Jorge Hombrados and Birte Snilveit for their input and guidance throughout the process.

Summary

Mobile phones are the fastest diffusing information and communication technology of all time. Governments, international government and non-government organisations, private companies and non-governmental entities have a strong interest in understanding the impact of this technology on economic and productive outcomes in rural areas. This systematic review provides a comprehensive answer.

The existing literature on the impacts of mobile phones was systematically screened and the most generalizable and robust studies identified. Because these studies were quite different from each other, they are classified into three categories and the conclusions presented in a narrative form. The evidence of impacts on economic and productive outcomes in rural areas was the strongest with regard to infrastructure interventions, wherein mobile network coverage reaches a population that was previously lacking connectivity.

Five studies, among the many that were analysed, provided the most robust evidence. They were natural experiments, measuring an outcome variable before, during and after network roll-out. Mobile coverage is clearly shown as enhancing economic activities, leads to more price transparency and more efficient markets and benefitting businesses, households and individuals.

Mobile coverage in rural areas makes markets more efficient by matching demand and supply across a larger geographical space. This results in benefits to consumers as well as producers. In the case of perishable agricultural produce such as fish, there is a significant reduction in waste as the markets clear. Mobile coverage in rural areas improves direct and indirect access to employment. In the case of rural South Africa, mobile coverage increased the likelihood of a person being employed by 33.7 percent within one year. The contribution made by mobile coverage of rural areas is reflected in increased disposable income and therefore also in expenditure. Expenditure increased by nearly 44.6 percent, six years after coverage arrived in Peru. The strong evidence of mobile coverage contributing to economic growth and producer and consumer welfare suggests that governments should rethink policies whereby mobiles are subject to additional taxes. Other interventions to facilitate network investment include better spectrum management and access to land for construction of base stations. The findings may also be used as a basis for calculating expected returns from subsiding rural network coverage.

Studies of access-device interventions, wherein mobile phones and / or SIM cards are bought by the user or are provided by a third party, did not produce findings as robust as those from infrastructure. Four studies were included. One study, among the four that made it through multiple screens, provided credible results for the impact of mobile adoption, showing that the purchase of a mobile phone led to an increased growth rate of per capita consumption between 11 percent to 17 percent depending on the sample and the specification chosen. This indicates that the mobile phone does indeed contribute to higher incomes and thus higher consumption. However, this study was of poor farm households in the Philippines. While the direction of impact will be similar across the globe and various population segments, the magnitude is likely to be different.

Weaker results were generated by studies of content and application interventions, wherein services such as information about prices or agricultural advisory services are made available to the general

populace for a free or at a charge. Four studies made it to the final level, but only one, because of a serendipitous suspension of bulk SMS, was able to show clear impacts. The randomized controlled trials within the set showed no impacts. The limited duration of the studies and the fact that the services were provided free for short periods militates against identification of benefits.

Overall, the evidence indicates that the making available of mobile coverage where none existed before clearly yields positive economic impacts. The findings of benefits from access-device and information-service interventions are less robust, with only one study in each category providing usable evidence. The very nature of infrastructure interventions is conducive to effective study design through natural experiments with causality established through econometric techniques.

The meta-analysis complements the macro-level findings of positive contributions from the introduction of mobile networks. It shows that the possibility of communicating and coordinating activities across space offered by the extension of networks yields economic benefits even without subsidized provision of access devices and specially designed information services. It is not that the devices and services do not have impact, but that these impacts are difficult to demonstrate.

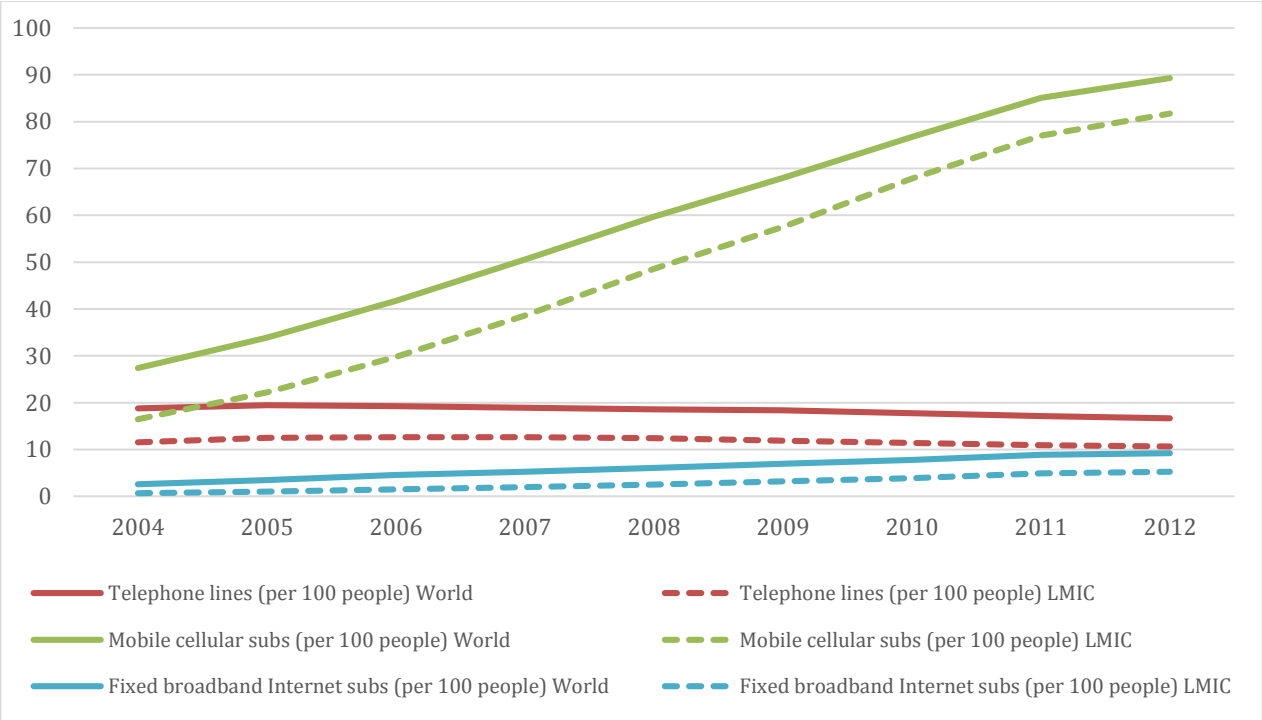
In conjunction with the macro studies, the conclusions of the meta-analysis support policy recommendations to keep mobile-only taxes at a minimum and facilitate network investments in rural areas through efficient spectrum management and access to land for the construction of base stations. They also provide a basis to calculate the benefits of rural subsidy schemes.

Background

The condition (or problem)

The link between economic growth, development and Information and Communication Technology (ICT) has been debated in the literature extensively. The studies on the topic have been covered both by academia and international development agencies (e.g., Avgerou, 2003, UNDP, 2001). ICT, as per the World Bank's definition, "consists of the hardware, software, networks, and media for the collection, storage, processing, transmission and presentation of information (voice, data, text, images), as well as related services."[1] This encompasses a wide range of technologies, including but not limited to television, radio, fixed telephony, mobile telephony, computers with access to Internet and the Internet. ICTs facilitate connectivity. As such, the term "Digital Divide" emerged to describe the economic inequality faced by those who had lesser access to ICTs. The early literature on the topic, focusing on the developed economies, often referred to access to computers and Internet when they mentioned ICTs however, in relation to developing economies, this largely refers to access to mobile phones.

Figure 1 containing data from the World Bank shows that in comparison to fixed line telephony and access to fixed broadband connectivity, mobile telephony is the form of ICT that is consumed most by the population in low and middle income countries (LMICs).



Source: World Development Indicators, 2014, World Bank Data

As mentioned above, mobile phones, particularly in LMICs, help connect individuals, districts, provinces and regions. Rural areas are often referred to as those that are less connected and are "information-poor" (Chapman and Slaymaker, 2002).

[1] http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/0,,contentMDK:21035032~menuPK:282850~pagePK:210058~piPK:210062~theSitePK:282823~isCURL:Y,00.html#I

Studies (e.g., Batchelor, 2002) have shown a high demand for information exists in rural areas. De Silva & Ratnadiwakara (2008) demonstrated the considerable costs associated with searching for information. For example, some of the costs incurred are transport costs to seek information. This situation is often worse in rural areas due to the increased distances that have to be traversed to obtain the necessary information. Lack of information often leads to economic losses. Both demand and supply factors affected the adoption of mobile phones, particularly in developing countries or in the low and lower middle income countries. The liberalisation of telecom markets, increased competition and decreased prices, the introduction of pre-paid services and advances in technology are some of the factors credited with driving mobile phone adoption (Samarajiva, 2010). Affordability is a major reason for the popularity of mobiles phones among the poor (Bhavnani, et al., 2008).

Mobile phones facilitate communication and the exchange of information among users. It bridges the spatial gap and can help reduce the information gaps, especially in rural areas. The reach of mobile phones is so vast that governments (or relevant ministries) have started to use it as a means of communicating with citizens in the form of e-Gov (or m-Gov) services.[2]

The academic literature on the topic is vast. This includes studies that address the social impacts of mobile phones. Given the proliferation of phones and the increased interest by multiple stakeholders in using the technology to bridge the spatial and information gaps, the present study seeks to answer the following questions. What are the economic impacts of mobile phones? Can users of mobile phones gain access to information that they may not have otherwise? Does this change in access to information result in users experiencing improvements in their livelihoods? If so, under what conditions did they see such improvements?

The review will focus on micro-level studies, conducted at individual, household or enterprise levels in rural areas. The following sections detail the selection criteria, methodology used in the review and the findings.

The interventions

The review looks at the impact of mobile phone for economic and productive outcomes in rural areas. The reviewers identified four interventions (or areas of action) in the protocol document. This was done by scoping the existing literature and examining the ways in which mobiles phones are introduced and used. The reviewers understand that some papers may appear to subscribe to more than one intervention, particularly with regard to infrastructure interventions and access device interventions. However the classification of the studies by intervention was done to reflect the "types of intervention" that were identified in the primary study. These were;

I. Infrastructure interventions / access to mobile communication networks: This is where a mobile communication network becomes available to a previously unconnected area/population. The intervention is operator driven, as only a telecom operator can roll out a network. The intervention can be by a new network operator entering the market or an existing operator expanding its coverage area.

[2] This is further elaborated in the "why is this review important" section

II. Access device interventions / access to a mobile phone: Where an individual or business purchases a mobile phone/SIM card; is gifted a mobile phone/SIM card or uses (or borrows) someone else's mobile phone/SIM card.
III. Service interventions / provision of and access to relevant services: Value Added Services (VAS), such as information about prices, agricultural advisory services and mobile money services are made available to a population for free or at a price.
IV. Application interventions: Relevant applications are made available for downloading and use on the mobile phone.

It should be stressed that users of mobile phones do not necessarily have to be owners of the phone. There is evidence of shared mobile usage (Zainudeen, 2008).

How the intervention might work (Theory of Change)

It is not access to a mobile phone per se that is likely to cause an economic or productive impact. It is the ability to use the mobile phone to shorten the spatial disparity between economic agents; the ability to gain access to information and knowledge that would have otherwise been inaccessible or 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. In order to capture the effects of the above, the review looks at four interventions; access to mobile communications networks, access to mobile phones, access to relevant services and access to relevant mobile applications (Figure 2).

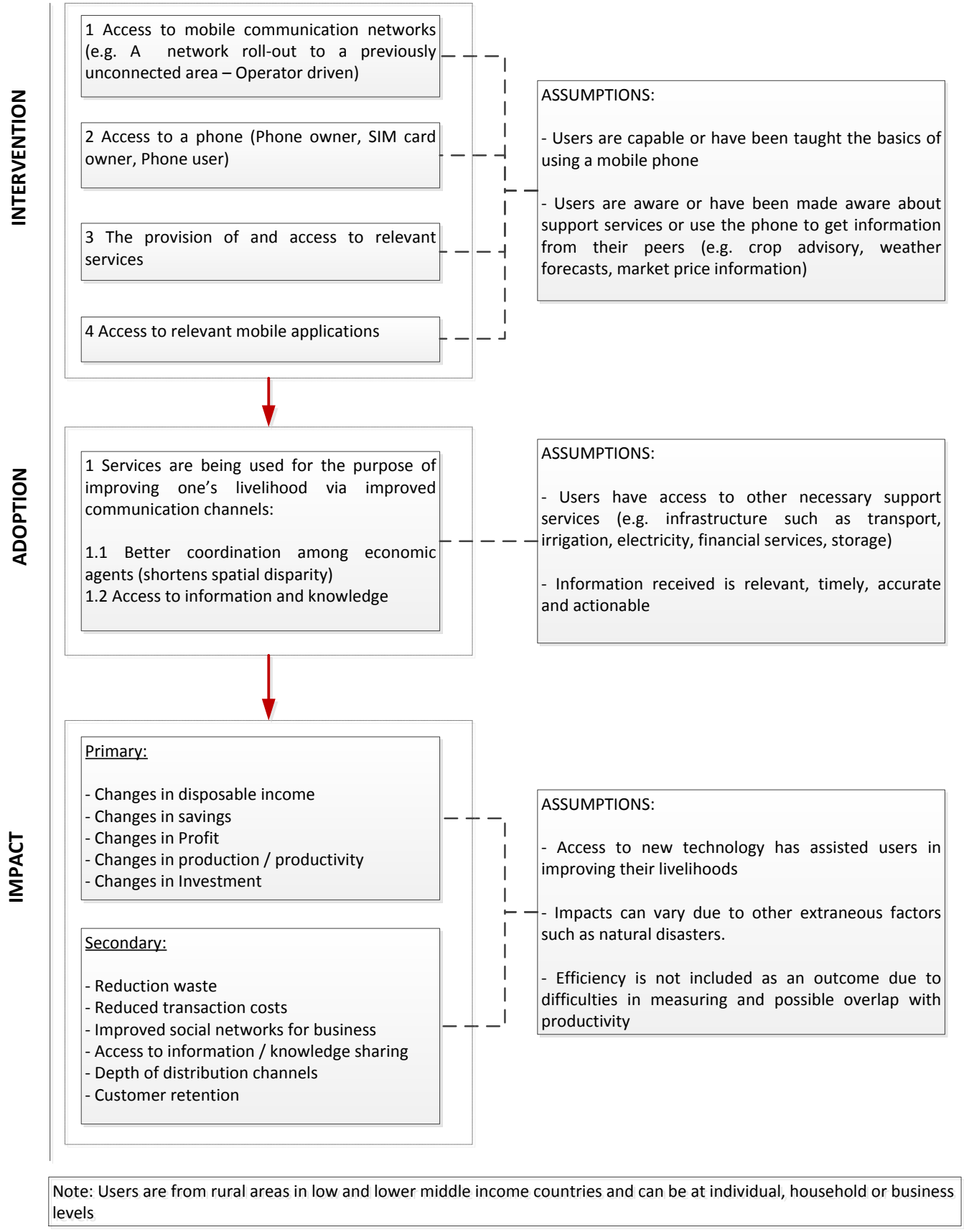


Figure 2: Theory of Change

The four identified inventions can be grouped together as access to mobile connectivity (interventions 1 and 2) and access to specialised services (interventions 3 and 4). In all the interventions, the assumptions

are that the users have prior knowledge of how to use a mobile phone and they have been made aware that the phone can be used to either contact a person with information or knowledge or access a particular service. Given the above, users are then able to utilize the mobile phones and access information, knowledge or services that will be of use to them for their livelihoods.

A majority of the rural population is involved in agriculture. Ozowa (1995) and Lokanathan & Kapugama (2012) discuss the different types of information required by farmers and other micro enterprises. The types of information required by those in agricultural occupations include price information, information about buyers and sellers, information on disease control, fertiliser and pesticides. For households, one of the main economic benefits may be information on potential employment prospects. Apart from information, users may also access services such as mobile money/banking.

Access to information per se will not result in economic or productive impacts. For this, the information and knowledge should be utilised to make improvements to livelihoods. In the case of the farmers they are often unable to get a price that is reflective of the current market price from the first handlers (or traders). Access to price information may mean that they are more likely to get prices that reflect the actual market prices. The theory behind the dissemination of information to farmers or producers is that increased information will lead them to allocate their factors of production more efficiently by adjusting their production plans. Price information will give farmers greater ability to negotiate with the first handlers (or traders) (Jaleta, & Gardebroek 2007 and Cramton, 1984) and thereby be able to obtain better prices for their produce and reduce wastage. The scenarios explained above are illustrated with the relevant assumptions in Figure 2.

In addition, mobile users may have access to services such as mobile money (m-Money) or mobile banking (m-Banking). The use of these services reduce transaction costs to the users and often provide banking facilities to those who are unable to benefit from the more formal or established banking systems due to lack of collateral or established credit worthiness or credit histories (Hughes & Lonie, 2007).

The above, if achieved, will lead to an increase in income and savings at an individual or household level and an increase in profits at a business level.

However the above theory of change includes certain assumptions. Structural issues that exist in a specific country or region must be taken into account. Complementary infrastructures such as transport, electricity, access to financial backing, storage and warehousing are necessary to ensure efficiency gains are realized from the increased ability to communicate. Coordination between two economic entities will not result in productive outcomes if the necessary transport facilities are not in place. An individual in a rural area who finds information about employment will not be able to make use of the information if transport facilities are unavailable. Similarly, access to financial services is necessary to make independent decisions (Abrahams, 2006). Farmers and other micro entrepreneurs who lack access to financial services have to depend on the informal sector. This often includes their buyers or first handlers as sources of credit. This dependent relationship often leads to a lack of bargaining power which reduces the ability to use price information.

Information seeking can be in two forms. One is the sharing of information and knowledge among peers, the other is obtaining information from a specialized entity. In both cases, the information should be relevant, accurate and timely. If not it is not actionable. Untimely information is useless; inaccurate information could be harmful to the user. Furthermore, once trust in the system is lost, it will be hard to re-

establish (Molony, 2007). However, in order to realize these benefits, users first have to be aware of the available services, especially in the case of specialised services such as agriculture information or mobile money.

Why is it important to do this review

The literature on the topic is vast. A number of systematic reviews are available detailing the effects of mobiles phones in the health and education sectors. However, there are no systematic reviews evaluating the economic and productive outcomes of mobile phones in low and lower-middle income countries. Donner and Escobari (2010) conducted an analysis of 14 studies on the use of mobile telephony by micro and small enterprises (MSEs) in the developing world, detailing findings about changes to the internal processes and external relationships of the enterprises, and about mobile use vs. traditional fixed line (landline) use. There is evidence that the benefits of mobile use accrue mostly (but not exclusively) to existing MSEs rather than new MSEs in ways that amplify existing material and informational flows as opposed to transforming them. The study looked at both urban and rural areas in developing countries.

The present systematic review looks only at effects in rural areas in low and lower-middle income countries. According to the World Bank, the majority of the population in low and lower middle income countries live in rural areas. The figures for 2011 showed that 72% of the population in low income countries, 61% in lower middle income countries and 39% in upper middle income countries lived in rural areas. Given the above, this study will cover a majority of their populations. Furthermore, a significant proportion of the rural population is involved in agriculture. The review will look at the impact of mobile phones on all enterprises rather than just on micro and small enterprises in rural areas.

The number of studies both (academic and institutional) done in this area is considerable. However, do these studies comprehensively answer the question of economic and productive impacts or do they talk only about adoption or theoretical frameworks? This is one of the questions that the review will answer. The review follows the IDGC guidelines and is limited to quantitative studies that can comprehensively establish impact.

Mobile phones are subject to a country's ICT or Telecom Policy. ICTs are deeply implicated in multiple sectors, including but not limited to agriculture, health and education. For example, the Indian National Telecom Policy states that its "vision is to transform the country into an empowered and inclusive knowledge-based society, using telecommunications as a platform."[3] The Policy also acknowledges that the country's fastest growing mode of telecommunication is mobile phones.

Governments wish to use ICTs to deliver services to citizens. Given the reach of mobiles, it is often seen as an ideal mode to carry information to citizens. Given the amount of funds that are being invested in some of these programmes such as Agriculture Marketing Information Systems (AgMIS), it is of paramount importance to try and identify if these services are actually being availed (FAO, 2012). These systems are often built on the credo "build it and they will come" (Markus and Keil, 1994). Interventions 3 and 4 are particularly selected for gaining more insight into the use of some these targeted information services. Impact evaluations or primary studies done on such services will help bring about those insights. In the event these services are not successful, the reviewers hope to identify the reasons for the lack of success and the event of a positive impact, the reasons for the success. ICTs, particularly mobiles in

[3] http://www.trai.gov.in/WriteReadData/userfiles/file/NTP%202012.pdf

developing countries, are often seen as "silver bullets" that can improve livelihoods independently solving structural problems affecting a country (Heeks, 2010). The review also seeks to shed light on whether this is true or if structural problems such as lack of access to finance, land tenure issues, lack of transportation facilities and land fragmentation hinder the ability to reap economic and productive benefits from use of mobile phones and subsequently from information and knowledge.

Apart from governments, international government organizations are also placing considerable weight on the use of ICTs, particular mobile technology, for service delivery. A number of e-government and AgMIS programmes are funded by organisations such as the World Bank and the FAO. Such organisations have shown interest in using mobile applications (apps) for development (World Bank, 2012, FAO 2012). Therefore, the findings of the review will be of value to the international government organizations.

On one hand, mobile services are being heralded as the medium that will bridge the urban-rural divide though information and knowledge[4] (Bhavnani, 2008). On the other hand, it is often subject to higher levels of retail and corporate taxes (Katz, et al, 2010; Samarajiva, 2009). The telecom sector in low and lower middle-income countries is often subject to policy uncertainty (Gillwald and Stork, 2012). This can lead to lower adoption and use. It is hoped that the review will be able to shed some light on the economic and productive impacts on the use of mobile phones in rural areas and better inform policy processes in low and lower middle-income countries.

Furthermore, a number of the countries included in the review have Universal Service Obligation (USO) funds (Hudson, 2010). For example, the unspent USO funds in India amount to approximately USD 4 Billion.[5] These funds have been created to bring about development of telecom sector, particularly in the rural areas. Telecom operators are required to contribute a percentage of their turnover to the fund. The percentage varies from country to country. Given that some of these funds have amassed a considerable amount of resources, it is hoped that the results of this review can help identify ways by which the funds can be better utilized (Malik, 2008; Calandro and Moyo, 2010).

Objective

The primary objective of the review is to assess and synthesise the evidence on the effects of mobile phone interventions on economic outcomes for households, individuals and enterprises in rural areas of low and lower middle-income countries.

As a secondary objective the review will assess whether effects are moderated by gender, age and socio-economic status, if the data are available.

[4]http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/0,,contentMDK:23019948~pagePK:210058~piPK:210062~theSitePK:282823,00.html

[5] http://www.gsma.com/newsroom/gsma-calls-for-re-evaluation-and-reduction-of-the-universal-service-fund-levy

Selection (Inclusion) Criteria

The review follows Campbell and Cochrane Collaboration approaches to systematic reviewing.[6] The review uses the theory of change (Figure 2) as the framework, informing the inclusion criteria, data extraction and coding. Figure 3 below outlines the scope of the review.

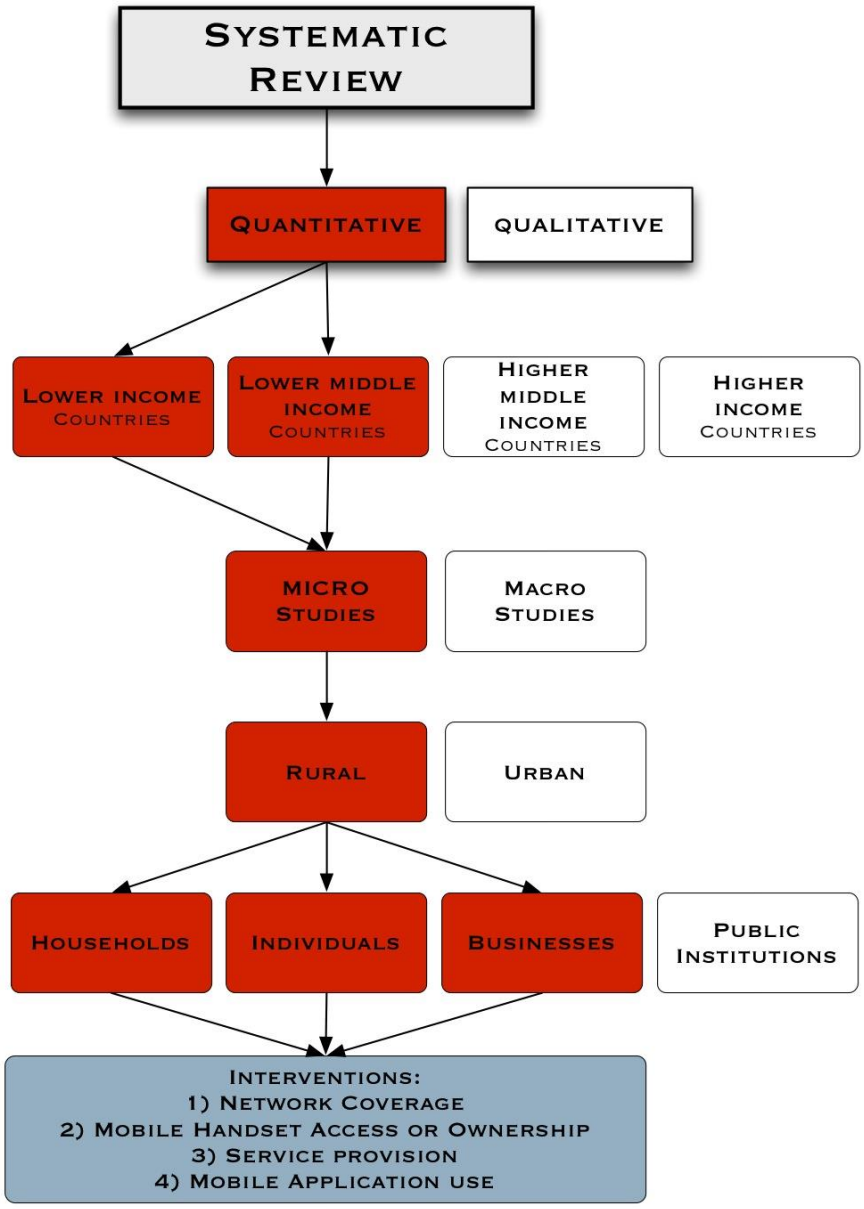


Figure 3: Scope of the review

The criteria for considering studies for inclusion in the review are summarised in Table 1 and detailed below.

[6] *Cochrane Handbook for Systematic Reviews of Interventions*, http://www.cochrane.org/training/cochrane-handbook.

Table 1: Inclusion criteria	
PICOS	**Description**
Participants	Countries: Low and Middle Income Countries Individuals: Any age group, any gender, any ethnicity, any 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 versus uncovered area by mobile telecommunication services Adoption versus non-adoption of mobile telephony Use versus non-use for services and applications Treatment group versus control group
Outcomes	Individuals: Income/savings Households: Household income Businesses: Profit, productivity Markets: Price dispersion / waste reduction
Study types	Longitudinal Panel studies Experimental and quasi experimental designs Living labs[7]
Time Frame	2000-2013

Studies are included with participants from any age, gender, socio-economic and ethnic group, living in rural areas in economies classified as low and lower middle-income by the World Bank in 2012.[8] The selected studies should have been conducted at a micro level with the units of analysis as individuals, households, businesses or markets.

Cross sectional studies which report only descriptive statistics were excluded from the study. Qualitative studies and quantitative studies without a comparison group design have been excluded. The reviewers acknowledge that a large portion of studies in this area use qualitative study methods. Furthermore qualitative studies are better at informing the causal mechanism and answering the "why" questions. However, the reviewers believe that the identified interventions are best addressed through quantitative methods.

Given that mobile phones were introduced to most developing countries in the 1990s and achieved substantial penetration by the middle of the next decade, the review only covers studies published after 2000.

Studies that fall within the specified inclusion criteria were considered for this review.

[7] Living labs was included as a study design at the time of finalising the protocol given that it was gaining attention as a research method however, no studies using this study design was found.
[8] Please refer appendix 1 for the exhaustive list of countries

Economic and productive impacts in this review are defined as changes in income, consumption, expenditure; savings at individual, household and enterprise level and productivity; and profits at enterprise level. .

Types of Actions

Mobile phone interventions are broadly defined as those that promote the use of mobile phones, either by providing network infrastructure and therefore coverage; or providing hardware (phones, SIM cards, network access); or supplying services and information using mobile technology. Interventions also include mobile applications developed for specific tasks or communities. The following are included:

- Infrastructure interventions: Mobile network coverage reaches a population that did not previously have connectivity. This occurs when a new mobile network operator enters the market or an existing operator rolls out its network to reach the population in question.
- Access Device interventions: When mobile phones and / or SIM cards are bought by the user or are provided by a third party.
- Content interventions: When Value Added Services (VAS), such as information about prices or agricultural advisory services, are made available to the population for a fee or at no charge.
- Application interventions: When applications are designed for particular tasks and or for particular communities.

Types of comparisons

Eligible comparisons include groups who receive no intervention or those receiving a different intervention.

Types of outcome measures

Access and use of mobile phones may affect a range of different outcomes from social to economic. The review assesses the economic and productive outcomes of mobile phone interventions as defined above in Table 1 for farm and non-farm enterprises in rural areas in low and lower middle-income countries. The outcomes defined here are limited to individual, household, business and market levels.

For example, in the agriculture sector this includes access to crop advisory services, price information and the ability to coordinate better with others in the value chain. Another example is the use of services such as mobile money to reduce transaction costs and therefore increase profits for small and medium enterprises.

The above may also result in unintended negative outcomes. Mobile phone usage may crowd out necessary expenditures leading to a lowering of effective living standards, for example. The primary outcomes below measures both positive and negative:

- Individuals: income/savings/consumption
- Households: household income/consumption
- Businesses: profit / productivity
- Markets: Price dispersion, waste reduction

Methodology

Search methods for identification of studies

Keywords were utilised for the searches. These were identified by examining the populations, interventions and outcomes. Combinations (or permutations) of the keywords were then used to identify relevant studies. Further, searches were conducted through references and bibliographies of the relevant studies. The team also contacted some their colleagues especially to identify published studies or grey literature.

Table 2: Search terms

Population	All low and middle income, countries as per the World Bank Classification 2012 Rural population in the selected countries only.
Intervention	Use of mobile phones Access to mobiles / mobile phones / mobile technology / wireless technology / mobile communication / mobile network / communication technology / communication networks / mobile services / mobile applications (Substitute the word mobile with cellular and mobile cellular.)
Outcome	Income, profit, productivity, savings, investment

The above keywords were used to develop a generic search strategy for the electronic databases. This was then modified to the requirements of the multiple databases used. The generic strategy is given in the Annex 2. Apart from electronic databases, conference agendas and proceedings, institutional websites and journals were searched. Multiple sources were used to reduce publication bias. See Annex 3.

The electronic database searches yielded 14,128 hits. Of these, 3,196 studies were published before the year 2000 and 1,951 were duplicates. These were deleted from the reference management system. The remaining 8,981 were subject to an initial title and abstract screening as per the criteria defined in Annex 4.

The above criteria were used for the first screening which was saved on EPPI Reviewer. A detailed abstract screening was conducted for studies retained after the initial screening. Studies that were retained after the above screening were subjected to a full text screening with the same criteria. Data extraction was done on the final set of included studies.

A majority of the studies that were rejected (7,178) were excluded based on intervention scope. The method of operationalising of this screening criteria is as follows: the search results contained literature relevant to m-health and distance education sectors which were outside the scope of this review. A significant number of studies looked at theoretical frameworks, used secondary data or were conceptual papers. These studies, which did not contain an intervention as defined in the inclusion criteria, were rejected. Studies that were not primary studies were rejected as no intervention could be identified. Studies conducted at the macro level were rejected as were studies that did not identify impact and examined only adoption. Due to the use of the term “mobile” in the search strategy, the search results also contained a considerable amount of literature relevant to the concepts “migration” or “nomadic” as well as “technology” as a whole that had to be rejected. Only studies that specified or identified an intervention were included.

178 were rejected based on country categorisation. This was the case when the studies were done in countries that were not low or middle-income countries. 177 were excluded based on study design. These were either case studies, qualitative studies cross sectional studies reporting only descriptive statistics. 25 studies were excluded because they focused on urban areas.

After the initial title and abstract screening, a total of 1,460 studies were subjected to detailed abstract and full-text screening. Of these, 1,060 were excluded based on the types of intervention the papers addressed. These included studies that were not primary studies, papers that looked at theoretical frameworks and papers that addressed the subject from a macro perspective. Studies that did not have a clearly identifiable intervention was excluded under this criteria.

319 were excluded based on the study design. 12 and 21 studies were rejected as they did not deal with economic outputs and did not explicitly deal with mobile technology, respectively. 20 were rejected for being urban focused. 28 studies were selected for critical appraisal. Of this, eight studies were also found in the institutional (grey literature) searches and four studies could not be located.

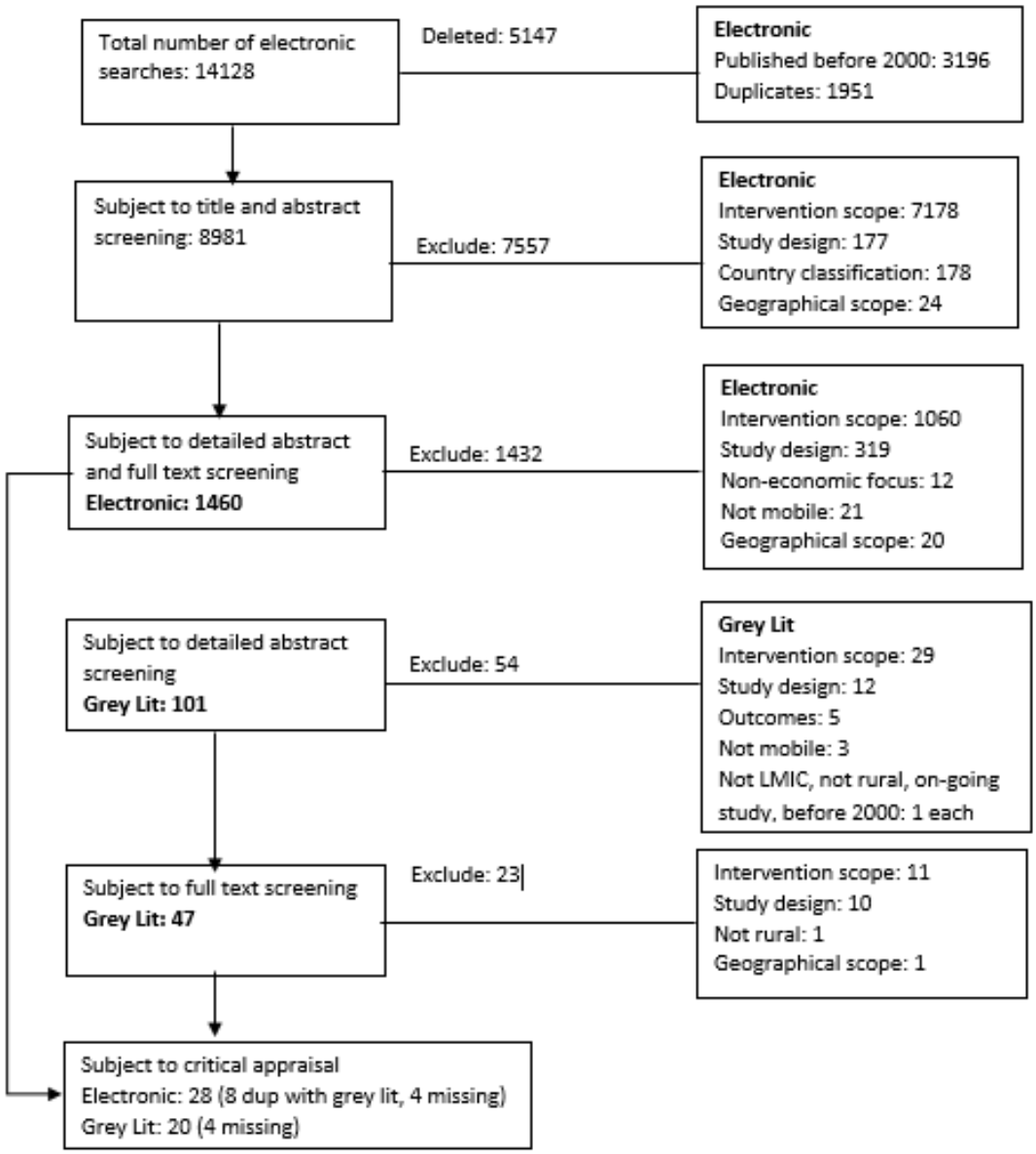
Apart from electronic database searches, the reviewers also searched through the institutional databases given in Annex 3. The primary phrase used was “information and communication technology”. If the number of hits on this was high, then the word “mobile” was used. The title and abstract screenings were done on the sites themselves. Abstracts which passed the initial assessment (a total of 101 entries) were pulled into an Excel sheet. 54 were rejected after detailed abstract screening. Of these, 29 were rejected due to the type of intervention. These included theoretical papers, review studies, and concept papers. In some cases no interventions could be identified. 12 were rejected due to study design. 5 were rejected due to outcomes. 3 were not mobile, 1 each were urban, not in LMIC category, and published prior to 2000. One study is still on-going and one was a book.

Of the remaining 47 studies, 43 were subjected to a full text screening while four could not be located as full-text. 23 were rejected. 11 were filtered out as due to the intervention, 10 were rejected due to study method used and one each excluded due to being an urban-based study and one due to outcomes of the study.

A total of 20 studies (as four could not be located) were subject to critical appraisal. Ten studies were included in the review.

Of the electronic searches, four were included in the review. The excluded studies and the reasons for rejection are given in Annex 5.

Figure 4: Study screening process



Four reviewers were involved in the initial title and abstract screening. Two reviewers were involved in the detailed abstract screening with one more reviewer participated in the full text screening for the selection of the final papers.

Table 3: Data collection variables	
General information	Author, publication date, publication type, funding agency, author affiliation
Intervention design	Intervention type, intervention agency, intervention aim, programme theory, intervention description, intervention start date, end date, control/comparison conditions, time period of intervention, additional interventions provided,

Table 3: Data collection variables	
Study design	Study type, study design, description of treatment, exposed and comparison group, frequency and period of data collection, allocation method, sample size, sample attrition, spill-overs, contamination, methods of analysis, take-up results, take-up measured, take-up diffusion, comments
Context	Country (low and lower-middle income), location (rural), size of enterprises (farm / non-farm) size of households, age, gender, education, socio-economic classification, occupation, land size, base access to mobiles, base use of mobiles, base use other, policy history, farm systems, access to infrastructure and formal systems, significant events
Cost Effectiveness and sustainability	Sustainability, cost
Primary outcomes	Changes in: disposable income, savings, profits, production, productivity, investment
Secondary outcomes	Reduction waste, reduced transaction costs, improved social networks for business, access to information / knowledge sharing, depth of distribution channels, customer retention

All primary studies were appraised to ascertain the quality of the findings.

The studies included in this review can be categorised into experimental designs, quasi-experimental designs, observational studies and natural experiments. This categorisation is based on the control a researcher has over the design of the experiment, in particular the treatment.

- Experimental designs: Participants are randomly assigned to treatment and control group.
- Quasi-experimental designs: Participants are not randomly assigned to treatment and control group but the distinction is based on other factors such as the quality of participants, being female, for example. The treatment is intentional and planned. Instead of control group the term comparison group is often used (Rempler and Van Ryzin, 2010)
- Observational studies: Treatment and control conditions are determined by nature or by other factors outside the control of the researcher. The treatment is endogenous, such as mobile phone ownership. Observational studies include the risk of self-selection bias.
- Natural experiments: Treatment and control conditions are determined by nature or by other factors outside the control of the researcher. The treatment is exogenous, such as network rollout.

This distinction is important since the types differ in their ability to establish causality and in the ways validity is assessed. Establishing causality becomes more complex the less control a researcher has about the experiment. Rempler and Van Ryzin (2010) point out, for example, that it is important to distinguish between quasi-experiments and natural experiments. The treatment for the former is consciously implemented to produce some impact, which provides more opportunity for establishing causality based on control. The table below summarises differences between these types of studies.

Table 4: Type of experiments				
Type	**Group Assignment**	**Randomized Treatment**	**Intended Treatment**	**Group characteristics**
Experiment	Yes	Yes	Yes	Control group
Quasi experiment	No	No	Yes	Comparison group
	No	No	No	Time series (before/after) Cross sectional Panel (time series and cross sectional)
Natural experiment	No	No	No	Time series (before/after) Cross sectional Panel (time series and cross sectional)

Of the 14 studies included in this review, seven were natural experiments, five were observational studies and only two were Randomised Controlled Trials (RCTs), i.e., experiments.

Table 5: Classification of selected studies				
Treatment	**Author**	**Dependent variable**		**Type of Study**
Mobile network Coverage	Jensen (2007)	Max-Min spread of prices between market		Natural Experiment
		Coefficient of variation of price spread		
		Waste reduction		
	Klonner & Nolen (2008)	Additional likelihood of a person being employed one year after coverage		Natural Experiment
	Megumi (2009)	Banana and maize market participation		Natural Experiment
		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		Natural Experiment
	Aker & Fafchamps (2011)	Price dispersion for cowpea measured as absolute value of the differences between in logs of producer prices of two markets		Natural Experiment
		Price dispersion for cowpea measured as difference in Max-Min spread of prices between two markets		
		Price dispersion for cowpea measured as difference in coefficient of variation between two markets		
	Beuermann, et al. (2012)	Effect sizes for 6 years of coverage compared to no coverage	wage income (log)	Natural Experiment
			expenditure (log)	
			assets (log)	
Mobile phone ownership	Labonne & Chase (2009)	Per capita monthly consumption		Observational study
Mobile phone ownership	Blauw & Franses (2011)	Progress in terms of Poverty Index (PPI)		Observational study
Mobile phone ownership	Lee & Bellemare (2012)	Price for onions		Observational study
Receiving	Zanello et al (2012)	Selling at the farm gate (0) or at the market (1)		Observational study

Table 5: Classification of selected studies			
Treatment	**Author**	**Dependent variable**	**Type of Study**
information via mobile phone		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	Experiment - RCT
		Higher sale price	
		Farmers' revenues	
		Household expenditures	
		Crop loss	
Free one- year subscription to the Reuters Market Light service, market and weather information delivered SMS	Fafchamps & Minten (2011)	Price dispersion	Experiment - RCT
		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 et al. (2012)	Standard deviation of geographic price dispersion for crops for each state	Natural Experiment
Having made use of ICT assisted agricultural extension services	Fu and Akter (2012)	Quality Index (QI)	Observational study

Internal and external validity

Studies were assessed for internal and external validity. Internal validity includes

- the cause precedes the effect in time,
- cause and the effect are related, and
- no plausible alternative explanations for the observed link exist.

External validity may include the ability to generalise the findings across situations, people, products, markets and countries.

Waddington et al. (2012) note that methods of assessing the internal validity of experimental designs are well established. It is less so for quasi-experimental design. Waddington, et al. (2012) propose a list of criteria and questions to assess the risk of bias (Table 6).

Table 6: Assessment internal validity for quasi-experimental designs (Waddington et al, 2012)		
Evaluation criteria	**Category of bias**	**Example evaluation questions**
Mechanism of assignment	Selection bias and confounding	Does the allocation mechanism generate equivalent groups? Does the model of participation capture all relevant observable and unobservable differences in covariates between the groups?
Group equivalence in implementation of the methodology	Selection bias and confounding	Is the method of analysis adequately executed? Are the groups balanced on observables, and all relevant confounders taken into account in the analysis? Is non-random attrition a threat to validity?
Hawthorne effects	Motivation bias	Are differences in outcomes across the groups influenced by participant motivation as a result of programme implementation and, or monitoring?

Table 6: Assessment internal validity for quasi-experimental designs (Waddington et al, 2012)		
Evaluation criteria	**Category of bias**	**Example evaluation questions**
Spill-overs and cross-overs	Performance bias	Is the programme influencing the outcome of the individuals in the comparison group (including compensating investments for the comparison groups)?
File-drawer effects	Outcome reporting bias	Is there evidence that results have been reported selectively?
Selective methods of analysis	Analysis reporting bias	Is the analysis convincingly reported and justified?
Other bias	Other biases	Are the results of the study subject to other threats to validity (for example, placebo effects, courtesy bias, inadequate survey instrument and so on)?
Statistical significance	Biases leading to type I and type II errors	Is the study subject to a unit of analysis error? Does the study take into account effect heterogeneity between sub-groups? Is insignificance due to lack of power? For regression-based studies, is heteroskedasticity accounted for?

This systematic review mostly examines studies based on natural experiments or observations. In general the assessment of risk of bias for natural experiments and observational studies is different from that for experimental or quasi-experimental designs.

For experiments and quasi-experimental designs the criteria of Waddington, et al. (2012) were used to assess internal validity. Observational studies and natural experiments were assessed based on the suitability of econometric modelling. The following techniques are considered appropriate for controlling for selection bias for empirical studies:

- Statistical matching (e.g. propensity score matching or covariate matching),
- Instrumental-variable (IV) models
- Fixed-effect models and
- 'Heckman' selection models.

External validity was assessed based on the sampling methodology for the primary data collection.

Calculation of effect sizes

Data relevant to the study (e.g., authors, date, type of publication, etc.) and those relating to intervention process and implementation, and contextual factors were extracted. Effect sizes were calculated based on the approaches suggested in Waddington, et al. (2012). Aggregation of effect sizes was only partially possible.

Table 5 demonstrates how diverse the included studies are with no two studies measuring the same depend variable. The heterogeneity among the included studies meant that only meta-analysis in a narrative form was possible. The aggregation of effect sizes in a meta-analysis for all the included studies was considered inappropriate. A meta-analysis within specific sub-groups for which contextual heterogeneity was weaker (i.e., at least the independent variable (treatment) was the same or similar such as mobile network coverage or mobile phone ownership) was conducted.

Implementation Experience

A majority of the studies included in this review are either natural experiments or observational studies. Two, however adopt an experimental approach; Camacho and Conover (2011) and Fafchamps and Minten (2011). This section will address the issues faced by the above two studies. The problems and biases identified in the other types of studies are addressed in the detailed summary of each of the studies.

Both studies have faced issues in implementation. Camacho and Conover (2011) sent price and weather information to a sample of farmers via SMS. The information corresponded to typical crops grown in the region and not necessarily those grown by an individual farmer. There was variation across farmers on the number of crops for which they received prices that coincided with their particular crops. Some farmers may have received information on all of their crops while others on none. Given the need for accurate and relevant information, this is an issue in terms of targeting and may have had an effect on the outcome of the study.

Fafchamps and Minten (2011) had a similar intervention where they used an existing paid service, Reuters Market Light (RML) which sent market price, weather and crop advisory information via SMS. For the purpose of the study, the service was offered free to the treatment group. The study found that only 59% of the farmers that were offered RML actually ended up using it. Among the reasons for not using the service were: the fear of getting charged for the service later on; issues with literacy; not completing the service activation sequence; changes in phone number; migration and phone (mainly Chinese made handsets) not being compatible with incoming SMS in local language.

Mobile Coverage

This section reviews papers dealing with mobile infrastructure interventions such as roll out of mobile network coverage. The intervention is operator driven, as only a telecom operator can roll out a network. The intervention can be made by a new network operator entering the telecom market or by an existing telecom operator expanding its coverage area.

Jensen (2007), Klonner and Nolen (2008), Megumi (2009), Aker (2010) and Aker and Fafchamps (2011) use panel data:

- Jensen (2007), Aker (2010) and Aker and Fafchamps (2011) use a panel of market data, i.e., prices from the same markets over time.
- Klonner and Nolen (2008) use household data clustered at municipality level, thus comparing average values of municipalities over time.
- Megumi (2009) interviews the same households in 2003 and 2005.
- Beuermann, et al. (2012) use pooled data from nationally representative household surveys.

Endogenous placement of mobile phone towers, i.e., the roll-out, is linked to outcome variables. It is addressed in different ways in the reviewed studies. Therefore, the reviewers decided to place the above six papers in the "mobile coverage" or "Infrastructure intervention category" as opposed to "Mobile device access and use category".

It is clear that telecom companies do not build a network on arbitrary ground, but take into account population density, household income, and cost of providing services (i.e., availability of electricity, road access, permissions to build etc.), among others. Beuermann, et al. (2012) and Aker and Fafchamps (2011) confirm this empirically. Klonner and Nolen (2008) and Aker and Fafchamps (2011) address this problem with an instrumental-variable approach. Other authors go to great length to test alternative explanations for the outcome of their studies (Jensen, 2007 and Beuermann, et al., 2012).

Jensen (2007)

Jensen (2007) documents 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 fishermen 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 not available during the first month and in some cases the first years of the experiment. Apart from coverage being gradually introduced, the adoption was also gradual after services became available. The parameters of the longitudinal study were:

- Sample frame for 15 out 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, in total 300 units.
- Interviews of sampled fishing units each Tuesday afternoon for the period September 3, 1996, to May 29, 2001.

- The interviews collected information about the morning market sales on amount of fish caught, in which market they were sold, 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 survey districts by May 21, 2000.

For the modelling, the responses are grouped into three regions, which received coverage at different points in time. The data is further grouped into four periods.

- Period 0: no coverage in any of the selected areas.
- Period 1: Region 1 covered, 31 January 1997
- Period 2: Region 2 covered, 6-31 July 1998
- Period 3: Region 3 covered, 21 May 2000

Table 7: Jensen (2007)	
Title	The digital provide: Information (technology), Market Performance, and Welfare in the South Indian fisheries sector
Year	2007
Authors	Robert Jensen
Dependent variables	Max-Min spread of prices between markets coefficient of variation percent of units having waste
Independent variables	Fuel cost, wind index
Treatment variable of intervention	Mobile network coverage provided by mobile operators
Population	Kerala Fishermen in three districts: Kasaragod, Kannur, and Kozhikode
Representativeness	sardine fishermen at the selected markets
Data	Panel of markets and randomly selected fishing units at these markets
Sample Size	74,700 observations for nearly 6 years
Model	Regression
Type	Natural Experiment
Internal validity	A detailed sensitivity analysis was performed and various alternative explanations for the findings explored by the author
External validity	Generalizable to small-scale fishing markets around the world. Transfer in principle to other markets with different magnitudes.
Effect Size	Price dispersion between markets and waste reduction (standard errors in brackets): 1) Reduction in min-max spread: - INR 5 (0.27) 2) Reduction in coefficient of variation: -0.38 (0.03) 3) Waste reduction: -0.048 (0.0004)

Jensen (2007) pooled the data. The model specifications included dummies for regions, periods and an indication of whether phone coverage was available for the period and region. The main finding was that the mobile phone allowed fishing markets to work better. Fishermen were able to choose the market to sell to on the way back to shore by asking for current prices from multiple harbours or even agree on a sale. Jensen (2007) found that the presence of mobile phones also benefited fishermen without a mobile due to better demand and supply matching across the various markets. He found that price dispersion in terms of minimum-maximum spread between markets in the same region dropped by Indian Rupees (INR) 5 per kg of Sardines on average, from the initial INR 7-8 per kg. The price dispersion measured through the coefficient of variation (standard deviation / mean) dropped by 38 percent between markets. Also waste,

unsold fish, was reduced by 4.8 percent. Jensen (2007) went to great lengths to examine and exclude alternative explanations to arbitrage being the explanation for the lower price dispersion and also estimated consumer and producer surpluses resulting from mobile phone coverage.

Klonner and Nolen (2008)

Klonner and Nolen (2008) analyse the impact of mobile network roll-out on household income and employment status in rural South Africa using household and labour force survey data from the national statistical office (StatsSA). The data, which are collected for census enumerator areas (EAs) are mapped to coverage data from Vodacom. Klonner and Nolen (2008) merge the October Household Survey (OHS) from 1996, 1997 and 1998 with the September Labour Force Survey for 2000 and 2001, thus creating a municipal panel over 5 years. All individuals from the household survey that were in the labour market were included in the data set. Klonner and Nolen (2008) avoid the problem of larger households affecting the results by clustering the standard errors at a level above the household to account for the correlation of employment within the household.

Table 8: Klonner and Nolen (2008)	
Title	Do ICTs Benefit the Poor? Evidence from South Africa
Year	2008
Authors	Stefan Klonner and Patrick Nolen
Dependent variables	Employment status
Independent variables	Mobile coverage in the previous year, demographic composition of area, schooling, age, location, gender
Treatment variable of intervention	Mobile coverage
Population	Rural South Africa
Representativeness	National - South Africa
Data	Panel data at municipal level, constructed from October household surveys for 1996 to 1998 and labour force surveys for September 2000 and September 2001
Sample Size	Observations: 57486
Model	Regression and IV
Type	Natural experiment
Internal validity	No concern: IV to control for endogeneity
External validity	No concern: nationally representative data from national statistical office. 88 models were run testing for various factors. Also clustering at municipality level was checked against a wider clustering at district level.
Effect Size	Increase in employment for the year following coverage 33.7% higher (0.102)

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 reflecting topographical factors under the assumption that topography would be an important factor for the roll out of a network. The roll out of networks depends on many factors and topography may only be one of them and unlikely to be an important one at the beginning of network roll-out. The instrumental variable (IV) for topography thus may not be ideal. The initial roll-out was in urban areas and along national highways, as can be seen from Figure 2 on page 22. Klonner and Nolen (2008) ensured that the IV picked up exogenous factors that predicted roll out, thus confirming that they established a suitable instrument.

Another potential limitation could be that at the time of the survey there were two mobile operators that even in 2013 had a slightly different network footprint. MTN and Vodacom at that time were roughly of 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 IV is, however, robust to measurement error as pointed out by Klonner and Nolen (2008).

A third potential concern is the clustering by municipality. The sampling done by StatsSA is representative nationally and for provinces and districts but not for municipalities. The randomly selected enumerator areas (EAs) within a municipality in one year may thus be very different from those randomly selected in the next. South Africa has among the highest Gini coefficients in the world which is also reflected in where people live within a municipal area, rural as well as urban. Klonner and Nolen (2008) ran regressions at the district level to confirm that this would not have an impact. They found that if a municipality goes from 0 percent to 100 percent coverage employment increases by 33.7 percent the following year. Applied to this specific case is a 15 percent increase in employment, on average, for rural areas that had cellular coverage during the period of 1997 until 2001. Ideally the models would be re-run with MTN coverage included to reduce the measurement error.

Megumi (2009)

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

Table 9: Megumi (2009)	
Title	The Impact of Mobile Phone Coverage Expansion on Market Participation: Panel Data Evidence from Uganda
Year	2009
Authors	Muto Megumi
Dependent variables	1) Banana and maize market participation 2) Proportions of production sold 3) Relative price of bananas and maize
Independent variables	Survey year 2005 as a dummy Network coverage Distance to district centre in miles Interaction variable between coverage and distance to district centre
treatment variable of intervention	Mobile Coverage Mobile phone ownership
Population	Purposefully selected farm households

Table 9: Megumi (2009)	
Representativeness	Only representative for the sampled households as the survey was stratified but not based on random sampling.
Data	Panel of households interviewed in 2003 and 2005
Model	Fixed effects
Sample Size	856 households
Type	Natural experiment
Internal validity	No concern: author controlled for endogeneity
External validity	The study is only representative for participating households. The findings cannot be generalised. The author does not explore alternative explanations in detail
Effect Size	Measured by distance-coverage interaction variable 1) Bananas: a) Banana market participation: 0.007 (2.53) b) Proportions of banana production sold: 0.003 (1.81) c) Relative price of bananas: 7.543 Uganda shilling(2.48) 2) Maize: a) Maize market participation: not significant b) Proportions of maize production sold: not significant

Megumi (2009) concludes that coverage expansion led to higher market participation of farmers who are located in remote areas and produce perishable crops, cooking bananas (in local language Matooke) in this case. No significant impacts could be determined for maize.

Aker (2010)

Aker (2010) measures price dispersion across millet markets in Niger using market and a trader-survey and finds 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 of price dispersion, unlike Jensen (2007).

Table 10: Aker (2010)	
Title	Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger
Year	2010
Authors	Jenny C. Aker
Dependent variables	Price dispersion for millet, measured as absolute value of the price differences between two markets
Independent variables	Transport cost, occurrence of droughts, geographic location, urban status, market size, lagged values of dependent variable,
Treatment variable of intervention	Mobile network coverage provided by mobile operators
Population	Grain markets in Niger
Representativeness	Survey: full sample of traders at randomly selected markets
Data	Panel of Markets based on two data sets: 1) survey and agricultural prices from markets; 2) agricultural prices from 37 domestic markets from Agricultural Market Information Service (AMIS)
Sample Size	53,820 observations
Model	Fixed effect panel data analysis
Type	Natural experiment
Internal validity	The author explores alternative explanations in great detail

Table 10: Aker (2010)	
External validity	No concern: full sample of traders at randomly selected markets. Results can be generalised for similar markets
Effect Size	Reduced price dispersion (standard errors in brackets): 16% or 3.51 CFA/kg) (0.645)

Aker and Fafchamps (2011)

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

- A market trader and farmer survey data for the period 2005 to 2007.
- A 10-year (1999-2008) dataset for 37 domestic markets covering millet and cowpea prices.

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

Table 11: Aker and Fafchamps (2011)	
Title	How Does Mobile Phone Coverage Affect Farm-Gate Prices? Evidence from West Africa
Year	2011
Authors	Jenny C. Aker and Marcel Fafchamps
Dependent variables	Price dispersion for cowpeas 1) measured as absolute value of the differences between logs of producer prices of two markets 2) measured as difference in Max-Min spread of prices between two markets 3) measured as difference in coefficient of variation between two markets
Independent variables	Fuel prices, transport costs, road distances, market latitude and longitude and rainfall
Treatment variable of intervention	Mobile network coverage provided by mobile operators
Population	Grain markets in Niger
Representativeness	37 domestic grain markets
Data	1) Panel of markets: A 10 year (1999-2008) dataset for 37 domestic markets covering millet and cowpea prices. 2) A market trader and farmers survey data for the period 2005 to 2007.
Sample Size	Model based on market pairs: 39,120 observations 970 market pairs 37 markets Model based on min-max spread across all 37 markets: 2503 observations 37 markets
Model	Fixed Effect Panel Data Analysis
Type	Natural experiment
Internal validity	The author explores alternative explanations in great detail
External validity	No concern: full sample of traders at randomly selected markets. Results can be generalised for similar markets. The results are robust and several factors have been accounted for including market fixed effects, month fixed effects, infrastructure, transport costs and droughts.

Table 11: Aker and Fafchamps (2011)	
Effect size	Price dispersion between markets (standard errors in brackets): 1) absolute price differences between two markets: 6.3% (-0.007) 2) min-max spread: (standard error): 50% (0.105) 3) coefficient of variation: 6% (0.14)

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

Aker and Fafchamps (2011) found that coverage reduced price dispersion for cowpeas by 6.3 percent when comparing market pairs. In terms of min-max spread across all markets. Coverage led to a reduction of 50 percent in the spread and 6 percent 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 droughts.

Beuermann, et al. (2012)

Beuermann, et al. (2012) analyse the impact of mobile coverage roll out in rural Peru on household assets, income and expenditure. They construct a data set based on coverage data and national household surveys from 2001 and 2007. Beuermann, et al. (2012) ran various models to test for the impact of mobile coverage on household characteristics, controlling for roll out bias towards more populated and higher income areas by mobile operators, for time varying effects to account for growth areas and for migration.

Table 12: Beuermann et al (2012)	
Title	The Effects of Mobile Phone Infrastructure: Evidence from Rural Peru
Year	2012
Authors	Diether W. Beuermann, Christopher McKelvey and Carlos Sotelo Lopez
Dependent variables	Wage income, mobile ownership, expenditure, assets, profits of home businesses / farms
Independent variables	Dummies for coverage, year fixed effect, village fixed effect / Dummies for years a village had coverage, year fixed effect, village fixed effect
Treatment variable	Mobile network coverage provided by mobile operators
Population	Households in rural areas
Representativeness	Using nationally representative household income and expenditure survey data, but limiting the analysis to rural areas
Data	Pooled data for 6 years based on household survey data and coverage data of mobile operators
Sample Size	Around 40,000 observations, varies with models
Model	Fixed effects panel data analysis
Type	Natural experiment
Internal validity	No concern: Controlled for roll-out bias towards more populated and higher income areas by mobile operators Controlled for time varying effects to account for growth areas Controlled for migration
External validity	No concern, nationally representative data
Effect Size	Effect sizes for 6 years of coverage compared to no coverage: wage income (log): coefficient =0.34, standard error =0.043 expenditure (log): coefficient =0.446, standard error =0.073 assets (log) : coefficient =0.538, standard error =0.168 profits of home businesses / farms: coefficient =not significant

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

Discussion

The six studies reviewed in this section produced valuable and credible insights on the impact of mobile coverage on markets and households. The studies benefited from the advantages of natural experiments, measuring an outcome variable before, during and after network roll-out. For natural experiments several potential biases encountered in RCTs fall away such as spill over, Hawthorne effects and motivation bias. However, causality becomes more complex to establish. Confounding variables are usually dealt with by the use of instrumental variable and fixed effect regression models. The risk of findings being biased by the choice of where operators build the next base station was addressed by all authors, except Megumi (2009).

Mobile coverage enhances economic activities, leads to more price transparency and more efficient markets and benefits businesses, households and individuals.

Mobile Device Access & Use

This section reviews papers based on access device interventions. This can be based on mobile phones or SIM cards gifted to someone as an intervention or self-selection, i.e., the impact of mobile adoption. The only study reviewed that yields credible results for the impact of mobile adoption is based on panel data. Labonne and Chase (2009) analyse the impact of mobile phone adoption on income approximated by expenditure of a panel of farmers over three years.

Blauw and Franses (2011), Zanello et al. (2012) and Lee and Bellemare (2012) use small sample size, non-representative, cross section survey data, which means that the results cannot be generalised.

Labonne and Chase (2009)

Labonne and Chase (2009) explore the impact of access to information through mobile phones on poor farmers' consumption in the Philippines by constructing a panel of households, visited in 2003 and 2006. The panel data set is combined with spatially coded mobile coverage data. The first wave interviewed 2,400 households and the follow-up survey in 2006 re-interviewed 2,092 households. The households were selected from 135 villages in 16 of the poorest municipalities of the Philippines.

The impact of information is measured through mobile phone ownership, based on the assumption that the 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 expenditure, particularly for poor households.

Labonne and Chase (2009) construct an instrumental variable based on mobile phone availability in the village in 2003 and highest level of education achieved by children in school in 2003. This is thought to be correlated with the decision to buy a mobile phone through network effects and education driving adoption. Labonne and Chase (2009) test for weakness of the IV and were able to reject it.

Table 13: Labonne and Chase (2009)

Title	The Power of Information The Impact of Mobile Phones on Farmers' Welfare in the Philippines
Year	2009
Authors	Julien Labonne and Robert S. Chase
Dependent variables	Per capita monthly consumption
Independent variables	Education of household members, household size, age, land ownership
Treatment variable of intervention	Mobile phone purchase
Population	Farmers from some of the poorest areas of the Philippines
Representativeness	Only representative for the purposefully selected households
Data	Panel Data: 2 visits to same household 2003 and 2006 in 135 villages in 16 of the poorest municipalities in the Philippines.
Sample Size	2092 households
Model	OLS
Type	Observational Study
Internal validity	IV to establish causality: self-selection with IV controlling for self-selection
External validity	Concern: Sampling not random, results cannot be generalised.
Effect Size	Increase in growth rate of per capita consumption: 15% (0.032)

Table 13: Labonne and Chase (2009)	
Sensitivity analysis	The authors test for alternative explanations for the outcome (including re-estimation of the results excluding durable goods such as a mobile phone)

Labonne and Chase (2009) find that mobile phone adoption leads to an 11-17 percent higher growth rate of per-capita consumption depending on the sample and the specification chosen.

Blauw and Franses (2011)

Blauw and Franses (2011) analyse the impact of phone use on the poverty status of households and individuals, using the Progress out of Poverty Index (PPI) developed by the Grameen Foundation for Kenya. The index ranges from 1 to 100, with lower values indicating high probability of poverty. Telephone use was classified as

- Basic telephone use: public phone use, mobile phone use by head of households, 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. The responses from 167 households were used in the empirical model. The selection was based on judgment and was not random. The results can thus not be generalised. Blauw and Franses (2011) use IV estimations to deal with endogeneity, but the paper does not state how the instrumental variables were constructed.

Table 14: Blauw and Franses (2011)	
Title	The Impact of Mobile Telephone Use on Economic Development of Households in Uganda
Year	2011
Authors	Sanne Lise Blauw and Philip Hans Franses
Dependent variables	Progress in terms of Poverty Index (PPI)
Independent variables	Household size, years of education of the head of household, being a farmer
Treatment variable of intervention	Mobile ownership of head of household Mobile use of any member in household
Population	Household heads in three interview locations
Representativeness	Only representative of respondents
Data	Non representative cross section
Sample Size	167 households
Model	IV
Type	Observational Study
Internal validity	Concern: IV specifications are unclear
External validity	Concern: Judgmental sampling, results cannot be generalised
Effect Size	Mobile use of head of household: 0.618 (0.221)
	Mobile use any household member: 0.891 (0.342)

The sampling methodology and sample size make this at best an indicative study. The number of respondents that used mobile banking services and mobile search were low (12% and 5% respectively) as such no statistical analysis was done on advanced telephone use. Therefore the study has only been categorised in “Mobile device access and use”.

Lee and Bellemare (2012)

Lee and Bellemare (2012) analyse the impact of mobile phone ownership of farmers and family members on the price of yellow onions for 95 farm families. The data was collected between May and June 2010, two or three month after farmers sold their onion harvest. The farm families are located in three districts surrounding San Jose in the Nueva Ecija province of the Philippines.

Table 15: Lee and Bellemare (2012)	
Title	Look Who's Talking: The Impacts of the intra household Allocation of Mobile Phones on Agricultural Prices*
Year	2012
Authors	Kyeong Ho Lee and Marc F. Bellemare
Dependent variables	Price for onions
Independent variables	First model: household characteristics, dummy for each one in household owning a mobile. Second model: replaces the mobile dummy with individual dummies for each household member
Treatment variable of intervention	Not intervention but characteristic: mobile phone ownership
Population	Purposefully selected farmers in Philippines
Representativeness	Representative only for selected farmers, no random sample selection
Data	Non-representative cross section data
Sample Size	95 households
Model	2 stage: first stage probit regression, second stage OLS
Type	Observational Study
Internal validity	Concern, study did not establish causal link
External validity	Concern: Judgmental sampling, results cannot be generalised, Weights applied were designed to adjust sample characteristics to population proportions, which does not make the data any more representative to the unweighted data
Effect Size	Higher onion price if farmer had a mobile: 0.053 (0.032)
Sensitivity analysis	Several configurations are tested by the authors

Lee & Bellemare (2012) find that when the farmer or spouse own a mobile phone they manage to obtain five to seven percent higher prices for their crops compared to farmers and spouses that both do not own a mobile phone. The sample size is small and the sampling was not done randomly. The results cannot be generalised. The authors state that they could not establish the causal impact of mobile phones on the prices received by farmers in this context.

Zanello, et al. (2012)

Zanello, et al. (2012) analyse determinants that drive the farm household's decision of the marketplace. They use data collected from Ghanaian farmers in five communities from three rural districts, 30 per community, in total 447 farm households. The final data set only uses data from 197 farm households. Zanello, et al. (2012) test for whether the decision to sell at a market or at the farm gate is 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 if the farmer decided to sell at a market, which is chosen out of community, district or regional market options. The two decisions were analysed for a group of crops together including, millet, sorghum, maize, rice, cowpea and groundnut. Zanello, et al. (2012)

used an instrumental variable to control for endogeneity. This is however not linked to receiving information via the mobile phone. Several concerns arise:

- The main concern is the reliability of the survey. It is not clear how the districts and communities were selected. The authors state that the 30 households per community were randomly selected but do not provide any details about the sample protocol.
- Sample size is of further concern. 197 households for multiple agricultural products seems too low. Sample size was not determined by any of the usual formula (UNSD 2005, for example).
- It is not clear whether the selected respondents received any relevant information for the 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 co-operative business model. They found only weak evidence of the use of mobile phone to reduce search costs and attract farm gate buyers. The findings cannot, however, be generalised due to small sample size and absence of representative sampling.

Table 16: Zanello et al (2012)	
Title	Transaction costs, information technologies, and the choice of marketplace amongst farmers in northern Ghana
Year	2011
Authors	Giacomo Zanello, Bhavani Shankar and C. S. Srinivasan
Dependent variables	Dichotomous variable: 1) Selling at the farmgate (0) or at the market (1) 2) Choosing the marketplace: community (C), district (D), or regional market (R)
Independent variables	Mark-up price; bike ownership; distance to markets; bargaining done by spouse; trust on buyer; receiving information via mobile phone, radio, word of mouth, neighbours or extension agents; whether market prices are known
Treatment variable of intervention	Receiving information via mobile phone
Population	Farm households
Representativeness	Only for sampled farm households
Data	Cross section data of a small none representative survey
Sample Size	197 households
Model	Probit model
Type	Observational Study
Internal validity	No concern, IV
External validity	Concern, no random sampling, results cannot be generalised
Effect Size	Selling at market -0.642 (0.374) sign. at 10% level

Discussion

Only the study by Labonne and Chase (2009) provides credible results for the impact of mobile adoption. They find that purchasing a mobile phone leads to an increased growth rate of per capita consumption between 11 percent to 17 percent depending on the sample and the specification chosen. This indicates that the mobile phone indeed creates more productive opportunities leading to higher incomes and thus higher consumption. However, Labonne and Chase (2009) studied poor farm households in the Philippines and while the direction of impact will be similar across the globe and various population segments, the magnitude is likely to be different.

Applications and Services

This section deals with the impact of service or application interventions such as information about prices, agricultural advisory services and mobile money services that are made available to a population for free or for a fee.

Camacho and Conover (2011)

Camacho and Conover (2011) use a randomised controlled trial methodology to analyse whether the recipients of price and weather information via SMS would change what they plant and be able to get a higher price on regional markets. Camacho and Conover (2011) randomly sampled 500 farmers from two irrigation associations in Colombia. Those were divided into a control and a treatment group based on random assignment. The selected farmers were surveyed in March-April 2009 and in December 2009. During the period from July to December 2009 each farmer of the treatment group received 144 price messages, 34 weather messages, and four administrative messages on average.

Table 17: Camacho and Conover (2011)		
Title		The Impact of Receiving Price and Climate Information in the Agricultural Sector
Year		2011
Authors		Adriana Camacho, Emily Conover
Dependent variables		Lower dispersion in sale price Higher sale price Farmers' revenues Household expenditures Crop loss
Independent variables		Education, experience, age, gender, percentage of time dedicated to farming, size of the crop, storage capacity, own means of transport, whether the farmer is credit constrained, distance from the farm to markets
Treatment variable of intervention		Price and weather information using text messages (SMS technology)
Population		Farmer from two irrigation co-operatives in Colombia
Representativeness		Only respondents
Data		Panel data of 500 farmers
Sample Size		500
Model		RCT
Type		Experiment
Internal validity appraisal	Mechanism of assignment or identification	No concern
	Group equivalence in implementation of the methodology	No concern
	Hawthorne effects Motivation bias	No concern
	Spill-overs and cross-overs	Spill over is documented by authors. There were no significant price differences of prices yielded at markets between treatment and control group, the overall price went up.
	File-drawer effects	No concern
	Selective methods of analysis	No concern

Table 17: Camacho and Conover (2011)		
	Other biases	No concern
	Statistical significance	No concern
Effect Size		No significant difference between the treated and untreated farmers in the actual sale price
		No significant changes in farmers' revenues or household expenditures
		No significant reduction in crop loss

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 reported prices by SMS. This is hardly surprising given that they received 144 price SMS during a six month period. Testing knowledge about the content of SMS sent and expectation based on this knowledge cannot have been the objective of this intervention. They 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 compared to the farmers in the control group not to be significantly different. However, they recorded a significant increase in the sale prices of the products included in the intervention, which is likely a spill-over effect of the program. The reported prices, via SMS, were average prices from central markets. Informed buyers entering the market will have an impact on the average price, from which the uninformed buyers may also benefit even in the absence of a spill over.

Camacho and Conover (2011) did not find significant differences for crop loss.[9]

Fafchamps and Minten (2011)

Fafchamps and Minten (2011) investigate the benefits of the Reuters Market Light (RML) information service for Indian farmers through randomised controlled trials (RCTs) in 100 villages of Maharashtra. They did not find significant treatment effects for price 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 that are sold by small-scale farmers in Maharashtra. These five crops were selected due to their different characteristics. Wheat and soybean are storable. Pomegranate is a tree fruit which is sensitive to weather. Tomato and onions cannot be stored for long.

- One district in Maharashtra was chosen for each crop where small farmers grow and sell that crop.
- In each of the five districts 20 villages were chosen, 100 in total. The villages were selected purposefully in close consultation with Thomson-Reuters to ensure the villages were not previously targeted by Thomson-Reuters marketing campaigns.
- Ten farmers were randomly selected from each village: 1000 farmers in total. Only farmers that grew the respective crop, had not previously used RML and owned a mobile phone were eligible for selection and entered into the sample frame for the village.
- The 20 villages were grouped into 6 triplets and one pair based on similarity characteristics.
- Villages from each triplet were randomly assigned to be treatment 1, treatment 2 or control village.

9 Camacho and Conover (2011) will release a revised paper is due course.

- In treatment 1 village all 10 farmers got access to the RML service, in treatment 2 village only 3 out of 10 and none in the control villages.
- A baseline survey, June-July 2009, confirmed that all 100 villages had electricity and mobile phone coverage.
- The ex-post survey, after one year free subscription to RML, was conducted in June-July 2010.

Table 18: Fafchamps and Minten (2011)		
Title		Impact of SMS-Based Agricultural Information on Indian Farmers
Year		2011
Authors		Marcel Fafchamps Bart Minten
Dependent variables		Price received by farmers, crop value added, crop losses resulting from rainstorms, likelihood of changing crop varieties and cultivation practices for tomato, pomegranate, onions, wheat, and soybean
Independent variables		
Treatment variable of intervention		Free one- year subscription to Reuters Market Light service, market and weather information delivered via SMS
Population		Non random selection of 100 villages of Maharashtra
Representativeness		Representative sampling of farmers with a cell phone and not RML customers at baseline
Data		Baseline and Follow-Up Survey Data
Sample Size		Total Target: 1000 Farmers Treatment 1: 325 Farmers Treatment 1: 336 Farmers Control: 272 Farmers
Model		RCT
Type		Experiment
Internal validity appraisal	Mechanism of assignment or identification	No concerns
	Group equivalence in implementation of the methodology	No concerns
	Hawthorne effects Motivation bias	No concerns
	Spill-overs and cross-overs	No concerns, spill overs reported in Table 2 and addressed
	File-drawer effects	No concerns
	Selective methods of analysis	No concerns
	Other biases	No concerns
	Statistical significance	No concerns
Effect Size		No significant impact on price dispersion No significant impact on price received by farmers No significant impact on crop loss due to rainstorms No significant impact on likelihood of changing crop varieties and cultivation practices

Fafchamps and Minten (2011) controlled for various potential or actual spill-over effects. A potential spill-over for treatment 2 villages was examined by analysing 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 that did not get RML services. Running the analysis separately for only treatment 1 villages did not yield significant results either.

Farmers from the control villages could have received RML services on own account. The paper states that this contamination was limited to 10 out of 272 farmers of control villages. Non-compliance, not making use of the free service, was common, but also controlled for by running the analysis for users of RML only. The authors could not rule out that supply factors could have played a role.

Parker, et al. (2012)

Parker, et al. (2012) analyse the impact of access to information on geographic price dispersion within state boundaries for two crops in rural India using a data set of Reuters Market Light (RML), an SMS based information service.

Table 19: Parker et al. (2012)	
Title	Is IT Enough? Evidence from a Natural Experiment in India's Agriculture Markets
Year	2012
Authors	Chris Parker, Kamalini Ramdas, Nicos Savva
Dependent variables	Standard deviation of geographic price dispersion for crops for each state
Independent variables	1) Perishability(high, medium, low) 2) Dummy for bulk message ban, dummy for data after the bulk ban was lifted 3) Day of week 4) Number of subscribers in state for a crop (sum of subscribers for all market for a crop - duplication for subscribers registered for more than one market)
Treatment variable of intervention	Ban on bulk SMS for 12 days
Population	Reuters Market Light (RML) subscribers for selected markets in India
Representativeness	Representative for subscribers of Reuters Market Light (RML) services
Data	RML's subscribers database, market information database
Sample Size	14,349
Model	Regression
Type	Natural experiment
Internal validity	No concern: Reasons for omitting data for Sundays and public holidays and markets is infrequent training is well founded and justifiable
External validity	No concern: Use of full data set for a particular market. The results demonstrate the effect the magnitudes cannot be generalised for other markets dealing in other products.
Effect Size	5.2% higher spatial price dispersion during ban

During the period of investigation bulk text messages were banned unexpectedly for twelve days across India allowing the authors to identify the difference information availability made to the analysed crop prices.

Thomson Reuters provided two distinct databases for the study, a subscriber database and a market information database. The subscriber database contains start and end date of subscription and the up to three markets chosen by subscribers. The market information database contains daily data for all markets in India where the crop is being traded for volume, and high and low price. Price data covered the period 22 August - 8 November, 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 that the impact was positively related to the number of users and the perishability of crops, which is not surprising given that the bulk SMS ban was only in place for 12 days. They found that the average spatial price dispersion for 170 crops across 13 states increased by 5.2 percent

during the time of the ban. Price dispersion was measured as standard deviations of high prices recorded across market-clusters for each day.

Fu and Akter (2012)

Fu and Akter (2012) examined the impact of a mobile agricultural extension services provided by a project named 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 specialists and farmers to meet to report problems and provide solutions. 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 the intermediation through Munnas with mobiles. They conducted two surveys, a baseline survey in July 2008 and a follow up survey in March 2009. The treatment group contained all beneficiaries of the KHETI project from 30 villages, total of 698 farmers. The comparison group was made up of 507 farmers randomly selected from 26 villages where KHETI agricultural extension services were not provided.

Fu and Akter (2012) investigated the mobile assisted agricultural extension services among farmers. The majority of 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.

Table 20: Fu and Akter (2012)	
Title	Impact of Mobile Telephone on the Quality and Speed of Agricultural Extension Services Delivery: Evidence from the Rural e-services Project in India
Year	2012
Authors	Xiaolan Fu and Shaheen Akter
Dependent variables	Quality Index (QI)
Independent variables	Age, caste, education, marital status, access to credit, irrigation facilities, gender, ownership of land and village characteristics
Treatment variable of intervention	Having made use of ICT assisted agricultural extension services
Population	Selected farmers that were members of an NGO that introduced an ICT assisted extension service
Representativeness	Only for selected respondents.
Data	Panel of 1336 farmers, 698 of whom received the treatment
Sample Size	1336
Model	OLS and Tobit
Type	Observational study
Internal validity	White heteroskedasticity-corrected estimates. However, the results may have been influenced by farmers expecting to receive the services also in future for free. Causality is not clearly established.
External validity	Concern, results cannot be generalised
Effect Size	OLS: 0.35 (0.005)

Fu and Akter (2012) constructed a quality index based on evaluation of the quality of service. They use 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 is 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 (Wooldridge, 2009). The OLS results are used in the summary table above for which the coefficient for the Quality Index is lower compared to the coefficient for the latent dependent variable of the Tobit model. They found based on the OLS model that the Quality index (QI) improved by 0.35 points, and increased in the QI from 0.57 to 0.92 after the treatment.

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

Discussion

Parker, et al. (2012) were able to demonstrate the effects of an electronic price system on price dispersion. The evidence from other others has either been insignificant or not convincing. Parker, et al. (2012) were able to use a natural experiment for their study.

Not having found significant differences between control and treatment group does, however, not mean that there were no benefits. The spill-over from SMS intervention in Columbia (Camacho and Conover, 2011) resulting in higher sales prices for all farmers is an example. Another reason why RCT studies for services via a 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 value of the intervention based on the paper alone.

An example could be a SMS based weather services. Farmers in the control group may, for example, receive the required weather information from other sources. At the same time farmers from the treatment group may not rely on the information provided via SMS and instead rely on traditional sources. Farmers of the treatment group could also lack the ability to use the weather information effectively or not trust it enough to make changes that may impact adversely on their livelihoods. An SMS weather service would need to prove itself over many years before it could replace traditional means and instincts of farmers learned over generations.

Meta-Analysis

The meta-analysis is limited to studies that delivered credible and generalizable results. Generally, studies using panels of markets, farmers, households or municipalities were able to provide results that are both credible and generalisable. Parker, et al. (2012) did not use a panel data set but were fortunate to be able to work with data before, during and after a ban of services. Small sample size cross-section studies using non-representative sampling were not considered for the meta-analysis, since results cannot be generalised.

Trying to standardise absolute and relative effect sizes for markets, farmers and households across different dependent variables makes little sense. Instead, the practical implications for policy makers, regulators and stakeholders for whom the research may be of interest are highlighted in this section.

Mobile Coverage

The coverage studies worked well since there could not have been any spill-overs but also because they were based on panel data and addressed endogeneity issues. Six studies were included in this review that dealt with the impact of mobile phone coverage, five of which produced credible results that can be generalised. Jensen (2007), Aker (2010) and Aker and Fafchamps (2011) demonstrated how agricultural markets work more efficiently and price volatility decreases with the extension of mobile phone coverage to rural areas.

Table 22: Treatment variable mobile coverage

Author	Dependent variable		Observations	Effect Size	Standard Error
Jensen (2007)	Max-Min spread of prices between market		74,700	-5 Rs	0.27
	coefficient of variation price spread			-0.38	0.03
	Waste reduction			-0.048	0.0004
Klonner and Nolen (2008)	Additional likelihood of a person being employed one 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%, 3.51 CFA/kg	0.645
Aker and Fafchamps (2011)	Price dispersion for cowpeas measured as absolute value of the differences between in logs of producer prices of two markets		39,120	6.3%	-0.007
	Price dispersion for cowpeas measured as difference in Max-Min spread of prices between two markets		2,503	50%	0.105
	Price dispersion for cowpeas measured as difference in coefficient of variation between two 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	0.073
		assets (log)		0.538	0.168

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 very different and at a very different point in time. The results of a roll-out would be different to an upgrade of base stations for example. Also, fish markets in India, where the fish have to be sold that day, will benefit differently from mobile coverage compared to cattle auctions and grain markets in Niger.

The evidence relevant for policy makers and regulators from these studies are that:

- Mobile coverage in rural areas makes market more efficient by leading to a more efficient matching of demand and supply, leading to both consumer and produce welfare gains by moving close to the one-price ideal. The 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 percent, i.e., if 50 percent of the labour force was employed prior to coverage, then 66.9 percent of the labour 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 expenditure. Expenditure increased by nearly 44.6 percent six years after coverage arrived in Peru.

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

Device access and use

Only the study by Labonne and Chase (2009) provides credible results for the impact of mobile adoption. They find that purchasing a mobile phone leads to an increased growth rate of per capita consumption between 11 percent to 17 percent depending on the sample and the specification chosen.

Table 23: Treatment variable Device access and use

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

The implication of this for policy makers is that mobile adoption is desirable and that policies should be geared to allow wide access to mobiles. Low prices would further stimulate use. Lower access and usage prices can best be established by 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 the increased income.

Mobile services and applications

The only randomised controlled trial studies in this review are by Fafchamps and Minten (2011) and Camacho and Conover (2011). Both did not yield significant results, which is a finding in itself. A mobile phone or application service may not be an ideal treatment to measure impact. An information service provided for free for a year does not mean that the service is of actual value to farmers. Neither does it

mean that farmers that do not get the treatment service do not have access to this service indirectly nor have alternative sources of information.

Table 24: Treatment variable Mobile services and applications					
Author	**Treatment variable**	**Dependent variable**	**Observations**	**Effect Size**	**Standard Error**
Fafchamps and Minten (2011)	Free one- year subscription to the Reuters Market Light service, market and weather information delivered SMS	Price dispersion	1000 farmer, 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 and Conover (2011)	SMS information service on weather and prices	Sale price	1107	Not significant	
		Farmers' revenues	1107	Not significant	
		Household expenditures	1107	Not significant	
		Crop loss	1107	Not significant	

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

Another 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. It is not possible to assess the value of the intervention based on the paper alone.

Conclusion

The heterogeneity among the studies that remained after the various screens were applied meant that meta-analysis was only possible in narrative form. A meta-analysis that aggregates effect sizes for all the included studies was not possible. Therefore, the meta-analysis was done within specific sub-groups anchored on different kinds of actions or interventions. Heterogeneity exists within the sub-groups but is less than if the studies are taken as a whole.

Mobile-phone interventions may be broadly classified as those that promote the use of mobile phones either by providing network infrastructure and thus coverage, hardware (phones, SIM cards, network access) or by providing services and information using mobile technology. Interventions also include mobile applications developed for specific tasks or communities. The following are the sub groups, anchored on different kinds of interventions:

- Studies of infrastructure interventions: When mobile network coverage reaches a population that was previously lacking connectivity. The intervention is entry of a new mobile network operator into a market or an existing operator who rolls out its network to reach a hitherto unserved population. Five studies were included.
- Studies of access-device interventions: When mobile phones and / or SIM cards are bought by the user or are provided by a third party. Four studies were included.
- Studies of content and application interventions: When Value Added Services (VAS) such as information about prices or agricultural advisory services are made available to the general populace for free or at a charge or when applications are designed for particular tasks and or for particular communities (m-health application for example). Four studies were included.

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 benefited from the advantages of natural experiments, measuring an outcome variable before, during and after network roll-out. The risk of findings being biased by the choice of where operators build base stations was addressed by all authors, except Megumi (2009). Therefore, it may be concluded that four well-designed and executed studies provide 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) provide 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 between 11-17 percent depending on the sample and the specification chosen.

The evidence from the content-and-application interventions category is similarly 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. However, the fact that the only randomised control trial (RCT) studies in this review which were in the content and applications category did not yield significant results indicate the need for further research on whether RCTs are the most appropriate for the kinds of interventions that are found in relation to mobile-phone use.

A mobile phone or content and application service may not be an ideal treatment to design a rigorous study around. An information service provided for free for a year does not mean that the service is of actual value to farmers. It is not possible to exclude the possibility that study participants who do not receive the treatment do not have access to the access-device, the content or application indirectly.

The policy-relevant evidence generated by this systematic review include

- Mobile coverage in rural areas makes markets more efficient by matching demand and supply better, leading to both consumer and producer welfare gains and by 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. The case of South Africa demonstrates how mobile coverage leads to an increased likelihood of someone being employed by 33.7 percent.
- Mobile coverage in rural areas provides economic development that is reflected in disposable income and thus expenditure. Expenditure increased by nearly 44.6 percent six years after coverage arrived in Peru.

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

The review also aimed to look gender and socio-economic classifications as secondary outcomes. A gender-differentiated analysis in Klonner and Nolen (2008) shows that with wider mobile coverage comes increased employment by women, in particular those who are not burdened with child care responsibilities at their homes. However, other studies do not bring about such conclusions to draw from. While there is no particular focus on socio-economic classifications, all of the studies focus on low-income earners in LMICs.

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

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Databases

World Bank Data

ITU Database

Annex 1: Country Classification by the World Bank

Table 24: Low and middle-income countries according to the World Bank		
Afghanistan	Guyana	Nepal
Albania	Haiti	Nicaragua
Algeria	Honduras	Niger
American Samoa	India	Nigeria
Angola	Indonesia	Pakistan
Antigua and Barbuda	Iran, Islamic Rep.	Palau
Argentina	Iraq	Panama
Armenia	Jamaica	Papua New Guinea
Azerbaijan	Jordan	Paraguay
Bangladesh	Kazakhstan	Peru
Belarus	Kenya	Philippines
Belize	Kiribati	Romania
Benin	Korea, Dem. Rep.	Russian Federation
Bhutan	Kosovo	Rwanda
Bolivia	Kyrgyz Republic	Samoa
Bosnia and Herzegovina	Lao PDR	Sao Tome and Principe
Botswana	Latvia	Senegal
Brazil	Lebanon	Serbia
Bulgaria	Lesotho	Seychelles
Burkina Faso	Liberia	Sierra Leone
Burundi	Libya	Solomon Islands
Cambodia	Lithuania	Somalia
Cameroon	Macedonia, FYR	South Africa
Cape Verde	Madagascar	South Sudan
Central African Republic	Malawi	Sri Lanka
Chad	Malaysia	St. Lucia
Chile	Maldives	St. Vincent and the Grenadines
China	Georgia	Sudan
Colombia	Ghana	Suriname
Comoros	Grenada	Swaziland
Congo, Dem. Rep.	Guatemala	Syrian Arab Republic
Congo, Rep.	Guinea	Tajikistan
Costa Rica	Guinea-Bissau	Tanzania
Cote d'Ivoire	Guyana	Thailand
Cuba	Haiti	Timor-Leste
Djibouti	Honduras	Togo
Dominica	India	Tonga
Dominican Republic	Indonesia	Tunisia
Ecuador	Iran, Islamic Rep.	Turkey
Egypt, Arab Rep.	Mali	Turkmenistan
El Salvador	Marshall Islands	Tuvalu

Table 24: Low and middle-income countries according to the World Bank		
Eritrea	Mauritania	Uganda
Ethiopia	Mauritius	Ukraine
Fiji	Mexico	Uruguay
Gabon	Micronesia, Fed. Sts.	Uzbekistan
Gambia, The	Moldova	Vanuatu
Georgia	Mongolia	Venezuela, RB
Ghana	Montenegro	Vietnam
Grenada	Morocco	West Bank and Gaza
Guatemala	Mozambique	Yemen, Rep.
Guinea	Myanmar	Zambia
Guinea-Bissau	Namibia	Zimbabwe

Annex 2: Search Strategy

1. (agricultur* or rural or farm* or smallhold* or “micro entrepreneur*” or “micro enterprise*” or microentrepreneur* or microenterprise* or microbusiness* or “micro business*” or “small business*” or Grower* or “non-grower*” or “agri trade*” or agritrade* or “first-handler*” or intermediar* or middleman or middlemen)

2. (((mobile* or cell or cellular or smart or digital) adj (phone* or telephon* or network* or technology or application* or Tablet*)) or cellphone* or smartphone* or ICT)

3. ((communication or telecommunication or wireless) adj (network* or technolog* or service*))

4. 2 or 3

5. 1 and 4

6. (evaluat* or assess* or impact or intervention* or effect* or analy* or innovation)

7. 5 and 6

8. (agricultur* or rural or farm* or smallhold* or villag* or "remote area*" or "remote region*" or "country area*"or countryside or "country region*")

9. 4 and 8

10. exp Developing Countries/

11. (Africa or Asia or Caribbean or West Indies or South America or Latin America or Pacific or Central America)

12. (Afghanistan or Albania or Algeria or Angola or Antigua or Barbuda or Argentina or Armenia or Armenian or Aruba or Azerbaijan or Bahrain or Bangladesh or Barbados or Benin or Byelarus or Byelorussian or Belarus or Belorussian or Belorussia or Belize or Bhutan or Bolivia or Bosnia or Herzegovina or Hercegovina or Botswana or Brazil or Bulgaria or Burkina Faso or Burkina Fasso or Upper Volta or Burundi or Urundi or Cambodia or Khmer Republic or Kampuchea or Cameroon or Cameroons or Cameron or Camerons or Cape Verde or Central African Republic or Chad or Chile or China or Colombia or Comoros or Comoro Islands or Comores or Mayotte or Congo or Zaire or Costa Rica or Cote d'Ivoire or Ivory Coast or Croatia or Cuba or Cyprus or Czechoslovakia or Czech Republic or Slovakia or Slovak Republic or Djibouti or French Somaliland or Dominica or Dominican Republic or East Timor or East Timur or Timor Leste or Ecuador or Egypt or United Arab Republic or El Salvador or Eritrea or Estonia or Ethiopia or Fiji or Gabon or Gabonese Republic or Gambia or Gaza or Georgia Republic or Georgian Republic or Ghana or Gold Coast or Greece or Grenada or Guatemala or Guinea or Guam or Guiana or Guyana or Haiti or Honduras or Hungary or India or Maldives or Indonesia or Iran or Iraq or Isle of Man or Jamaica or Jordan or Kazakhstan or Kazakh or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Kirghizia or Kyrgyz Republic or Kirghiz or Kirgizstan or Lao PDR or Laos or Latvia or Lebanon or Lesotho or Basutoland or Liberia or Libya or Lithuania or Macedonia or Madagascar or Malagasy Republic or Malaysia or Malaya or Malay or Sabah or Sarawak or Malawi or Nyasaland or Mali or Malta or Marshall Islands or Mauritania or Mauritius or Agalega Islands or Mexico or Micronesia or Middle East or Moldova or Moldovia or Moldovian or Mongolia or Montenegro or

Morocco or Ifni or Mozambique or Myanmar or Myanma or Burma or Namibia or South Africa or Nepal or Netherlands Antilles or New Caledonia or Nicaragua or Niger or Nigeria or Northern Mariana Islands or Oman or Muscat or Pakistan or Palau or Palestine or Panama or Paraguay or Peru or Philippines or Philipines or Phillipines or Phillippines or Poland or Portugal or Puerto Rico or Romania or Rumania or Roumania or Russia or Russian or Rwanda or Ruanda or Saint Kitts or St Kitts or Nevis or Saint Lucia or St Lucia or Saint Vincent or St Vincent or Grenadines or Samoa or Samoan Islands or Navigator Island or Navigator Islands or Sao Tome or Saudi Arabia or Senegal or Serbia or Montenegro or Seychelles or Sierra Leone or Slovenia or Sri Lanka or Ceylon or Solomon Islands or Somalia or Sudan or Suriname or Surinam or Swaziland or Syria or Tajikistan or Tadzhikistan or Tadjikistan or Tadzhik or Tanzania or Thailand or Togo or Togolese Republic or Tonga or Trinidad or Tobago or Tunisia or Turkey or Turkmenistan or Turkmen or Uganda or Ukraine or Uruguay or USSR or Soviet Union or Union of Soviet Socialist Republics or Uzbekistan or Uzbek or Vanuatu or New Hebrides or Venezuela or Vietnam or Viet Nam or West Bank or Yemen or Yugoslavia or Zambia or Zimbabwe or Rhodesia)

13. ((developing or less* developed or under developed or underdeveloped or middle income or low* income or

underserved or under served or deprived or poor*) adj (countr* or nation? or population? or world))

14. ((developing or less* developed or under developed or underdeveloped or middle income or low* income) adj (economy or economies))

15. (low* adj (gdp or gnp or gni or gross domestic or gross national))

16. (low adj3 middle adj3 countr*)

17. (lmic or lmics or third world or lami countr*)

18. transitional countr*

19. or/10-18

20. 9 and 19

Annex 3: Sources

Table 25: Sources			
Academic (electronic databases)	**Institutional Databases (grey literature)**	**Peer reviewed journals**	**Conference proceedings**
Econlit	Infodev, World Bank	Information Technologies and International Development	Information Communication Association (ICA)
Web of Knowledge	DIME, World Bank	Electronic Journal of Information Systems in Developing Countries	Information and Communication for Development (ICTD)
Academic Search Complete, EBSCO	JOLIS, IMF, World Bank	Journal of development effectiveness	
Business Source Premier, EBSCO	DFID's Research for Development	Information Technology for Development	
CAB Abstracts	IDRC's Digital Library	Asian Journal of Communication	
LISTA	IDEAS	Information Development	
	J-PAL	International Journal on Advances in ICT for Emerging Regions	
	ELDIS	African Journal of Information & Communication Technology	
	British Library of Development studies	International Journal of Information Communication Technologies and Human Development	
	Millennium challenge	World Development	
	USAID	Telecom Policy	
	FAO	The Information Society	
	UK Theses Ethos	New Media & Society	
	US/Canada Dissertations	Telematics and Informatics	
	SSRN	International Journal of Communication	
	Google Scholar	World Bank Economic Review	
		Innovations: Technology, Governance, Globalisation	
		International Journal of Mobile Communications	

Annex 4: Screening criteria

Table 26: Initial title and abstract screening	
Title:	
Type of Publication	
Is the study based on the relevant interventions and technology?	Yes or maybe: Continue No: Terminate
Is the study based in a low or lower middle income country	Yes or maybe: Continue No: Terminate
Is the study conducted in a rural area	Yes or maybe: Continue No: Terminate
Is it of the relevant study design (quantitative, primary study, impact evaluation)	Yes or maybe: continue No: terminate
Does the study refer to economic impacts at household, individual, business or market level (micro perspective)	Yes or maybe Continue No: Terminate

Annex 5 List of full papers reviewed

Title	Year	Authors	Include/Exclude
Is IT Enough? Evidence from a Natural Experiment in India's Agriculture Markets	undated	Chris Parker, Kamalini Ramdas, Nicos Savva	Include
Look Who's Talking: The Impacts of the Intrahousehold Allocation of Mobile Phones on Agricultural Prices*	2012	Kyeong Ho Lee and Marc F. Bellemare	Include
Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger	2010	Jenny C. Aker	Include
How Does Mobile Phone Coverage Affect Farm-Gate Prices? Evidence from West Africa	2011	Jenny C. Aker and Marcel Fafchamps	Include
The Impact of Receiving Price and Climate Information in the Agricultural Sector	2011	Adriana Camacho Emily Conover	Include
Impact of SMS-Based Agricultural Information on Indian	2011	Marcel Fafchamps Bart Minten	Include
The Digital Provide: Information (technology), market performance and welfare in the South Indian fisheries sector	2007	Robert Jensen	Include
Does ICT Benefit the Poor? Evidence from South Africa	2008	Stefan Klonner, Patrick Nolen	Include
The Power of Information The Impact of Mobile Phones on Farmers' Welfare in the Philippines	2009	Julien Labonne and Robert S. Chase	Include
Impact of Mobile Telephone on the Quality and Speed of Agricultural Extension Services Delivery: Evidence from the Rural e-services Project in India	2012	Xiaolan Fu and Shaheen Akter	Include
The Effects of Mobile Phone Infrastructure: Evidence from Rural Peru	2012	Beuermann et al	Include
The Impact of Mobile Telephone Use on Economic Development of Households in Uganda	2011	Sanne Lise Blauw and P. H. Franses	Include
The Impact of Mobile Phone Coverage Expansion on Market Participation: Panel Data Evidence from Uganda	2009	Muto Megumi	Include
Transaction costs, information technologies, and the choice of marketplace amongst farmers in northern Ghana.	2012	Giacomo Zanello, et	Include
Social Influence in Mobile Phone Adoption: Evidence from the Bottom of Pyramid in Emerging Asia	2009	De Silva et al	Exclude: Adoption Model: Mobile dependent variable not independent variable
Mobile Telephony and Access in Africa	2009	Chabossou et al	Exclude: Adoption Model: Mobile dependent variable not independent variable
Socio-economic Impact of Cellular Phones Growth in Pakistan: An Empirical Analysis	2009	Malik et all	Exclude: Adoption Model: Mobile dependent variable not independent variable
Role of Mobile Phone Technology in Improving Small Farm Productivity	2008	Surabhi Mittal and Gaurav Tripathi	Exclude: FGD in-depth interviews
Mobile telephone opportunities: the case of micro- and small enterprises in Ghana.	2009	Frempong Godfred	Exclude: Quantitative but only descriptive

Making market information services work better for the poor in Uganda.	2008	Ferris et al	Exclude: descriptive only, biased survey
Mobile Phones and the Cultural Ecology of Fishing in Kerala, India.	2011	Sreekumar T T	Exclude: descriptive only, biased survey
Running out of credit: the limitations of mobile telephony in a Tanzanian agricultural marketing system.	2008	Molony T	Excluded, qualitative
Contribution of mobile phones to rural livelihoods and poverty reduction in Morogoro Region, Tanzania.	2011	Sife et al	Excluded, descriptive
Mobile Phones and Rural Livelihoods: Diffusion, Uses, and Perceived Impacts Among Farmers in Rural Uganda.	2011	Martin Brandie	Excluded, descriptive
Bangladesh calling: farmers' technology use practices as a driver for development	2011	Islam MS and Gronlund, A	Excluded, descriptive
Tracking the Introduction of the Village Phone Product in Rwanda	2009	Michael Futch and Craig McIntosh	Exclude: Impact of Public phone not mobile phone
I need my own mobile phone : use of mobile phones and payphones in Ghana	2007	Araba Sey	Full paper not found
ICT-Based Market Information and Adoption of Agricultural Seed Technologies: Insights from Uganda	2012	Barnabas Kiiza, Glenn Pederson	Full paper not found
A Personal Touch: Text messaging for Loan Repayment	2012	Dean Karlan,Melanie Morten,Jonathan Zinman	Excluded: No Urban Rural disaggregation
Zap It to Me: The Short-Term Impacts of a Mobile Cash Transfer Program	2011	Jenny C. Aker,Rachid Boumnijel,Amanda McClelland,Niall Tierney	Excluded: Questions about the analysis. Author contacted
Mobile telephony as a change drivers in rural areas	2010	Anastasios Michailidis,Stefanos A. Nastis	Excluded: Does not measure any impact
Mobile Phone Usage by Micro and Small Scale Enterprises in Semi-Rural Ghana	2012	Paul Adjei Kwakwa	
Mobile Phone-Based Agricultural Extension in India	2012	Shawn Cole, Asanga Nilesh Fernando	Excluded: treatment is agricultural extension not mobile phone
Text Message Reminders and Incentives to Save in Bolivia	2009	Dean Karlan, Margaret McConnell, Sendhil Mullainathan, Jonathan Zinman	Final report not found
Mobile Money: The Economics of M-PESA	2012	William Jack, Tavneet Suri	Exclude: Descriptive
Livelihood Solutions through Mobile Technology: An Assessment	2010	S. M. Haider Rizvi	Exclude: Descriptive
"Ever upwardly mobile": how do cellphones benefit vulnerable people? Lessons from farming cooperatives in Lesotho	2009	K. Vincent; T. Cull; N. Freeland	Full report not found
Mobile Phone Banking and Low-Income Customers: South africa	2006	Gautam Ivatury, Mark Pickens	Excluded: Descriptive not quantitative
Farm household level impacts of information communication technology (ICT)-based agricultural market information in Ghana		Ramatu M. Al-Hassan*, Irene S. Egyir and James Abakah	Exclude: Does not deal with mobile phones
ICTs and poverty reduction: user perspective study of rural Madhya Pradesh, India.	2008	Tiwari Meera	Excluded descriptive

Annex 6: Summarised data extraction sheet

AUTHORS	GRADE/RANK	PUB DATE	PUB TYPE	INTERV TYPE	INTREV DESC	INTERV AIM/OBJECTIVES	INTERV CONTENT	LENGTH (WKS)	METHOD	COUNTRY	SAMPLE/ OBSERVATIONS	REPRESNTATIVENESS	DATA	DEPDT VARIABLES	INDEPDT VARIABLES	EFFECT SIZE
Camacho, A. & Conover, E.		May 2011	Working paper	Service Intervention	SMS with market price and weather information	Examines the impact of provision of weather and price information to farmers to determine whether this information improved their welfare	Price and weather information	6 months (185 days)	Randomised control trials	Colombia	500	Only respondents	Panel data of 500 farmers	Lower dispersion in sale price; higher sale price; farmers' revenues; household expenditures; crop loss	education; experience; age; gender; % of time dedicated to farming; size of the crop; storage capacity; own means of transport; whether the farmer is credit constrained; distance from the farm to markets	No significant difference between the treated and untreated farmers in the actual sale price. Overall sale price of crops which received price info showed an overall increase; No significant in changes in farmers' revenues or household

																d expenditures; No significant reduction in crop loss
Fu, X. & Akter, S		Aug 2012	Working paper	Service Intervention	mobile agricultural extension services provided by a project named KHETI in India	Examine the impact of a mobile phone technology enhanced services on agricultural extension services delivery system in India; to what extent such technology diffuses new practices and can help farmers gain agricultural knowledge, and whether it has been	The mobile phones are used to create Short Dialogue Strips (SDSs), which are audio visual creations on the local agriculture problem, issues and knowledge. An SDS includes a maximum of six images and two minutes of audio recordin	8 months	Randomised control trials	India	1336	Only for selected respondents.	Panel of 1336 framers, 698 of which received the treatment	Quality Index (QI)	Age; caste; education; marital status; access to credit; irrigation facilities; gender; ownership of land and village characteristics	OLS: 0.35 (0.005)

						effective in delivering quality and speedy extension services as expected.	g. In this system specialists do not need to visit farmers to know problem and answer queries and farmers do not need to physically visit specialists to report problems and get solutions.									
Parker, C., Ramdas, K. & Savva, N.		2012	Unpublished study	Service Intervention	SMS with Market price	Empirically investigate whether a third-party information provider, on which farmers can rely for **timely and accurate**	Price Information	Price Data: 80 days	Natural Experiment	India	14,349	representative for subscribers of Reuters Market Light (RML) services	2 databases, provided by RML. 1) RML's subscribers database. 2) market information.	Standard deviation of geographic price dispersion for crops for each state	perishability (high, medium, low); dummy for bulk message ban, dummy for data after the bulk ban was lifted; day of week; number of	5.2% higher spatial price dispersion during ban

						information transmitted through the ICT infrastructure, has an impact on the matching of supply and demand of agricultural commodities, over and above the now widely recognized impact of having access to an ICT.									subscribers in state for a crop (sum of subscribers for all market for a crop - duplication for subscribers registered for more than one market)	
Fafchamps, M. & Minten, B.		Sept 2011	Published	Service Intervention	market and weather information delivered to mobile phone by a commercial service called Reuters Market Light (RML)	Ascertain whether the distribution of agricultural information through mobile phones generates important economic bene…fits. –e.g.,	market price information, weather updates, and crop advisory information	52 weeks (One year)	Randomised control trials	India	Total Target: 1000 Farmers Treatment 1: 325 Farmers Treatment 1: 336 Farmers Control: 272 Farmers	representative sampling of farmers with a cell phone and not RML customers at baseline	Baseline and Follow-Up Survey Data	price received by farmers, crop value added, crop losses resulting from rainstorms, likelihood of changing crop varieties and cultivation practices for		No significant impact on price dispersion No significant impact on price received by farmers No significant impact

						better ability to arbitrage across space and time, better prices, better ability to bargain with traders, and increased awarenes s about quality premium leading to an improvem ent in quality through better agricultur al practices and better post-harvest handling (e.g., grading, packing). better crop managem ent, reduced losses, or								tomato, pomegranat e, onions, wheat, and soybean		on crop loss due to rainstorm s No significan t impact on likelihood of changing crop varieties and cultivatio n practices

						improved quality.										
Aker, J. C., Boumnijel, R., McClelland, A., and Tierney, N		Sep-11	published	Service Intervention	Households in targeted villages received monthly cash transfers as part of a social protection program. One-third of targeted villages received a monthly cash transfer via a mobile money transfer system (called zap), whereas one-third received manual cash transfers and the remaining one-third received manual cash transfers	To ascertain if the delievery of transfer payments through mobile phones brings about different outcomes in comparison to transferring through traditional methods	cash transfer via the mobile phone. After receiving the electronic transfer, recipients had to take the mobile phone to an m transfer agent located in their village, a nearby village or a nearby market to obtain their physical cash	52 weeks (One year)	Experimental design	Niger	1200 sample in 96 villages		household survey of 1200 sample; weekly agricultural price information from over forty-five markets for a variety of goods between May 2010 and January 2011, as well as the date of each cash transfer in each village.		household food security, demographics, asset ownership, agricultural production and sales, mobile phone ownership and usage, uses of the cash transfer and village and household-level shocks	

					plus a mobile phone.											
Klonner, S., Nolen, P.		May 2008	Unpublished study	Mobile coverage	Mobile phone adoption	Measure the effect of cellphone network roll-out on employment, occupational choice and welfare	Exchange of information via mobile phone	6 years	Natural Experiment	South Africa	57486 observations	National - South Africa	Panel data on municipal level, constructed from October household surveys for 1996 to 1998 and labour force surveys for September 2000 and September 2001	Employment status	mobile coverage in the previous year, demographic composition of area, schooling, age, location, gender	Increase in employment for the year following coverage 33.7% higher (0.102)
Jensen		2007	Journal Publication	Mobile coverage	Observing the effects of the use of mobile phones	To assess: how much market performance can be enhanced by improving access to information, how much society gains from such improvements, and	Exchange of information via mobile phone	6 years	Natural Experiment	India	74,700 observations for nearly 6 years	Sardine fishermen at the selected markets	Panel of markets and randomly selected fishing units at these markets	Max-Min spread of prices between markets coefficient of variation Percent of units having waste	fuel cost, wind index	Price dispersion between markets and waste reduction (standard errors in brackets): 1) Reduction in min-max spread: -5 Rs (0.27)

						how those gains are shared between producers and consumers remain largely unanswered.										2) Reduction in coefficient of variation: -0.38 (0.03) 3) Waste reduction: -0.048 (0.0004)
Muto, M.		2008	Published	Mobile coverage	Observing the effects of the use of mobile phones on Maize and Banana farmers	To assess the impact of mobile phone network expansion on farmers' market participation in Uganda.	Exchange of information via mobile phone	2 years	Panel study	Uganda	856 households	Only representative for the sampled households as the survey was stratified but not based on random sampling.	Panel of households interviewed in 2003 and 2005	1) Banana and maize market participation 2) Proportions of production sold 3) Relative price of bananas and maize	Survey year 2005 as a dummy Network coverage Distance to district centre in miles Interaction variable between coverage and distance to district centre	Measured by distance-coverage interaction variable 1) Bananas: a) Banana market participation: 0.007 (2.53) b) Proportions of banana production sold: 0.003 (1.81) c) Relative price of bananas: 7.543 Uganda shilling(2.48)

																2) Maize: a) Maize market participation: not significant b) Proportions of maize production sold: not significant
Aker, J.		2010	Published	Mobile coverage	Observing the effects of the use of mobile phones on grain markets in Niger	Estimates the impact of mobile phones on agricultural price dispersion in one of the world's poorest countries, Niger.	Exchange of information via mobile phone	5 years	Natural Experiment	Niger	53,820 observations	Survey: full sample of traders at randomly selected markets	Panel of Markets based on two data sets: 1) survey and agricultural prices from markets; 2) agricultural prices from 37 domestic markets from Agricultural Market Information Service (AMIS).	Price dispersion for millet, measured as absolute value of the price differences between two markets	transport cost, occurrence of droughts, geographic location, urban status, market size, lagged values of dependent variable,	Reduced price dispersion (standard errors in brackets): 16% or 3.51 CFA/kg) (0.645)
Aker, J. & Fafcha		Sep-11	publsihed	Mobile covera	Observing the effects of	Estimates the impact of	Exchange of informa	7 years	Natural Experiment	Niger	Model based on market	37 domestic grain	1) Panel of markets:	Price dispersion for cowpeas	Petrol prices, transport	Price dispersion

mps, M.				ge	the use of mobile phones on farm-gate prices in Niger (grain)	mobile phones on farm-gate agricultural price dispersion in one of the world's poorest countries, Niger. Between 2001 and 2008, mobile phone service was phased-in throughout the country. assesses the impact of mobile phone coverage on farm-gate price dispersion for a staple grain and cash crop, which are directly relevant for farm households' welfare.	tion via mobile phone				pairs: 39,120 observations 970 market pairs 37 markets Model based on min-max spread across all 37 markets: 2503 observations 37 markets	markets	A 10 year (1999-2008) dataset for 37 domestic markets covering millet and cowpea prices. 2) A market trader and farmers survey data for the period 2005 to 2007	1) measured as absolute value of the differences between logs of producer prices of two markets 2) measured as difference in Max-Min spread of prices between two markets 3) measured as difference in coefficient of variation between two markets	costs, road distances, market latitude and longitude and rainfall	between markets (standard errors in brackets): 1) absolute price differences between two markets: 6.3% (-0.007) 2) min-max spread: (standard error): 50% (0.105) 3) coefficient of variation: 6% (0.14)

Beuermann et al		Apr-12	Published	Mobile coverage	Exploit the timing of cell phone coverage in rural Peru to investigate its effects on economic development	Exploits the timing of cell phone coverage in rural Peru to investigate its effects on economic development	Exchange of information via mobile phone	6 years	Natural Experiment	Peru	around 40,000 observations, varies with models	Using nationally representative household income and expenditure survey data, but limiting the analysis to rural areas	Pooled data for 6 years based on household survey data and coverage data of mobile operators	wage income, mobile ownership, expenditure, assets, profits of home businesses / farms	Dummies for coverage, year fixed effect, village fixed effect or Dummies for years a village had coverage, year fixed effect, village fixed effect	Effect sizes for 6 years of coverage compared to no coverage: wage income (log): coefficient =0.34, standard error =0.043 expenditure (log): coefficient =0.446, standard error =0.073 assets (log) : coefficient =0.538, standard error =0.168 profits of home businesses / farms: coefficient =not significant
Labonne, J; Chase, R.S.		July 2009	Working paper	Access and use of device	Mobile phone ownership	Explore the impact of informatio	purchase and use of a phone	3 years	Panel study	Philippines	2092 households	Only representative for the	Panel Data: 2 visits to same	Per capita monthly consumption	Education of household members,	Increase in growth rate of per capita

				s		n technologies on farmer welfare in developing countries; assess whether the growth rate of per capita consumption is larger for farmers purchasing a mobile phone and channels through which those impacts might materialize.						purposefully selected households	household 2003 and 2006 in 135 villages in 16 of the poorest municipalities in the Philippines.		household size, age, land ownership	consumption: 15% (0.032)
Blauw, S. L. & Franses, P. H.		October 28, 2011	Discussion Paper	Access and use of devices	use of phone for economic activities.	study the micro-economic impact of mobile phones by using the PPITM to measure development at the	Exchange of information via mobile phone		Cross-sectional survey	Uganda	196	only representative of respondents	non representative cross section	Progress in terms of Poverty Index (PPI)	household size, years of education of the head of household, being a farmer	mobile use of head of household: 0.618 (0.221); mobile use any household member:

						household level. Additionally, we investigate the impact of mbanking and mobile search in a developing country										0.891 (0.342) mainly important that individuals get access to mobile phones
Lee, K. H. & Bellemare, M. F.		May 19, 2012	Unpublished study	Access and use of devices	impact on price of mobile phone ownership at the household level	study the impact of mobile phone technology on agricultural producers; at both the household and intrahousehold levels, first by controlling for whether the household owns a mobile phone, and then by controllin	Exchange of information via mobile phone		2 stage: first stage probit regression, second stage OLS	Philippines	95 households	Representative only for selected farmers, no random sample selection	non representative cross section	price for onions	First model: household characteristics, dummy for each one in household owning a mobile. Second model: replaces the mobile dummy with individual dummies for each household member	Higher onion price if farmer had a mobile: 0.053 (0.032). mobile phone ownership by a farmer is associated with a 6-percent increase in the price received by the farmer for his cash crop. When removing price

						g for who within the household owns a mobile phone.										outliers, our results indicate that mobile phone ownership by the farmer's spouse is associated with a 7-percent increase in the price received by the farmer for his cash crop mobile phone ownership at the household level has no statistically significant impact on the prices received by farmers. Rather, it is the intrahousehold

																allocation of mobile phones that matters in determining the prices received by farmers