



INFORMATION TECHNOLOGY'S IMPACT ON DEVELOPMENT

How does information technology contribute to development in poor countries?

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"This thesis was written as a part of the masterprogram at NHH. Neither the institution, the advisor, nor the sensors are - through the approval of this thesis - responsible for neither the theories and methods used, nor results and conclusions drawn in this work."

Executive Summary

The goal of this thesis is to highlight how information technology is being used in new and innovative ways in poor countries to help promote development. I have looked at the impact of mobile phones, radio and the Internet, and I show that the potential gains from the use of information technology are substantial. Such technologies make services such as health care, education and banking available to a larger portion of the world's population, and help making markets more efficient by making information easily accessible. As technology is becoming cheaper and more common throughout the developing world, the gains from using it can potentially be very large and improve the lives of poor people.

Preface

This thesis is written as part of my Master of Science in Economics and Business Administration at Norges Handelshøyskole/the Norwegian School of Economics and Business Administration (NHH). The thesis accounts for 30 study points (studiepoeng) and is equivalent to one semester of full-time studies.

Writing this thesis has been an exciting, interesting, and at times challenging process. Not only has it allowed me to make excellent use of the knowledge gained during my studies, it has deepened my understanding of how economics can be used in the “real world” to great advantage in very practical applications. I wish to thank my mentor Professor Kjetil Bjorvatn for his constructive criticism and guidance throughout the process.

I believe this thesis gives an interesting insight into how technology is being used in the developing world and how it can contribute to development in poor countries.

Bergen 01.06.10

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1 Introduction

1.1 Background and motivation

In developed countries such as Norway we have easy access to an enormous amount of information through mobile phones, television, radio and not least the Internet. For people in developing countries the situation is somewhat different. Most poor countries have very low Internet penetration ratios, and not every household owns a TV. The main reason for this is that such "goods" are expensive and not affordable for the average individual. In addition, Internet coverage is mainly concentrated in urban areas, which means that large parts of the population living in more rural areas would not be able to access these services even if they wanted to. Mobile phones and radios are however becoming more widespread, and the coverage of such services has been extended greatly to include larger portions of the world's population. This makes it easier for poor people to seek information and for governments and other organizations to reach larger portions of a country's population through these channels.

I have always had a strong interest in development economics, an interest that has deepened during the last few years. As part of my master's degree at NHH, I spent a semester at the National University of Singapore (NUS). This semester gave me the opportunity to travel through South-East Asia, to countries much less developed than Norway, something that contributed to my interest in development and aid. I found it especially interesting that even the poorest areas in cities had TV antennas on every shed, there was mobile phone reception in the jungles of Malaysia and in the countryside in Laos, and even in the smallest villages you could find Internet cafés.

After this semester and doing a course in Development Economics (SAM465) at NHH, I decided to write my thesis in this field. The topic of information technology's contribution to development received a lot of media attention last autumn, particularly in the case of Grameenphone, a joint venture enterprise between the Norwegian telecom giant Telenor

and Grameen Bank of Bangladesh, and through a special report on telecoms in emerging markets in the Economist in September/October 2009. This motivated my choice of topic; information technology's impact on development in poor countries.

1.2 Research question and thesis structure

With this thesis I wish to take a closer look at how poor people are using technology to improve their lives and how information technology is helping development around the world. My research question is:

"How does information technology contribute to development in poor countries"

and I have given my thesis the title "Information technology's impact on development".

In this thesis I will begin by introducing some of the concepts that I will use for my analysis in section 2. In section 3, I will look at mobile phone technology. I will begin by looking at the mobile phone market in different parts of the world, before looking into how the technology is being used in the developing world. I continue with a case study looking at the introduction of mobile phones in southern India, and conclude with a summing up of how mobile phones are contributing to development. Section 4 deals with radio. The first part looks at how radio is being used for educational purposes in Madagascar, whilst the second part is an in depth case study of the impact of market information broadcasts in Uganda. The last part sums up how radio contributes to development. The 5th section looks at Internet, whilst the last section is a summary of my overall findings.

2 Theory

”The importance of information for the effective functioning of markets has been a central concern in economic theory. However, lack of information, or situations of asymmetric information, is rather the norm in most developing countries.” (Svenssson and Yanagizawa 2009)

2.1 Contract theory

Economics is related to understanding the activity of exchanging goods and services, and how scarce resources are allocated to their most efficient use. Contract theory is a part of economics that deals with how economic actors can and do construct contractual agreements, especially in situations where the actors have asymmetric information (Bolton and Dewatripont 2005).

In contract theory, asymmetric information refers to situations with imperfect or incomplete information, meaning situations where one party in the transaction has more or superior knowledge and information than the other parties. This is often the case between sellers and buyers, and situations like this can potentially be harmful as the more well-informed party can take advantage of his knowledge and exploit the other parties (Economicshelp 2010). Asymmetric information leads to an imbalance of power.

Asymmetric information is a source of market inefficiency, and can cause market failure. Market failure occurs when goods and services are being allocated inefficiently. An allocation of resources is inefficient when it would be possible to raise the well-being of some people, without making others worse off. This is according to the Pareto principle of efficiency. Market failures are in addition to non-competitive markets often associated with externalities, which are costs and benefits not transmitted through prices, or public goods, which are goods that everyone can use and one person using it does not reduce the availability of the good for consumption by others. There are two sources of market

failure associated with asymmetric information: *adverse selection* and *moral hazard*. (The Economist 2010)

Adverse selection is a term used to describe a situation where the “bad” products or customers are more likely to be selected. An example is that people that are at a high risk of getting sick, have dangerous jobs or live a high risk lifestyle are more likely to buy life insurance (The Economist 2010).

Moral hazard is a situation that occurs when a party insulated from risk behave in a different way than it would if it was fully exposed to the risk. It arises because individuals do not take on the full consequences of their doings and act less carefully, leaving another party to hold some responsibility for their actions. A type of moral hazard is principal-agent problems. This is when one party, called an agent, acts on behalf of another party (the principal). The agent will have more information about his actions and intentions than the principal, something that might give the agent incentives to act inappropriately in situations when the interests of the agent and the principal are different (The Economist 2010).

2.2 Arbitrage

Arbitrage is defined as the opportunity to buy an asset at a low price and then immediately selling it in a different market for a higher price (Economics glossary 2010). In other words the practice of taking advantage of price differences between markets. Arbitrage is possible if the same goods are not sold for the same price in all markets. In the case of arbitrage prices in different markets will tend to converge and eliminate the price difference.

3 Mobile telephony

Mobile phones have by far been the most rapidly adopted technology in history and is today the most widespread personal technology in the world. For the world's poor countries it represents the best chance they have had of bringing telecommunications to economically disadvantaged or isolated communities. In many poor countries the landline coverage is limited to urban areas leaving out the majority of the population. According to an analysis done by McKinsey¹, rural inhabitants represents more than 55 % of the emerging markets population and most of these people belong to low income groups.

3.1 The mobile phone market

By the end of 2009 there was an estimated 4.6 billion cell phone subscriptions, which means that 67 out of 100 inhabitants globally had a subscription. For developing countries, the penetration reached 50 per 100 inhabitants last year, and is currently at 57 per 100. This is still far below the penetration rate in developed countries, which is higher than 100 %, but it still shows a doubling in penetration for developing countries since 2005. The subscription trends are illustrated in figure 1 (ITU 2010).

Even though the developing countries lag behind more developed countries in mobile phone penetration they now account for about two-thirds of the mobile phones in use. In 2002 this number was less than 50 % (Tryhorn 2009). A difference between developed and developing countries worth noting is however that whilst in richer countries some people might have two cell phones it is normal that one handset is shared by several people in poorer countries. This should indicate that more people in developing countries have access to mobile phones than is estimated by the subscription rate. The “telephone lady”, a person that owns a mobile phone and an antenna and sells phone calls by the minute, is also popular in many of the least developed countries in the world. The “telephone

¹McKinsey analysis for Telenor

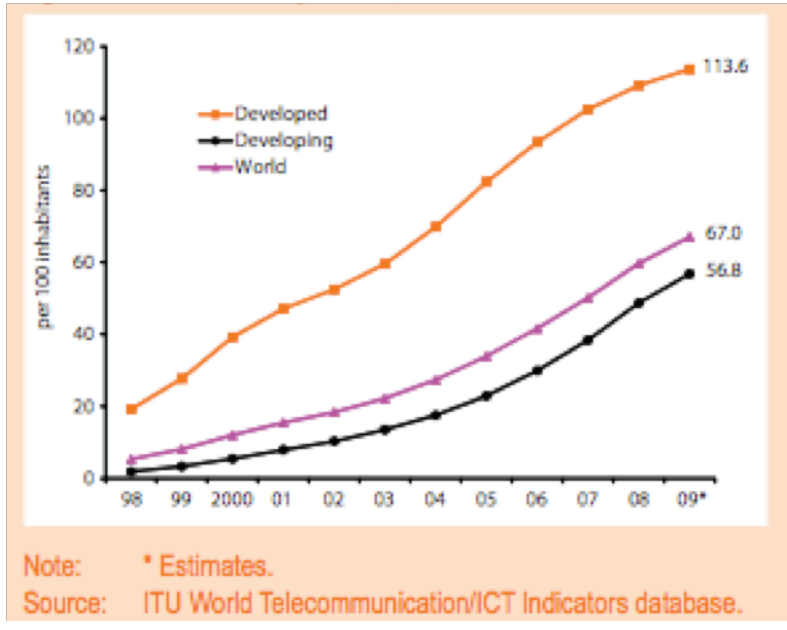


Figure 1: Subscription trends

lady” was first introduced in Bangladesh through Grameenphone, but has been adopted in several other countries too, and is an effective way for entire villages to get access to telecommunications even though owning their own handset is not affordable for most people (Grameenphone 2010).

The International Telecommunication Union (ITU)² prepares an annual Information and Communication Technologies (ICT) Development Index known as IDI. It is made up of 11 indicators covering ICT access, use and skills. This index shows that there is a clear link between a country’s income and its IDI score. Most of the countries with high scores are from the developed world, whilst the countries towards the bottom are considered amongst the least developed countries (LDCs). Nevertheless, most countries have seen an improved IDI score, including the developing countries. (ITU 2010)

One of the reasons why developing countries are still lagging behind when it comes to cell phone penetration is the mere fact that these countries are poorer than developed countries. We have seen a significant drop in prices both when it comes to prices of handsets and costs of using them in the last few years. Between 2008 and 2009 it is

²The leading United Nations agency for information and communication technology issues

estimated that prices for mobile services dropped by 25 % (ITU 2010). This trend is a clear contributor to the increased number of users in the developing world. However, when we compare the prices from different regions it is obvious that the prices, especially when looking at purchasing power parity prices (PPP\$) are not much lower in poor countries than in rich countries. In Africa they are actually higher. This indicates that even though prices have gone down, there is still a long way to go before cell phones will be affordable to everyone. Looking at the costs of mobile phones as a percentage of GNI (gross national income) it is evident that the developing parts of the world spend a significantly larger part of their income on such services than is necessary in developed countries, on average more than 6 times as much. The most extreme difference can be seen between Europe, where cell phone prices constitute 1.1 % of monthly income, compared with Africa where it constitutes 16.7 %.

As mobile penetration has increased sharply over the last few years, in all parts of the world, fixed line penetration has been nearly stagnant. As mentioned, in developing countries fixed lines mainly serve urban areas leaving out large parts of the population. For cell phones the story is different. With more than 100,000 masts being erected each year, more than 90 % of the global population has access to cell phone networks today, with only very remote areas such as Antarctica and large desert areas left out. The breathtaking growth of cellular technology is doing a lot to change society, particularly in developing countries where a lack of effective communications infrastructure has traditionally been one of the largest obstacles to economic growth. (Tryhorn 2009)

There are a number of factors that have allowed for the rapid growth in mobile communications in poor countries, but the most influential is prepaid billing systems. Most poor countries are cash societies, and few people have access to bank accounts if any banking services at all. The prepaid systems allow for people to top up their phones with credit when they need it and call until the credit runs out. In poor countries you can buy top-ups in denominations as low as \$0.50 from small shops on street corners, which makes telecom services available and affordable to poor people (Standage 2009). At the moment

the “digital divide”³ is closing at a rate of two million new subscriptions per day (World Economic Forum 2010).

3.1.1 Africa

Africa is the world’s poorest and most underdeveloped continent, struggling with problems such as the spread of deadly diseases and viruses, widespread corruption, high levels of illiteracy and frequent violent conflicts. By the turn of the millennium only 1 in 50 had access to mobile services. Between 2003 and 2009 however, Africa experienced an enormous growth in the number of mobile subscribers, with growth rates twice as high as the rest of the world, and penetration rates are now above 30 %. Even though Africa has seen a rapid growth, it is still lagging far behind the rest of the world. As we can see from figure 2, Africa is also lagging behind other parts of the developing world.

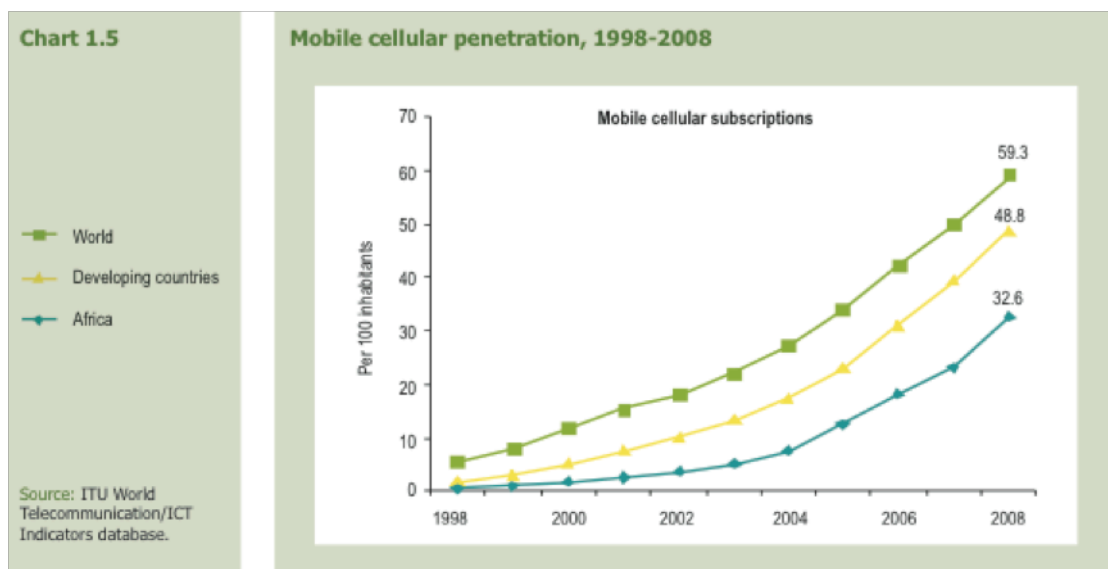


Figure 2: Mobile Cellular Subscriptions

Mobile coverage in Africa is somewhat lower than other parts of the world. Whilst most urban areas have adequate coverage, the coverage of the rural population is not sufficient.

³The gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities. (OECD 2001)

By the end of 2008 it was estimated that 60 % of the population in Africa was covered by mobile signal. This number has gone up a little bit since then, but there are still parts of the region uncovered.

The increase in subscribers that Africa has witnessed the last few years has taken place all over the region. Previously South Africa accounted for nearly all cell phone subscriptions; this is not the case anymore. As more and more companies have entered the market, competition has led to prices being pushed down which in turn has made mobiles affordable for a larger part of the continent's population.

In many African countries most inhabitants do not have access to banking services and other services that are considered normal in more developed countries. It is believed that significant parts of the increase in mobile phone subscriptions in developing countries, especially in Africa, have come as a response to such problems. Several money transfer services have been set up that allow people without bank accounts to send money quickly and safely simply by using text messages. In Kenya for example Vodafone's M-PESA money transfer service was launched in 2007 and now has 9 million users (Tryhorn 2009).

The largest problems facing further increases in penetration rates in the African region are the high price of mobile phone use relative to GNI, the high illiteracy rates in the region and the cost of extending the infrastructure to more remote areas. (ITU 2009a)

3.1.2 Asia and the Pacific

Asia is the world's largest and most populous continent. Many of the countries in the region have experienced rapid economic growth in the last few years. The wealth of the Asian countries and income distributions differ however widely due to its size and huge range of different cultures, history and governmental systems. In the last decade this region has experienced continuous ICT development, and the region is now considered an ICT leader even though penetration rates remain low in many parts. The region accounted for 47 % of the worlds cell phone subscriptions by the end of 2007. Mobile

phone subscriptions have been growing rapidly for several years, whilst growth in fixed lines has been stagnant and even negative the last couple of years. Extending fixed line coverage is more expensive than mobile coverage, and it is therefore unlikely that this trend will change.

Large parts of the increase in cell phone subscribers seen in the region come from the two large countries China and India. Between 2000 and 2007 these two countries added nearly 700 million mobile subscribers alone, out of a total of 1,100 million new subscribers. In India this increase meant a penetration increase from 1 % in 2002 to 20 % in 2007. Even though the region has seen rapid growth in subscription rates and ICT development they still lag behind the world average as shown below. The penetration is low even given the region's large population, difficult geographic conditions and major differences in income.

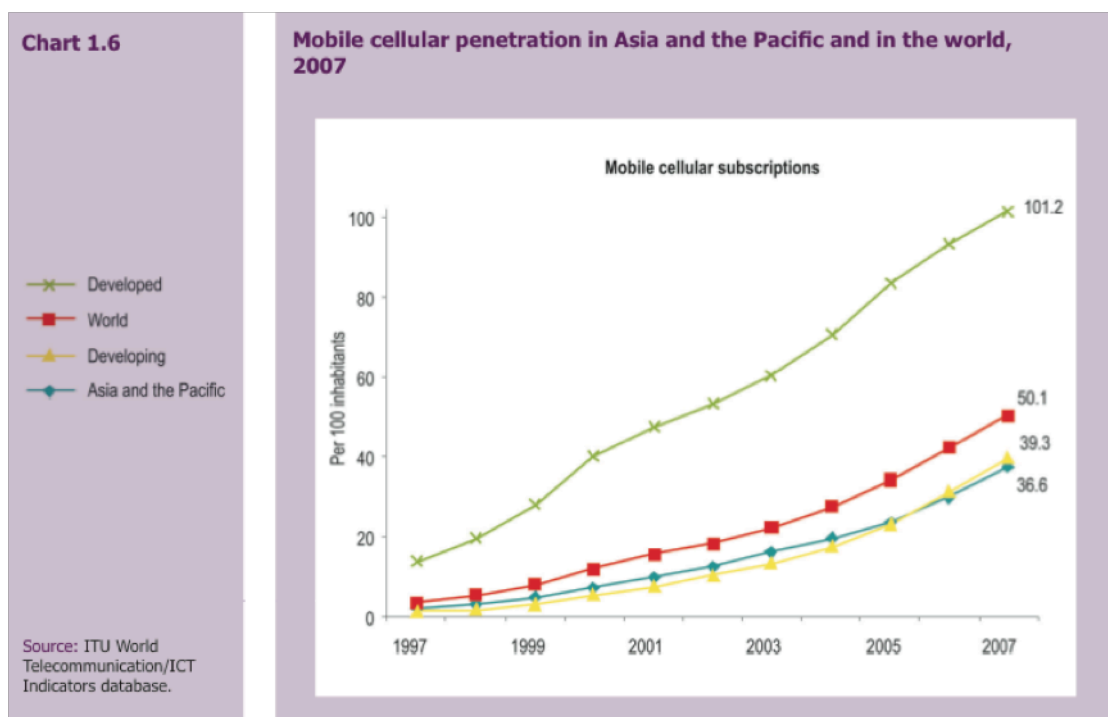


Figure 3: Mobile Cellular Penetration in Asia and the Pacific

Some remarkable progress has been made in the Asian Pacific region. Still there are large inequalities between economies with different income levels, and within each country. The trend is that there is a strong link between income level and ICT uptake (ITU 2009b).

3.1.3 Europe

Europe is currently the largest economy on Earth, but as with other continents, there are great differences within the region, especially between the Western and the Eastern parts. The European region is a leader when it comes to the uptake of ICT services, and over the last 5 years the region has seen strong growth in mobile phone subscriptions. Most countries have cell phone penetration rates above 100 %. The reason for rates above 100 % is because many subscribers have double SIM cards or several handsets for different use (work, personal etc).

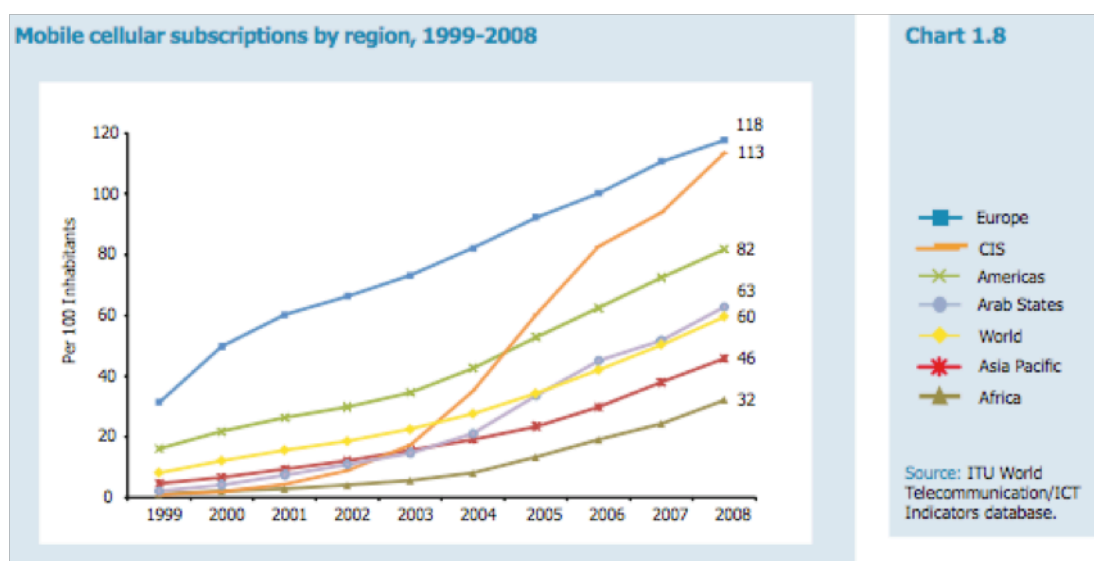


Figure 4: Mobile Cellular Subscriptions by Region

As we can see from figure 4, Europe is far ahead of most other regions with the exception of CIS (Commonwealth of Independent States, which among others include Russia, Ukraine and Belarus), which is catching up rapidly.

Both mobile handsets and the use of mobile phones have become cheaper over the last few years, with increased competition and less rigid regulation, which means that nearly everyone in the region can afford to own and use a mobile phone. (ITU 2009c)

3.1.4 Americas

The Americas consist of South-America, North America and the Caribbean, a group of very different countries both geographically and economically. A promising trend in the region is the cell phone uptake, and at the end of 2008, a dozen South American and Caribbean countries had a mobile penetration exceeding 100 %. In the Caribbean this is the situation for the Anglophone islands. A difference from other continents in the world is that several of the developing countries in the Americas have higher levels of mobile penetration than the region's developed countries.

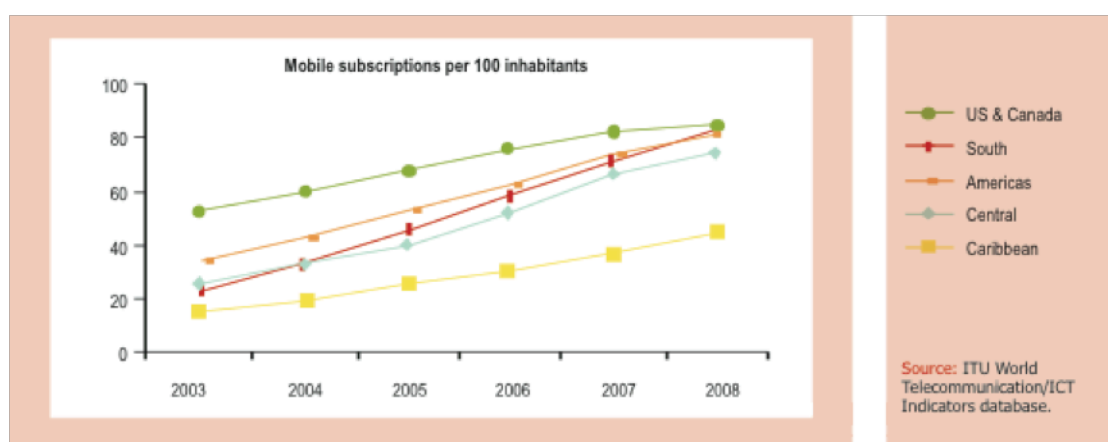


Figure 5: Mobile Subscriptions in the Americas

USA and Canada are both considered developed countries and will not be discussed any further in this thesis. It is however interesting to note that these two countries have penetration rates that are a lot lower than most other developed countries such as Western European countries. As we can see from the chart above, other parts of the Americas are catching up on the US and Canada when it comes to subscriptions per 100 inhabitants. The part of the region that seems to be lagging behind the rest is the Caribbean with a penetration of approximately 40 per 100 inhabitants compared to rates between 70 and 80 per 100 inhabitants in the rest of the region.

A difference between the Americas and other parts of the world is the strong presence of

strategic investors⁴. In Latin America and the Caribbean they account for 3 out of every 4 mobile subscriptions. (ITU 2009d)

3.2 The use of mobile technology in developing countries

In developed countries mobile phones are widely used for communication, both oral and written, and lately its features have been extended greatly to include music players, games etc. For many people the phone has become a source of entertainment, and the introduction of smart phones has made them into mini computers. In developing countries however, the mobile phone is being used in new and innovative ways to serve the needs of the poor, people that often lack access to basic services (by developed standards) such as banking services, health care, education, newspapers, television etc.

3.2.1 The Village Phone

As mentioned before, mobile services are still not affordable to many poor people around the world. Even though prices have been declining for years, people in developing countries need to spend considerable amounts of their incomes to afford such services. Grameenphone⁵ helped pioneer the village phone, a national program in Bangladesh that is operated by Grameen Telecom, a program that has served as the sole telecommunications provider in many rural areas. The unique idea intended to serve the underprivileged people of Bangladesh. The idea was that people from rural areas are given a loan of US\$200 (or more) through Grameen Bank to subscribe to Grameenphone and buy a handset and a small antenna. Most of the participants are women, a decision made to help empower women in a very male dominated society. Each participant is given training in how to

⁴A strategic investor is an investor that seeks to add value to the money he invests using his contacts or knowledge of the market. Examples of strategic investors include Comcast and Time Warner, two of the largest television companies in the US.

⁵Grameenphone is a joint venture enterprise between the Norwegian telecom giant Telenor and Grameen Bank of Bangladesh, a bank founded by the Nobel Peace Prize Winner Muhammad Yunus

operate the phone and how to charge others and make a profit from it (Grameenphone 2010). The program allows the very poorest people that are not considered creditworthy to stay in touch with their families that live in the cities or abroad. For a country like Bangladesh with large amounts of economic migration this helps families remain in contact (Lane et al. 2006). In rural areas where isolation and poor infrastructure are normal, access to telecommunication can play an important role in enhancing social and economic development. Today the program includes nearly 300,000 operators in Bangladesh (Shaffer 2007).

The Village Phone program has proven to be extremely successful, and it has helped many families escape poverty and build more businesses to diversify and increase their income sources. Because of this success, it has been replicated by other countries, amongst them Uganda and Rwanda.

A much cited success story from Bangladesh is the story of Begum, the first participant of the Village Phone program. Her monthly earnings exceeded the average yearly earnings in Bangladesh after only a few months, and today she owns a two-bedroom house, a television, a refrigerator, a barn, several shops and housing that she rents out to poor families. A lot has changed since her family lived on the streets. The program has however been criticized lately, as the profits per operator have been declining. The main reason for this is the fact that access to cell phones has expanded rapidly across the country and it is becoming more and more normal, and affordable, to own your own handset. In addition “Phone Ladies” today have a lot stiffer competition as there are so many of them. Despite recent criticism, the program has proven a success story in other countries too. In Uganda women were given microfinance loans to buy a handset and an antenna to ensure a reliable signal. The income that these women earn from selling phone calls enables them to set up other businesses and stores. This has helped poor women support their families and pay for their children’s education (Standage 2009).

3.2.2 M-PESA and other mobile money solutions

M-PESA is a product that was introduced by Kenya's largest mobile operator Safaricom in March of 2007. Vodafone, one of the largest shareholders in Safaricom, developed the service, which allows subscribers to send cash to other phone users simply by sending an SMS. The initial purpose of M-PESA was to make it easier for microfinance borrowers to collect and repay their loans, but it ended up with a much wider use than that. The name M-PESA translates into mobile money and it has been a revolutionary service that offers a fast, safe and affordable way of transferring money in a country where more than 80 % of the population is excluded from the official financial sector (Rice 2007). Customers are also able to keep nearly \$400 on their handset in a kind of virtual account. Even though it does not pay any interest, it works as a saving account for some people. This allows people to have a small cushion of savings in case of droughts, flooding, medical problems or other unforeseen situations that might leave the family without or with reduced income or with increased expenses. A lot of people fall back into poverty exactly because they do not have money to deal with the unexpected, and M-PESA gives them an opportunity to build up a safety cushion to prevent that. According to a recent study funded by FSD Kenya⁶, 21 % of the people interviewed said that they use M-PESA to store money and that this is their main way to save (Pickens 2009b). This shows that part of the demand for M-PESA is because of convenient and affordable ways to store money, even though Safaricom never advertise this to avoid regulatory issues (Pickens 2010a). This trend is not peculiar to Kenya, it can also be seen in the Philippines and in Brazil, countries where similar services are offered.

M-PESA is very simple to use. The customer hands over cash to a registered agent, who then credits the users' virtual account. The money is then sent to desired recipients, whether on the same network or not, simply by sending a text message. The recipient

⁶FSD Kenya is the Financial Sector Deepening Trust. It was established in 2005 to support the development of financial markets in Kenya as a means to stimulate wealth creation and reduce poverty (FSD Kenya).

can cash it in at an agent by showing ID and entering a secret code. The pin system was introduced to make transfers safe, especially in the case of stolen or lost handsets. Safaricom makes money on the service by charging a small commission on every transfer. This commission is however much smaller than banks would charge. Because of its simplicity and because it gives a large portion of the population access to services they otherwise would not be able to use, M-PESA has become extremely popular in Kenya. The service currently has 9 million registered users in Kenya alone (Ochieng 2009), and in January 2009 more than 160,000 P2P (person-to-person) transactions were registered every single day (Pickens 2009). These transactions add up to approximately US\$2million each day (Standage 2009).

Since M-PESA was launched 3 years ago it has been improved and extended to serve more purposes. In addition to person-to-person transfers, customers can now pay utility bills and receive payments such as benefits and salaries using their mobile phones, and it can also be used to pay for services such as taxis. Drivers often prefer this because it means they carry less cash. The service has recently been extended by Vodafone to also include Kenyan people living in the UK. They can now send money to family and friends in Kenya by using M-PESA. Because of the enormous success experienced in Kenya, M-PESA has been launched in several other countries, among them Tanzania and Afghanistan.

An interesting issue that has been discussed lately is using M-PESA to pay for scarce resources. In many drought stricken countries in Africa water is like liquid gold that leads to conflicts and corruption. Safaricom has been looking into establishing solar power driven water vending systems where people can pay for the amount of water they need by using credit-filled smartcards. These cards can easily be topped up using M-PESA (Schwartz 2009).

Up until now the biggest problem with the M-PESA service has been the cash float. Recipients of money need to go to a licensed agent to cash out the money, but the problem is that these agents are often small shops that keep a limited amount of cash. As most of the recipients live in rural parts of Kenya this means that shopkeepers need to travel

to larger cities where most of the banks are located, often by simple transportation such as bicycles, as other transportation is too costly. This can mean hours of travelling time every time agents run out of cash. Even though the service has problems such as these, interviews with people in rural areas of Kenya conducted by Olga Morawczynski, a doctoral candidate at the University of Edinburgh, shows that people still consider M-PESA the best and most affordable way of sending and receiving money (Rosenberg 2008). The general opinion was that it was much less time consuming to show up at the local agent to find out he was out of money and try again the next day than to travel to the nearest bank. Safaricom has however taken steps to overcome this problem by partnering with Equity Bank, a Kenyan commercial bank, to allow M-PESA customers to withdraw money from the bank's 550 ATMs located around the country. This can be done without the use of ATM cards or any formal relationship between the M-PESA customer and the bank (Pickens 2010b).

The main concern facing M-PESA's customers at the moment is Safaricom's lack of a regulatory status. Without a formal regulatory status many have pointed out that customers funds are at risk. Especially after studies showed that a large fraction of users use M-PESA to store money, banks have been putting pressure on the government to come up with regulations for the m-banking sector. (Pickens 2009a) The government expressed their concerns in late 2008 that M-PESA could potentially be a disaster waiting to happen. They based this on the fact that large amounts of people use the service as a safe deposit and by doing so M-PESA agents get custody of free cash that can be subject to abuse (Njiraini and Anyanzwa 2008). Regulations are currently being developed and will provide customers with much higher safety regarding their deposits.

Services that are similar to M-PESA or offer parts of their services have been launched in several countries. Among them are BillPay, launched by Grameenphone in Bangladesh. This service allows customers to pay utility bills in a secure way using their mobile phones. The service aims at reducing travel time and waiting time in order to pay bills which before had to be done at the district's main office or offices in larger cities (Grameenphone

2010). GCash in the Philippines and Smart in Brazil are more examples of m-banking services around the world.

In many countries carrying large amounts of cash will make you a tempting object for thieves. This is especially a problem in poor countries, such as most of Africa. However, having insufficient access to banking services, keeping the money at home or on you might be the only option. This problem was approached in Zambia already in 2005 (Economist:2005a). Instead of paying for deliveries of goods by cash, distributors send a text message and faraway computers record the transaction of goods and money in less than 30 seconds and issue a receipt. Distributors often have to pay amounts that exceed the average yearly wage for the goods that they receive. Being able to use non-cash payment makes transactions safer and cuts the time that would otherwise be needed to count the money. In Zambia mobile payment has been extended to large parts of the society, such as laundries, petrol stations and several restaurants and shops. Especially when there is a high risk of theft, non-cash payment is highly beneficial to both costumers and sellers.

As we can see from the discussion above, M-PESA and other mobile banking services are allowing people that have previously been excluded from financial services to use such services. This is helping development in poor countries as poor people that cannot afford bank accounts etc now can save money and receive remittances from family in cities or abroad easier than before. In addition it is cutting travel time drastically, as most people previously would have to deliver money by hand (FSD Kenya 2010). This time can now be used more productively in income generating activities.

3.2.3 Farmer's Friend and mobile advice services

In the developing world the main proportion of the population, especially in the rural parts, earn their living through farming. Many of the least developed countries have to deal with frequent droughts, flash floods and unpredictable weather conditions. Especially

in Africa there has been a trend that the traditional growing seasons are changing. Most farmers have up until now only relied on historic information kept by the elders in the village and stuck to the traditional growing season. This has however resulted in crops being destroyed by droughts or flash floods, leaving the poor and vulnerable even poorer and more vulnerable.

Initiatives have been put in place to help address these issues. One such initiative is Farmer's Friend in Uganda, an agricultural-information service, launched by the Ugandan mobile company MTN, Google and the Grameen Foundation's⁷ AppLab. Local farmers can send text messages to the service and ask for advice on crop and livestock, pest and disease, planting, storage or they can ask for seasonal weather forecasts for the region to make it easier to plan which crops to grow when (Standage 2009). Even though illiteracy rates are high in many rural areas, farmers can use the service with the help of local village-phone operators. That way they do not even need to own a handset to be able to make use of the service. One can send short queries such as "tomato blight", "how to plant ..." etc. and receive quick replies that are dispensed from information and advice stored in a database compiled by local partners. Experts call you back within 15 minutes to answer more complicated questions, or within a few days for very hard queries.

Grameen Foundation is a global anti-poverty organization and Farmer's Friend is only one of their initiatives trying to help farmers. The foundation established AppLab aiming to help people in rural areas in Uganda connect to the Internet with their mobile phones. An illustration of the project is the "Mobile Banana Disease Monitors" trained by the foundation. Local villagers are trained to monitor banana production, and enter and transmit required data using applications on their mobile phones. This is done to help limit the spread of disease and gather knowledge in the database that can be used other places. This specific example has been very beneficial in Uganda because more than 10 million people are dependent on them for food and income (Welter 2009). Banana diseases have been an increasing problem in the region, but through this pilot project the farmers

⁷A global anti-poverty organization

involved have been able to limit the spread of diseases and carry out successful treatment because of early detection.

Uganda is not the only country where services that aim at helping farmers have been widely adopted. Another example is China, where China Mobile and the agriculture ministry offer such services. China Mobile also runs a website that sends out information to farmers about planting techniques, how to avoid pests and market prices. The service is widely popular, sending out more than 13 million texts a day (Standage 2009).

Many poor people rely on farming in order to provide for their families. Initiatives such as Farmer's Friend can definitely help these people increase and reduce the volatility of their income. As so many people are dependent on farming, advice and help in this area is key to nourish development and help people escape poverty.

3.2.4 mHealth

Some of the biggest problems in a lot of poor countries are the lack of proper medical services and the critical shortages of trained healthcare personnel. It is estimated that globally there is a deficit of 2.4 million doctors, nurses and midwives, and in 57 countries the shortage is at a critical point (WHO 2006). In many countries it is also very hard to recruit doctors to rural hospitals and health centres as most of them want to work in urban areas where the pay is better and the overall conditions allow for a more comfortable lifestyle. This means that many villages and other rural areas have very poor health services or no access at all. In addition to the lack of clinics and health personnel, treatment and hospitalisation are often too expensive for the people that need it the most, which results in them not seeking the help they need.

The health challenges faced by developing countries are substantial, and it is argued that these challenges present the most significant barrier to sustainable global development. Epidemic diseases and inadequate preventative care take a significant toll on both the developing population and on poor countries' economies. As an example children born in

developing countries are 33 times more likely to die during their five first years compared to children in developed countries, and whilst entirely avoidable diseases such as malaria and tuberculosis are nearly non-existent in the rich world, they continue to kill lots of people in the developing world. (Vital Wave Consulting 2009)

As there has been an overwhelming uptake of mobile phones throughout the developing world, new ways to provide health services to rural resource-poor areas have been adopted. The term mHealth, short for mobile health, has become a familiar term and is used to describe the use of mobile telecommunications to provide health care. The most common applications are for education and awareness, help lines, diagnostic support either through conversations or pictures taken with mobile phones and sent to a doctor, disease surveillance and treatment support. The UN has set several millennium goals to deal with the health challenges in the developing world to be reached by 2015, and mHealth might prove to be one of the solutions that will help them achieve those goals. Below I will introduce several projects that aim at improving access to health care in the developing world.

Dealing with epidemics

Many poor countries struggle with epidemic diseases. Such diseases normally start in pockets and if left undetected, spread quickly to other areas. Disease and epidemic outbreak tracking have been initialised in several places to help prevent such pockets from developing into epidemics. One such technology is Nokia HealthRadar. Health care workers collect information rapidly and precisely using the program and the information is sent to a central server instantly. It is then aggregated and made into a picture of the situation that is sent back to the practitioners so that they can take appropriate action (JBC:2009). The data can be made into intensity maps or patterns that can help in developing the right strategies to deal with the spreading of the disease.

Another project aimed at limiting the spread of disease run by the Kenya Medical Research Institute (KEMRI) has been going on for more than 10 years. 200,000 people in the district of Kilifi have been monitored for malaria rates, and the monitoring has become

much more efficient and accurate since the introduction of mobile technology. The data is now reported immediately via cell phones, and this helps KEMRI plan their anti-malaria strategy more effectively and react quicker to current developments, something that is important in a district where malaria is more prevalent than any other place in the world (Ochieng 2010).

Tackling the HIV/AIDS problem

HIV/AIDS is a disease that has become a major problem for the developing world. The disease is still a taboo topic amongst most people, even in the developing world, and because of the social stigma it hinders people from getting tested and seeking treatment. Especially in South Africa the disease is a major issue that affects a large part of the country's population. The country has the highest number of people infected with HIV in the world and it is reflected in the dramatic change in South Africa's mortality rates. In some areas more than 40 % is infected, but only 2 % of the population have been tested for the disease! Project Masiluleke is an approach that aims to halt and reverse HIV and tuberculosis in South Africa, through the use of mobile telephones, by increasing awareness and encouraging people to get tested. The project uses "Please Call Me" texts, a special form of free SMS texts widely used in the country, with information about HIV/AIDS hotlines. Calls to the national hotline in Johannesburg jumped massively with more than 350 % as a response to the first trial run that sent out 20 million texts over a period of 6 weeks (Scola 2008). Trained operators give advice to the callers and refer them to local testing clinics. In addition the project reminds patients that are currently receiving treatment about scheduled clinic visits to ensure that they stick to the treatment. Only 10 % of South Africans with AIDS currently receive anti-retroviral (ARV) treatment and nearly half of them will stop the treatment within two years. Project Masiluleke also offers self-testing with counselling support via mobile phones. An important aim for the project other than increasing the amount of people that get tested is to reduce the social stigma associated with the disease and help crush myths about contamination and cures. (PopTech 2010)

The lack of medical personnel

As mentioned in the introduction the lack of medical personnel and clinics, especially in rural areas are a major issue in the developing world. Mobile phones have made it easier to treat patients in outpatient settings, something that has been crucial both because of the lack of hospital beds and the costs of being hospitalised. Researchers from the University of Melbourne have created a suite of applications for normal cell phones that help healthcare workers diagnose and determine drug dosages in Mozambique (Vital Wave Consulting 2009). Through the help of these applications healthcare workers can work faster and in the field rather than have patients travel to the nearest clinic. Another example that helps with the lack of doctors in rural areas is mobile phone applications with a step-by-step process that field workers fill in, that allows for remote professionals to diagnose the patients and prescribe the correct treatment. Such applications dramatically increase the access to medical care for poor rural areas.

Another service that is dealing with the lack of medical personnel is health lines. Bangladesh is one of several countries (India, Pakistan, Mexico etc) that have launched health lines. The HealthLine service from Grameenphone is a 24-hour medical call centre that works as a teleconference between a Grameenphone mobile user and a licensed physician. The service can be used in emergencies as well as in non-urgent situations. It can also be used to get information about medical facilities, drugs, and interpretation of lab and test results. Services like this are an important source of primary health care in a country where there is only one doctor per 4000 people, especially for the rural population (Grameenphone 2010).

Aftercare and chronic diseases

As mobile phone penetration is increasing in the developing world it is also getting easier to provide aftercare for patients. A pilot project in Thailand gave cell phones to people diagnosed with tuberculosis (TB) and patients would receive a daily phone call to remind them to take their medication. Medicine compliance rates reached 90 %, a lot higher than they were before. TB is a major cause of death in much of the developing world,

often because of failure to take medications on a regular basis. Through projects like the one described above survival rates are improving greatly. Medication regimen adherence is especially important in the combat of HIV/AIDS deaths. SIM Pill, a South African initiative managed to increase the adherence from the typical 22-60 % compliance to an impressive 90 %! (Vital Wave Consulting 2009)

Chronic diseases, such as diabetes and heart problems used to be problems for rich countries. However, they are becoming increasingly common in the developing world and it is estimated that 80 % of new diabetes cases will originate here. To ensure effective treatment for such diseases strict adherence to medication regimes are essential. China is one of many countries that have come up with solutions to meet the new challenges. Through the CADA (Chinese Aged Diabetic Assistant) diabetics are sent guidelines related to lifestyle and how to monitor glucose levels and blood pressure via SMS. (Vital Wave Consulting 2009)

Preventing disasters

When disasters hit a country or a region, poor people are often the ones that suffer the most. In disaster-prone areas such as Bangladesh's Cox Bazaar and Shirajganj districts, steps have been taken to establish early warning alerts of natural disasters such as flooding, cyclones and tropical storms. The two largest cell phone companies, Grameenphone and Teletalk, have agreed to send texts messages to their subscribers in case of disasters (OneWorld 2009). This will give them time to take measures to evacuate and seek shelter in safer locations. Being one of the most disaster-prone countries in the world, alert systems might help prevent deaths and limit material damage. After the 2005 Indian Ocean Tsunami that killed 230,000 people, warning systems have been put in place to prevent similar tragedies happening again. Many of these will provide subscribers with SMS alerts in the case of a new tsunami.

The problem of counterfeits

Lastly, another increasing problem in a lot of poor countries is counterfeits. According to the World Health Organisation (WHO) 25 % of drugs sold in the developing world

are inauthentic copies of real drugs, and contain little if any active ingredients. In the worst-case scenario such drugs can be fatal either because of dangerous components or because the sick person does not get the treatment he or she needs. MPedigree is a non-for profit Ghanaian start-up that was established to combat counterfeit drugs. The service is an SMS-based solution that provides individuals with the ability to text a special number that can be found on the packaging of drugs to verify that the medicine is authentic. In order to be able to offer such a service, mPedigree has teamed up with manufacturers that upload the necessary information from each pack to a registry using standard mass serialisation methods. (MPedigree 2009)

As we can see from the projects described above, mobile phones are being used in innovative ways to deal with the issues concerning health care in the developing parts of the world. By making basic health care services available to the poor this can improve the health and lives of people, which again will contribute to the development in poor countries.

3.2.5 Mobile market places

In rural communities most people rely on farming and selling their produce to support their families. Getting hold of market information is often difficult and puts poor people in a disadvantageous position when negotiating with buyers or middlemen. In many African countries farming is done by small-scale farmers that sell most of their crops to middlemen that sell it at the local marketplace. With highly volatile prices it is hard for farmers to stay up to date, giving them a weak bargaining position.

In Ghana, a software company called TradeNet is helping farmers get a better deal for their crops by allowing its users to advertise their merchandise to an international market. Since very few Ghanaian people have access to the Internet, the service is mainly SMS based. Farmers send texts explaining what they are selling, and the information is immediately published on the website in addition to being sent by SMS to everyone that

has signed up to receive alerts on that specific crop (Bartlett 2008). Even though the service is proving to help farmers reach a larger market and achieve a fairer price there are still some issues concerning how to reach more small-scale farmers, the main issue being illiteracy. To tackle this challenge efforts are being made to train village operators that can help illiterate farmers to advertise. Several studies have revealed that access to market information can help increase the income for everyone in the supply chain, and help poor farmers escape poverty.

CellBazaar is a mobile marketplace in Bangladesh, which is offered as a service from Grameenphone. The service is often referred to as the “mobile Craigslist of Bangladesh” and allows users to buy or sell goods and services simply by sending text messages. The service can also be accessed via WAP for those with more advanced mobile phones, or online for those with Internet access. CellBazaar aims to act as a platform that connects buyers and sellers regardless of what technology or type of handset being used. The service currently has a user base of just under 4 million people and processes approximately 1000 new posts every day (Poharel 2010). Unlike TradeNet the service is not limited to agricultural products. CellBazaar is a marketplace for anything from used cars and computers to tutors and pets to flat rentals and jobs. Through CellBazaar it has become easier to seek reliable, regular market information on price, availability and supplier options of essential goods. This is especially beneficial to the rural populations that otherwise have limited access to such information.

By making information on prices accessible for farmers and making it easier for sellers and buyers to find each other markets become more efficient and the problems caused by information asymmetries are reduced (the problems of moral hazard and adverse selection as presented under theory). In a situation with efficient markets it is more likely that resources are allocated to their best use, and the average person will be better off than in the situation of inefficient markets. The importance of market information will be discussed in detail in two case studies; one on mobile phones in the fishing industry in India and one on radio broadcasts in Uganda.

3.2.6 Combating corruption and human rights violations

The use of mobile phones has proven to have unforeseen advantages in parts of the world where corruption and human rights violations are common. A system called FrontlineSMS makes it possible for groups to communicate, and is being used to report human rights violations, aid coordination and conservation projects (Standage 2009).

Further, mobile phones have been used to monitor elections in several African countries (Standage 2009). Not long ago mobile phones played a central role in organising and co-ordinating political protests in Iran following the 2009 Iranian presidential election. The use of mobile phones in such circumstances makes it easier for people to stand up collectively against political violations and it makes it harder for election results to be fiddled with.

Corruption is also a major obstacle for developing nations and poor people are especially vulnerable to such abuse. A bureaucrat in Pakistan made it mandatory to file lists of daily transactions with price paid and mobile phone numbers of the buyers for land transactions (Standage 2009). He would then randomly call buyers and ask if they had been asked for bribes or commissions. Employees that had asked for bribes would be fired from their job.

As we can see from the discussion above the use of mobile phones can potentially be a helpful tool in combating corruption and other factors that might hinder development in poor countries.

3.2.7 Summing up

As illustrated in this section (3.2), mobile phones are being used to improve the lives of poor people. As mobile handsets have become increasingly affordable and "phone-ladies" are common in several countries, more and more people have access to mobile phone services. This means that larger portions of the world's population can seek advice on farming, get the medical help they need, and get access to basic banking services even if

they are not creditworthy. Furthermore it is helping to improve the functioning of markets as information becomes more widely available. All this is likely to impact development and help poor people improve their standards of living. I will look closer at the impact this has on development in section 3.4

3.3 Mobile phones in the fishing industry in Kerala, India

India is the second most-populous country in the world. The country has experienced robust economic growth, but despite this, economic inequality across India has widened, meaning that the difference between rich and poor has increased (Bardhan 2007). One of the large problems facing India's poorest is the high food price inflation that India has experienced lately, with inflation reaching 17 % (Economic Times India 2010).

Kerala is a state along the south-western coast of India. Agriculture and fishing industries are important contributors to the state's economy in addition to services, dominated by tourism. Because of the strong service sector, Kerala has had a paradoxical development of high human and low economic development. The fishing industry is large, directly employing more than 1 million people. As Kerala is a coastal region, fish is an important part of people's diets, and more than 70 % of adults eat fish at least once a day. (Jensen 2007)

3.3.1 A natural experiment in Kerala

Robert Jensen (2007) exploits the introduction of mobile phones in the Indian state of Kerala as a natural experiment of improved market information. Mobile phone services were introduced gradually in different regions due to high investment costs. Jensen looks at three regions in his article, Kozhikode, Kannur and Kasaragod, and the different regions had mobile services introduced in 1997, 1998 and 2000 respectively. The gradual introduction of mobile services is illustrated below in figure 6. Because mobile services were

introduced over time it makes it possible to see how regions with mobile services change and differ from those without mobile services. This is what Jensen did in his analysis to see if he could prove that access to information, via the use of mobile phones, made markets more efficient. Mobile phones became widespread among fishermen and buyers soon after the introduction of such services. The ultimate penetration rate was high, between 60 – 75 %, with the highest penetration among the larger boats. Fishermen reported that they used phones widely for fish marketing. Before mobile phones became available all marketing and sales were conducted via beach auctions, now fishermen reported that they would call several potential buyers before deciding on where to sell their catch.

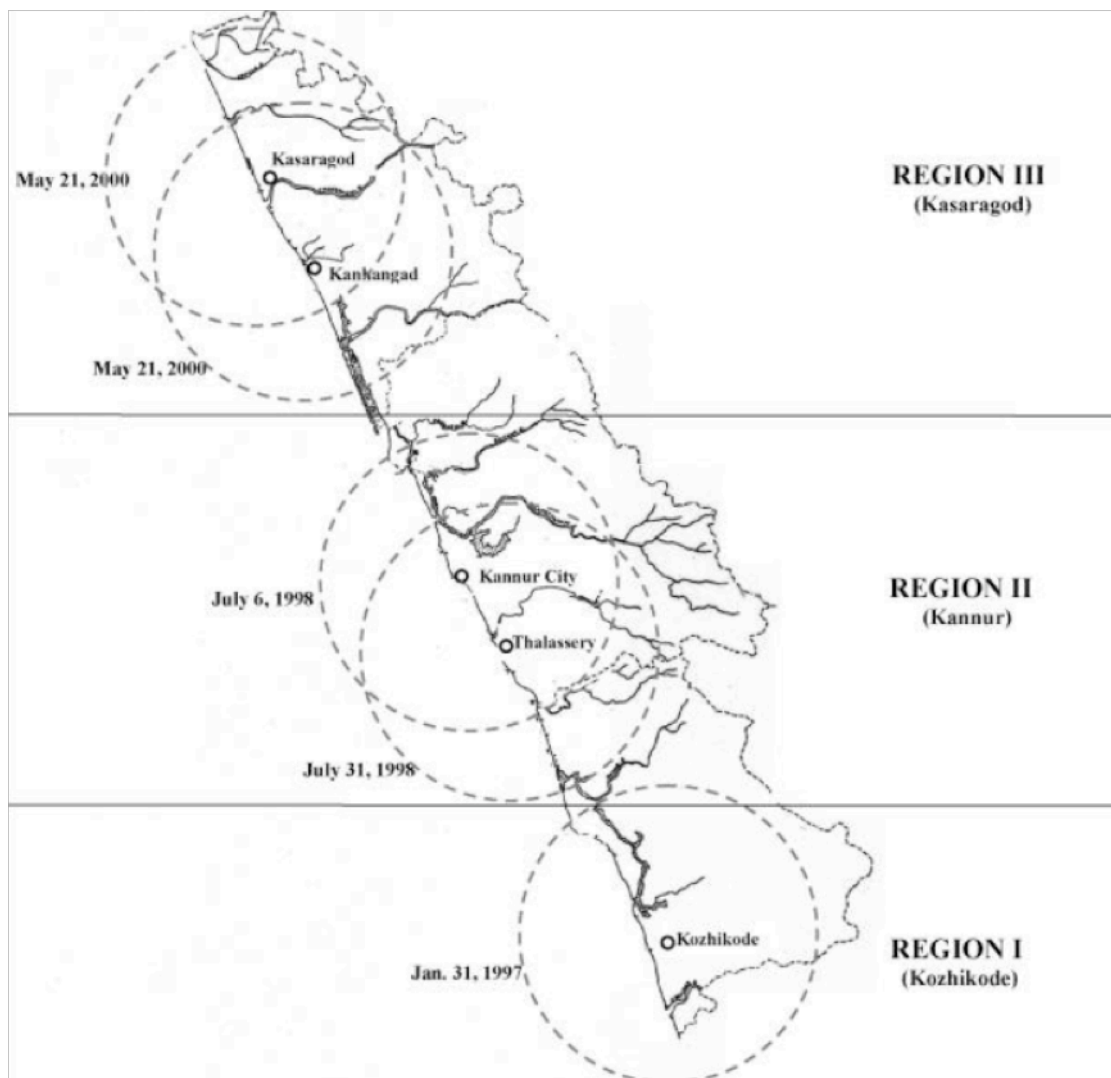


Figure 6: Introduction of Mobile Services in Kerala, India (Jensen 2007)

Jensen states in the introduction of his article, that when information is limited or costly to get hold of, agents are unable to engage in optimal arbitrage, which again might lead to goods not being allocated efficiently. A lot of critics argue that investments in IT should not be a priority for low-income countries as they lack more basic things such as food, health care and education. The thing is however that IT might actually help: by making markets work more efficiently. Critics overlook the fact that most poor people get their income from selling agricultural products, fish etc. and their income is to a large extent determined by the functioning of output markets.

As mentioned fishing is a large industry in Kerala and a lot of people depend on the sale of fish to support themselves and their families. Before the introduction of mobile services, fishermen, whilst at sea, were unable to observe prices at the numerous markets that are found along the Kerala coast. This meant that with few exceptions they would head back to their home market and sell their catch there. If demand exceeded what was caught that day, prices would be high, up to 8-9 Rs/kg⁸. But if supply exceeded demand the result was prices as low as zero and fish being thrown out. Prices would vary greatly from market to market and from day to day, which resulted in uncertain income for fishermen.

3.3.2 Data

The data comes from surveys conducted in the three northern districts of Kerala; Kasaragod, Kanur and Kozhikode. 300 sardine fishing units were surveyed on a weekly basis between September 1996 and May 2001. The 300 units are divided between 15 beach markets selected so that there is approximately one every 15 kilometres. In each beach market ten large units and ten small units were chosen to be part of the survey.

In the analysis, Jensen splits the observations into four different periods. Period 0 is before the introduction of phones, period 1 is when region I introduced phones, period 2 is when region II did and period 3 when region III did.

⁸1 Indian Rupee is equal to approximately 0.02 USD

3.3.3 Analysis

The observations show that nearly all (98 – 99 %) fishermen fish in their own catchment zone, and this trend is not affected by the introduction of mobile phones. Looking at where fishermen sell their catch however, shows a clear changing trend when mobile phones are introduced. This is illustrated in table 1 below.

TABLE 1: PERCENT OF FISHERMEN WHO SELL IN LOCAL CATCHMENT ZONE

	Period 0	Period 1	Period 2	Period 3
Region I	1.00 (0.00)	0.66 (0.005)	0.63 (0.005)	0.62 (0.006)
Region II	1.00 (0.00)	1.00 (0.00)	0.64 (0.004)	0.58 (0.006)
Region III	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	0.70 (0.005)

As we can see, 100 % of fishermen sold their catch within their own catchment zone before the introduction of mobile phones. As mobile phones are introduced in region I in period 1 approximately 1/3 of fishermen in this region sell outside their catchment zone. The assumption that this is caused by the introduction of mobile phones is supported by the fact that all fishermen in region II and III still sell within their catchment zone. We see similar trends in region II and III when mobile services are introduced here. Hence we can conclude that the introduction of cell phones result in significant amounts of arbitrage, as 30-40 % of fishermen sell in markets other than their "home market".

To compare prices, Jensen looks at the average price for all sales in a market occurring within a certain time interval. In the analysis he uses the average price between 7.30-8.00 AM, which represents the market closing price. Figure 7 illustrates the development in price trends by showing prices from week-to-week for each of the fifteen markets split into

the three regions (five markets in each region). As we can see, before mobile phones were introduced the degree of price dispersion across markets within a region on any day is high, and in many cases the price is zero, indicating that fish is going to waste. It is easy to see that within a few weeks after the introduction of mobile phones there is a sharp reduction in the dispersion of prices. It is also clear that phones are the reason for the change because the striking reduction in price dispersion in region I when phones are first introduced is not mirrored by changes in region II or III. The changes in these regions do not occur until they have mobile phone access. The initial large price dispersion is so large, that it is likely that the net welfare gains from arbitrage are substantial. Price after mobile phones became available rarely differs by more than a few rupees, compared to up to 10 rupees before.

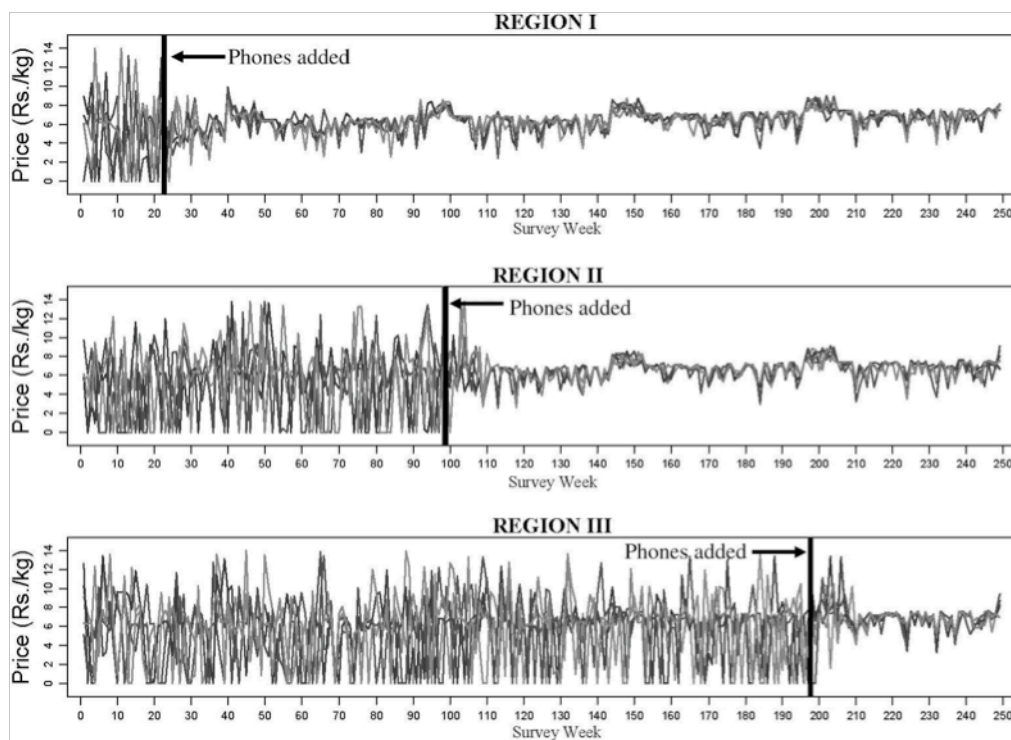


Figure 7: Change of Prices (Jensen 2007)

The introduction of mobile phones also has another important effect. It completely eliminates waste. Before mobile services became available in the region, an average of 5-8 % of fishermen were unable to sell their catch. With the introduction of mobile services the waste was eliminated. The initial significant amount of waste indicates potential large

gains from arbitrage and the possibility that both consumers and producers can gain from the improved access to market information. The change in waste levels is illustrated in table 2.

TABLE 2: PERCENT OF WASTE

	Period 0	Period 1	Period 2	Period 3
Region I	0.08 (0.01)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Region II	0.05 (0.01)	0.04 (0.01)	0.00 (0.00)	0.00 (0.00)
Region III	0.07 (0.01)	0.06 (0.01)	0.06 (0.01)	0.00 (0.00)

When mobile phones were introduced in region I in period 1 the waste was immediately eliminated. We also see a reduction in waste in region II and III in this period, but nowhere near the effect we see for region I. As mobile services become available in the other regions we see that waste is eliminated here too. This is an important result as it greatly reduces the volatility of fishermen's income. Before they could risk having no income some days, but with the elimination of waste, this is no longer the case, making income more certain.

Jensen runs a regression to estimate the impact of phones on price dispersion and waste. He pools the treatments and estimates the following equation:

$$Y_{r,t} = \alpha + \beta_1 Period_1 + \beta_2 Period_2 + \beta_I Region_I + \beta_{II} Region_{II} + \beta_A Phone_{r,p} + \gamma Z_{r,t} + \epsilon_{r,t} \quad (1)$$

where $Phone_{r,p}$ is a dummy that equals one in all periods p in which region r has mobile phone access. The results are shown in the table 3.

TABLE 3: EFFECTS OF PHONE SERVICES ON PRICE DISPERSION AND WASTE

	(1)	(2)	(3)
	Max-min	Coefficient of	Percent
	spread	variation	have waste
Phone	-5.0	-0.38	-0.048
	(0.27)	(0.03)	(0.004)
Region I	-0.92	-0.06	-0.007
	(0.26)	(0.03)	(0.005)
Region II	-0.46	-0.04	-0.011
	(0.21)	(0.02)	(0.004)
Period 1	-0.89	-0.12	-0.017
	(0.29)	(0.04)	(0.008)
Period 2	-1.1	-0.17	-0.019
	(0.32)	(0.04)	(0.008)
Period 3	-1.2	-0.19	-0.022
	(0.40)	(0.04)	(0.009)
Fuel cost	0.02	0.01	0.001
	(0.12)	(0.01)	(0.002)
Wind/sea index	0.086	0.001	-0.002
	(0.051)	(0.004)	(0.002)
Number of observations	747	747	74,700

The results are pretty much the same as presented earlier. In column (1) we see that the max-min spread across markets within a region is reduced by 5 Rs/kg when phones are introduced. This is a large reduction since the initial spread was 7-8 Rs/kg. Further we see that the introduction of phone services is associated with a reduction in standard deviation of 38 %, as shown in column (2). This indicates that fisherman have a less

volatile income. The last column illustrates the large reduction in waste associated with phone access. It shows that the percent that has waste is reduced by 4.8 %. All in all the regression confirms that the addition of mobile phones resulted in a substantial reduction in price dispersion and waste.

Both fuel costs and wind/sea conditions have the expected signs, with worse sea and wind conditions and higher fuel costs associated with greater price dispersion. The estimates are however not statistically significant, and we cannot say that these factors have a significant effect on price dispersion and waste.

3.3.4 Conclusion

The results above illustrate that the introduction of mobile phones make market information accessible to fishermen and gives them the possibility to take advantage of arbitrage opportunities by selling in zones other than their own catchment zone. This has reduced price differences between markets significantly, made prices less volatile and completely eliminated waste. This is likely to improve the welfare of both sellers and buyers on average.

3.4 The impact of mobile telephony in the developing world

As we have seen in the discussion above, cell phones are being used in new and innovative ways in the developing world to meet the challenges that these countries face.

There are numerous ways in which mobile services can have an impact on development. For example, in a 2008 report prepared for Telenor ASA⁹, Deloitte points to increased productivity as the most important effect (Deloitte & Touche LLP 2008), and they highlight several sources for increased productivity. The main source they find through

⁹Economic Impact of Mobile Communications in Serbia, Ukraine, Malaysia, Thailand, Bangladesh and Pakistan

interviews is improved information flows. As more farmers and others selling commodities have started using cell phones they have been able to cut out middlemen and seek reliable and up to date information on prices. This has helped raise the income of producers, which are often poor people in rural areas, and has reduced waste. Services such as mobile market places discussed above have had a great impact in this area. Improved information has also made a large impact on the efficiency of market places, especially when it comes to the agriculture sector, which in turn has made incomes and prices less volatile and reduced the amount of waste as illustrated by the study of the fishery industry in Kerala, India.

Further the Telenor-Deloitte report finds that mobile phones have a significant effect on travel time and costs. Before mobile phones became normal, people would have to travel far to pay bills, visit the doctor, sell their products, deliver news on family and friends etc. The need for this has been greatly reduced as information now can be given via mobile phones. This means that people can call doctors before visiting clinics to find out if they are open or even receive medical advice and help via phone calls, pay utility bills using their phones rather than visit district offices, and sell their produce via mobile marketplaces instead of travelling to actual marketplaces that might be far away. The impact on time and costs of travelling are particularly high for mobile workers such as maintenance and repair workers. Before they had mobile phones mobile workers would have to travel back and forth to a base where people in need of their services could find them. Now they can be reached wherever they are and travel directly from one job to the next. The reduced travel time is time that can be used for income generating activities.

The findings also show that the introduction of mobile services has made it easier for the unemployed to seek job opportunities. Rather than relying on word of mouth they can call around and actively seek for opportunities. Just the fact that you own a mobile phone makes you more likely to be hired as you can easily be reached when there is available work. Not only is seeking work easier, entrepreneurialism has also received a boost with the increased use of mobile phones. One example is women running hair and

beauty businesses in Pakistan. Instead of opening saloons, customers can reach them by phone and they will offer their services in people's homes. Another example is taxi drivers contactable by mobile phone. In countries with high unemployment rates and no welfare systems supporting those unemployed, mobile phones can potentially help reduce the problems of unemployment.

Increased productivity is important in developing countries. By reducing time and costs, people can increase their income and work their way out of poverty. As we have seen above, mobile phones have an important impact when it comes to improving productivity. Access to mobile services does however contribute to development in poor countries in more ways than through increasing productivity.

As mentioned under 3.2 mobile phone technology is playing a vital role in several areas of development such as health care, farming and banking. Through the use of cell phones poor people are getting access to services they have been deprived of before. In addition, advice and knowledge have become accessible through help lines, which helps development in two ways. First of all health lines make it possible for people to seek advice and help, and in this way prevent and treat diseases. Secondly, agricultural advice is helping farmers get the most out of their crops and this way helping them improve their income.

Lastly, mobile phones have proven an important tool in promoting social cohesion as it has made it easier for people to stay in touch with family and friends in other countries or parts of the country. Mobile banking has also made the tie between families easier as family members abroad can send remittances straight to their family's cell phone back home. In a society where families is the centre of life, mobile phones are making it easier to hold on to traditional values.

All the points mentioned above show how mobile technology is helping development in poor countries. People have embraced the technology and are using it to improve their lives. Several organizations have understood the impact that mobile technology can have and are using it to help development in poor countries.

4 Radio

Since the radio was invented more than a hundred years ago it has become a common household article. It became feasible in the late 1920s following the widespread introduction of radio receivers. It became a vital source of information, and it was the most important source of information in Africa long before countries gained independence in the 1950s and 60s. Whilst developed countries have more ways to communicate than ever; cell phones, e-mail, facebook, television, blogs etc., radio still remains the dominant means of communication in large parts of the developing world (Leichman 2009). In many countries radio reaches more people and has a higher penetration rate than television, newspapers and the Internet. One thing that makes radio more affordable is the fact that once you have bought one there are no costs of using it (except for batteries/electricity). This makes radio a powerful channel when it comes to reaching large groups of people with information, advertisement and news, and can be an important channel in order to raise knowledge about important topics such as health issues and sustainable agriculture.

4.1 The use of radio for educational purposes

Madagascar is ranked among the Least Developed Countries in the world, and large amounts of the population have very low income and high food insecurities. The situation is particularly bad in the south, and there is a historical division between the educated north and the ethnic coastal people in the south. Madagascar is very prone to natural disasters, something that results in chronic food insecurities in large parts of the country. Lack of primary education and poor health services are also major issues in the country. HIV/AIDS prevalence has historically been low in Madagascar, but during the last 15 years it has been increasing rapidly. (Metcalf et al. 2007)

The Andrew Lees Trust has implemented a project called Projet Radio (PR) in Southern Madagascar, funded by the European Commission since 1999. The aim of this project is to

meet some of the challenges that face the population in this region by empowering isolated populations to improve food security and reduce the effects of poverty through education delivered by radio. The radio coverage has been extended greatly as the government has liberalised airwaves, and the provision of radio sets to listening groups has proven a very successful strategy to reach larger parts of the population. The radio channels that has partnered with the Andrew Lees Trust reach more than 2 million people and air approximately 14 specially made programmes a month, using local dialects and engaging formats. Typical topics are protection of cattle from disease, reducing the risk of HIV infection, storing food and improving harvests, protecting forests and improving health.

Madagascar is facing a lot of challenges in meeting the Millennium Development Goals, and the radio shows aim at removing these challenges. A report by Metcalf et al (2007) funded by the Department for International Development has taken a closer look at the radio project and how radio broadcasting contributes to the achievement of the MDGs through increasing knowledge and changing attitudes.

The report finds that the project is receiving notable success in changing and enhancing knowledge and attitudes on several topics. As mentioned HIV/AIDS is an increasing problem in the country, and through several programs on the topic, PR has managed to raise awareness of the existence of the disease and how to avoid spreading it. Sexually transmitted diseases are taboo to talk about, but through radio the information can be spread to large groups of people without direct contact. The report also finds improvement in knowledge about family planning and mother and child health. In a country where children die from malaria, diarrhoea and other diseases that can be treated and prevented, such information is vital to reduce child mortality rates.

Madagascar has a very wide range of animals and plants, and many of them are unique to the island. In addition the island is prone to natural disasters. Because of this several radio broadcasts have focused on the importance of planting drought resistant trees and fruit, and stopping the rapid deforestation that is occurring because of increased demand for wood. Research done for the report shows that in areas with radios more people have

built better wood-burning stoves that limit the need for wood, and it is estimated that 90 % of tree purchases made following several radio programs on the importance of replanting trees came as a result of the broadcasts.

Another area where the radio broadcasts have proven to have an important impact is when it comes to farming advice. Nearly all the listening groups that were interviewed said that they had taken measures to follow the advice given on how to protect crops, vaccinate cows and practice rice thinning to increase production. People in the rural south are dependent on farming for food and for income, and it is therefore important to avoid diseases and crop failure to avoid hunger and poverty.

In Southern Madagascar women have traditionally played a very inferior role compared to men. PR has taken advantage of the fact that an increasing amount of men have to migrate to find work, and is encouraging communities to elect women to be responsible for listening groups because their presence is more stable. This way, women get more responsibility and get a more primary role in the society. Isolated populations are also stating that they are much more aware of social and administrative issues as a result of information broadcast on the local radio channels.

In summary, the radio broadcasts have resulted in an uptake of health services, increased enrolment in literacy classes, increased the construction of environmentally friendly woodstoves, and had a positive impact on tree planting and agricultural yield. This shows that radio as an information channel can prove to have a significant effect.

4.2 Radio and its impact on farmers in Uganda

Uganda is a landlocked country in the middle of Africa. Approximately 50 % of the population lives below the international poverty line of US \$ 1.25 a day according to the Human Development Index¹⁰, which means they are ranked 155/170 countries (Human

¹⁰The Human Development Index is a composite statistic used as an index to rank countries by level of human development. The statistic is composed from statistics on life expectancy, education, standard of

Development Indices 2007). The country has a troublesome history, but has experienced robust economic growth over the last few years.

Agriculture is important in most developing countries as the living standard of the world's poorest to a large extent are determined by how much they get paid for their agricultural produce. In Uganda, agriculture is an important contributor to the economy, and accounts for more than 50 % of the country's GDP and approximately 90 % of employment (Robbins 1999). During the colonial period most farmers were part of co-operatives. This was a successful strategy as collective marketing helped farmers maximize their income. Today however, Ugandan farming is done by small-scale individual farmers (Svensson & Yanagizawa 2009), with only tea and sugar grown on large estates. When it comes to maize production, 95 % of households engaged in production are small-scale farmers. Most of these farmers sell their crop to traders as soon as it is harvested due to lack of storage facilities. These traders normally travel through villages in pick-ups buying maize at farm-gate prices on a cash basis. Farmers are rarely in direct contact with the marketplace as traders travel back and forth to buy the crop. This means that sellers have less, if any, information about current market prices, whereas the trader is well informed. This leads to an asymmetric information relationship, where the seller has a weak bargaining position in relation to the trader. A factor that makes it especially difficult for individual farmers to keep track of the development in prices is the fact that they vary greatly over time and across locations. Further the market system in Uganda suffers from collusion amongst traders resulting in an environment lacking competition. This is especially a problem in rural and isolated areas (Robbins 1999).

4.2.1 The Market Information Service project

The Market Information Service (MIS) project in Uganda is a "natural" experiment run by Foodnet, an organization focusing on marketing and post harvest research in Eastern and Central Africa (Foodnet 2010). It was initiated in 2000 by two agricultural research

living and GDP.

organizations working closely with the Ministry of Trade, Tourism and Industry in Uganda. The service collects data on prices for 19 different agricultural commodities in major markets and disseminates this information using local radio stations. The information is broadcast in a 15 minute long show on a weekly basis using 8 local languages. Each day there is also a brief news bulletin. In addition to price information the service also collects data on traded volumes and growing conditions.

The project was initiated based on survey data indicating that most farmers had no knowledge of price and market trends. Economic theory says that information is key to the effective functioning of markets. In poor parts of the world however, information is often hard and costly to get hold of, resulting in information asymmetry. A lot of farmers are dependent on middlemen to sell their produce in the market place, and with imperfect information farmers might have a disadvantageous position when bargaining over prices with middlemen that have more up to date information on prices and demand. The aim of the project is to improve farmer's bargaining power through provision of timely and accurate market information so that they can achieve a higher price for their crop. Through this project, Foodnet is looking to provide farmers with the information they need to close the information asymmetry between them and traders, which in the end might lead to increased incomes for the poor. The project is estimated to reach 7 out of 24 million people each week (Svensson and Yanagizawa 2009).

4.2.2 Methodology

In the analysis I have used the same approach as Svensson and Yanagizawa (2009) to identify the effect of the market information service. They use a difference-in-differences analysis with fixed effects to exploit the difference-in-differences between MIS project districts and districts not covered by the project, and across households with and without access to radio.

Difference-in-differences

The difference-in-differences method is common to use when we are looking at natural experiments. A natural experiment always has a control group that does not receive treatment and a treatment group that receives some kind of treatment. In such experiments the groups are not randomly chosen, but arise from whom the treatment affects. In my case the group separations arise based on the districts where the MIS project broadcasts and the districts that are not part of the project. (Wooldridge 2006)

The simplest difference-in-differences set up is when outcomes are observed for two groups for two time periods. One of the groups will be exposed to treatment in the second period only, whilst the other group is not exposed to treatment at all. The basic premise is then to compare the treatment group before and after treatment, and to compare the treatment group to the control group (the group that did not receive treatment). A lot of other things might happen at the same time as the treatment, and the difference-in-differences method takes this into consideration by subtracting the average gain in the control group from the average gain in the treatment group. The key assumption is that other changes are identical between the control group and treatment group. This procedure does not only remove biases between the groups in the second period that can be a result of permanent differences between them, but also the biases over time that can be the result of trends (Imbens 2007).

The difference-in-difference method can be explained using this equation:

$$y = \beta_0 + \delta_0 d2 + \beta_1 dT + \delta_1 d2 * dT + other\ factors \quad (2)$$

where y is the outcome variable of interest. dT equals unity for those in the treatment group, and zero otherwise, whilst $d2$ is a dummy variable for the second period. δ_1 measures the effect of the treatment, and without other factors in the regression $\hat{\delta}_1$ is the difference-in-differences estimator. $\hat{\delta}_1$ is defined as follows:

$$\hat{\delta}_1 = (\bar{y}_{2,T} - \bar{y}_{2,C}) - (\bar{y}_{1,T} - \bar{y}_{1,C}) \quad (3)$$

When we include other explanatory variables in the equation, the estimate of δ_1 is no longer as simple as the equation above, but it has a similar interpretation.

Fixed effects

One of the main advantages of using panel data is that we can control for unobserved effects better than we can using other data samples. If we let i denote the cross-sectional unit and t the time period, we can write a model with one observed explanatory variable as:

$$y_{it} = \beta_0 + \delta_0 d2 + \beta_1 x_{it} + a_i + u_{it}, t = 1, 2 \quad (4)$$

the notation i denotes a person, firm, district etc, whilst t denotes the time period. $d2$ is as before a dummy that is 1 in period 2 and zero in period 1. This means that the intercept in period 1 is β_0 , whilst it is $\beta_0 + \delta_0$ in period 2, hence you are allowing for the intercept to change over time. a_i is called an unobserved effect, also known as fixed effect as it is fixed over time. The error term u_{it} the time-varying error and represent unobserved factors that change over time.

The differences-in-differences specification with fixed effects used in my analysis is as follows:

$$p_{ij} = \alpha + \beta_1 radio_{ij} + \beta_2 radio_{ij} * MIS_j + \beta_3 x_{ij} + \mu_j + \epsilon_{ij} \quad (5)$$

where p_{ij} is the farm-gate price for maize sold by household i in district j , $radio_{ij}$ is a dummy variable indicating whether household i in district j has a radio, MIS_j is a dummy variable indicating whether district j is an MIS district, x_{ij} is household specific controls whilst μ_j is district fixed effects, and ϵ_{ij} is the error term.

4.2.3 Data

The dataset that I have used in the following analysis is the same one that Jakob Svensson and David Yanagizawa used when they wrote the article “Getting Prices Right: The Impact of the Market Information Service in Uganda”. They used data from the Uganda National Household Survey from 2005, combined with data from the MIS project. The dataset consists of information on prices for households with and without access to radio, and has household data such as education, illness and household size from MIS districts and non-MIS districts.

As mentioned in the introduction, radio is still the main source of information in many developing countries, and can therefore be a powerful tool in increasing the efficiency and relative incomes of the poor. In our sample 65 % of households reported to have access to a radio. We have observations from July 2004 to June 2005, and if we split the observations into years we see that nearly 60 % of the households had access to radio in 2004, a number that increased to more than 70 % in 2005. There can be several reasons for this increase. First of all it is not the same households we are looking at, but assuming that it is a random selection, this should not be the cause of such big changes. The MIS project might have made it more desirable to own a radio, or it might simply be natural development, for example as radios become more affordable and signals extend to cover larger areas. The radio penetration is nearly identical for MIS and non-MIS districts.

Approximately 46 % of the sample live in districts where the MIS project broadcasts radio updates on prices and market trends. In the analysis we will look at observations from these districts compared to districts that are not covered by the MIS project.

Table 4: Summary statistics Uganda

	Mean	St.dev.	Obs.
Farm-gate price (per kg) of maize	177.36	75.15	5374
Farm-gate price of maize in MIS-districts	184.56	77.36	2448
Farm-gate price of maize in non-MIS districts	171.33	72.71	2926
Radio	0.65	0.48	5374
MIS project participants	0.46	0.5	5374

Note "Farm-gate price" is the reported value of maize sold in Ugandan Shilling divided by kilograms sold. Radio is a dummy variable indicating whether households own a radio. MIS project participants is a dummy indicating if a household is an MIS-district.

As we can see from the summary statistics reported above the average farm-gate price per kilogram of maize, over the period July 2004 – June 2005, was 177 Uganda Shillings (USh)¹¹. When we separate the sample into MIS districts and non-MIS district we see that the average price is a lot higher in districts where prices are broadcasted via radio compared to districts that are not part of the project. The prices are 185 USh and 171 USh respectively, a pretty large difference amounting to nearly 8 %. Just looking at these summary statistics it looks as if the projects have had a positive impact on the prices that farmers receive for maize, which in turn is likely to improve the lives of poor farming families.

In many developing countries access to education is a serious concern. Uganda is ranked 177 out of 201 countries when it comes to illiteracy (CIA World Factbook 2010), and according to the dataset 32.9 % of the household heads have no formal education. Another 32.5 % has less than primary school, whilst 14.3 % has finished primary school. As we can see from the table below, only a small fraction of household heads have achieved O- or A-levels. Because there is a chance that education might influence the prices farmers can get for their crop this is one of the household controls that will be used in the analysis.

¹¹100 Uganda Shilling is equal to approximately 0.04 USD

I will also go further than Svensson and Yanagizawa and look at whether the level of education is a determinant of how large the effect of having access to a radio is.

Table 5: Household Controls

	Mean	St.dev.	Obs.
<i>Education</i>			
No formal education	0.329	0.47	2741
Less than primary	0.325	0.47	2741
Completed primary	0.143	0.35	2741
Completed O-level	0.036	0.19	2741
Completed A-level	0.015	0.12	2741
<i>Other household controls</i>			
Household size	5.81	3.01	2761
Illness	0.44	0.31	2759

^{Note} We only have information on household controls for 2005. Illness reports the share of household members suffering from an illness the 30 days prior to the survey date.

The average household size of in the sample is 6 persons. Larger families, and having several generations living under the same roof is a lot more common in poor parts of the world, so the large average household size is as expected. Most households are between 1 and 10 people, and very few have households with more than 10 persons.

Being a developing country, Uganda lags behind the rest of the world when it comes to health indicators. HIV/Aids is a big problem in East Africa, and even though Uganda has managed to turn the negative trend around it is estimated that 5 % of the adult population has the disease (Uganda 2006b). The life expectancy in the country is only 50 years, and malaria, diarrhoea, tuberculosis and other preventable diseases kill thousands every year (Uganda 2006a). The high prevalence of diseases can be seen from the table above where we can see that 44 % of household members report that they have been

suffering from an illness during the 30 days prior to the survey.

Having access to a radio is in the following used as a proxy for having access to regular market information.

4.2.4 Analysis

Table 6 shows the results from my analysis in Stata¹². These results are nearly identical to the ones presented in table 2 in Svensson and Yanagizawa (2009).

Specification (i) shows that the coefficient estimate for radio is positive and significant indicating that owning a radio has a positive impact on the farm-gate price that farmers receive per kg of maize. There might however be several reasons why households that own radios differ from those without radios. I therefore proceed to split the sample in two: MIS-districts and non-MIS-districts.

Specification (ii) only includes those districts where the MIS project disseminates market information. As we can see from the table the radio coefficient is a lot larger than the one for the whole sample, and it is statistically significant. This indicates that having access to market information on a regular basis is consistent with higher farm-gate prices. Looking at specification (iii), which only consists of non-MIS districts, we see that the radio coefficient is small and insignificant, meaning that owning a radio does not have a significant impact on the prices farmers receive in areas that do not partake in the MIS project. Another thing we can see from the table is the much higher constant term associated with MIS districts (189 US\$) in comparison with non-MIS districts (160 US\$). The conclusion from (ii) and (iii) is therefore that owning a radio does not affect prices in areas where the market information was not disseminated, but that owning a radio is associated with higher farm-gate prices for maize in districts where the MIS project is active.

¹²Stata Intercooled 10.0: Data Analysis and Statistical Software

Table 6: Effects of market information on the price farmers receive

Dep. variable	Farm-gate price per kilogram of maize					ln(price)
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Specification	All	MIS	Non-MIS	All	No radio	All
Radio	12.56*	28.61*	1.12	2.86		0.013
	(3.39)	(5.62)	(4.16)	(4.36)		(0.03)
Radio * MIS				23.36*		0.1597*
				(6.61)		(0.05)
MIS					5.91	
					(5.43)	
Constant	172.83*	189.40*	160.26*	172.50*	177.79*	5.0419*
	(5.48)	(9.05)	(6.76)	(5.47)	(8.81)	(0.04)
District fixed effects	Yes	Yes	Yes	Yes	No	Yes
Household controls	Yes	Yes	Yes	Yes	Yes	Yes
Districts	53	17	36	53	53	53
Observations	2739	1164	1575	2739	810	2739

^{Note} Standard errors in parenthesis. * Significant at 1 % level. Household controls include household size, level of education of the household head, and health status of the household (measured as share of household members that reported suffering from an illness during the 30 days prior to the survey date).

Specification (iv) shows equation 5 as presented under method:

$$p_{ij} = \alpha + \beta_1 radio_{ij} + \beta_2 radio_{ij} * MIS_j + \beta_3 x_{ij} + \mu_j + \epsilon_{ij}$$

We use the whole sample for this specification, and the radio coefficient now becomes small and insignificant indicating that owning a radio does not in itself contribute to higher farm-gate prices. Radio x MIS is a dummy that takes the value 1 if a household resides in an MIS district and owns a radio. The difference-in-differences estimate is significantly

different from zero. This can be viewed as the causal effect of having information about markets and prices (measured as owning a radio and living in an MIS-district) on farm-gate prices, and it shows that having information is associated with a large increase in farm-gate prices received for maize.

Specification (v) looks at the problem with spillovers. There is a chance that households without access to a radio in MIS-districts learn about market trends and prices from their better-informed neighbours. As we can see from table 6, living in an MIS-district has a positive impact on prices, but the effect is not significantly different from zero, which means that we cannot reject the null hypothesis of no spillovers.

It is also reasonable to assume that some people residing in non-MIS-districts bordering MIS-districts will be able to receive signals from the radio stations that broadcast the price information. Whether this information is useful to them or not is another question, as prices vary a great deal even between markets located near each other. If farmers in non-MIS-districts are helped by information received this way that would work against the findings in specification (iv). It is therefore likely that the difference-in-differences estimate constitutes a lower bound of the effect.

As a robust test I have included specification (vi). This is the difference-in-differences equation from (iv), but instead of using prices as the dependent variable I use the natural logarithm of farm-gate prices. This way we will get a more robust result, as outliers are given less weight. In a log-level model like this the coefficients can be interpreted as percentage growth. As we can see from table 6 the effect of radio is still small and insignificant. The interaction term, radio x MIS, is significant and large. According to the estimates, owning a radio and residing in an MIS district is linked to an increase in farm-gate prices of nearly 16 %. This effect is slightly larger than we found in (iv), where it is approximately 13.5 %. The constant in specification (vi) is quite a bit smaller than in (iv), 154.8 (e5.0419) and 172.5 respectively. This change indicates that there are some outliers in the higher range of prices than are now given less weight, resulting in the constant to drop. Specification (vi) shows the same main results as (iv), showing that the

positive effect of radio in MIS districts is a robust effect.

The impact of education

I will in the following move beyond the results reported in Svensson and Yanagizawa's article and look more in depth at whether and how education plays a role when it comes to the effect of owning a radio. As presented above, the level of education in Uganda is generally low. I have chosen to create a dummy variable that takes on the value one if a household head has "no formal education" or "less than primary education". Combined these two groups constitute 64 % of the households interviewed, as we can see from the summary statistics in table 5. The dummy takes the value zero for the three other education groups: "completed primary education", "completed O-levels" and "completed A-levels". These groups amount to approximately 20 % of the sample. The rest of the sample has no registered level of education. Even if this division is very uneven when it comes to the number of observations, it is the division that I find the most relevant when analyzing whether there is a difference between farmers with and without education. I chose to group "less than primary education" with "no education" as this group can include people with close to no education and as this group has no completed education they might still be illiterate. From now on I will refer to the first group as non-educated farmers, and the second as educated farmers.

My hypothesis is that uneducated farmers have more to gain from the radio broadcasts than educated farmers, since literate, educated farmers can use other sources of information such as newspapers, cell phones and possibly the Internet. This means that they can seek information on prices in other ways, whilst for non-educated farmers the radio broadcasts provide information they did not have access to prior to this project. As we can see from the summary statistics below it looks as if educated households receive a higher farm-gate price than uneducated households. This can be an indication that educated farmers have a better bargaining position when selling their maize to traders than their non-educated neighbours.

TABLE 7: SUMMARY STATISTICS BY EDUCATION LEVEL

	Mean	St.dev.	Obs.
Farm-gate price non-educated	186.16	77.48	1792
Farm-gate price educated	190.94	84.70	529
Radio non-educated	0.704	0.46	1792
Radio educated	0.708	0.45	529

To see whether this difference in mean prices is statistically significant I have conducted a hypothesis test of the differences between the two means. My null hypothesis is that there is no difference between the means.

$$H_0 : m_1 - m_2 = 0$$

$$H_1 : m_1 - m_2 > 0$$

I use the numbers reported in table 7: $m_1 = 190.94$, $m_2 = 186.16$, $s_1 = 84.7$, $s_2 = 77.48$, $n_1 = 529$ and $n_2 = 1792$.

$$m_x = m_1 - m_2 = 190.94 - 186.16 = 4.78$$

$$s_x = \sqrt{\frac{s_1}{n_1} + \frac{s_2}{n_2}} = \sqrt{\frac{84.70^2}{529} + \frac{77.48^2}{1792}} = 4.112$$

We now have what we need to calculate the t-statistic:

$$t = \frac{m_x}{s_x} = \frac{4.78}{4.112} = 1.16$$

With a 5 % significance level, and 528 ($n_1 - 1 = 529 - 1$) degrees of freedom the t-table gives us the following value: $t_{95} = 1.96$.

$$1.16 < 1.96$$

As we can see, the test-statistic is smaller than 1.96, hence we can not reject the null hypothesis. It is therefore insufficient evidence to make a conclusion that educated farmers receive higher prices than non-educated farmers.

In the following I have looked at the same specifications as in table 6. I split the dataset in two; farmers who have not completed any formal education and farmers with education, as described above. I start off looking at *non-educated farmers* to see how radio effects the prices they receive for their maize. The results are presented in table 8.

Table 8: Effects of market information on the price non-educated farmers receive

Dep. variable	Farm-gate price per kilogram of maize					ln(price)
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Specification	All	MIS	Non-MIS	All	No radio	All
Radio	12.02*	29.62*	-0.77	1.05		-0.0031
	(4.05)	(6.72)	(4.94)	(5.29)		(0.04)
Radio * MIS				25.67*		0.1992*
				(8.00)		(0.06)
MIS					2.40	
					(6.61)	
Constant	171.98*	183.19*	162.73*	172.03*	176.18*	5.0479*
	(5.89)	(9.21)	(7.33)	(5.87)	(10.37)	(0.04)
District fixed effects	Yes	Yes	Yes	Yes	No	Yes
Household controls	Yes	Yes	Yes	Yes	Yes	Yes
Districts	49	17	32	49	53	49
Observations	1790	763	1027	1790	529	1790

Note Standard errors in parenthesis. * Significant at 1 % level.

As we can see from table 8 specification (i), radio has a significant effect on the farm-gate price of maize. Both the constant and the radio estimate are similar to what we found when we looked at the full sample. This indicates that non-educated farmers do not differ

a lot from the average person. This makes sense since they constitute 2/3 of the sample.

When we split the sample further into MIS- and non-MIS-districts in specification (ii) and (iii) we see the same trend. The results are very much similar to what we saw before. This shows that the radio broadcasts are helping uneducated farmers receive a higher price for their maize in MIS-districts whilst radio does not have an effect in other districts.

The main regression, specification (iv), also shows results consistent with what Svensson and Yangizawa (2009) found. The difference-in-differences estimate, Radio x MIS, is large and significant. It is actually slightly larger than for the full sample, but it also has a higher standard deviation. When we include this term as an explanatory variable, radio loses its effect and significance. This illustrates that radio in itself does not cause higher prices for non-educated farmer, it is the combination of owning a radio and living in districts where the MIS project broadcasts information that has a significant effect on farm-gate prices.

The last specification, (vi), has the logarithm of price as dependent variable. We see that the results are slightly different from specification (iv), but the conclusions are the same. The effect of the radio is still small and insignificant, but when we use the logarithm of price the effect is actually negative. The interaction term is again large and significant, illustrating that having access to radio in MIS districts is connected to nearly 20 % higher prices. Again we see that the effect of the interaction term is larger than before. The constant term is smaller in (vi) compared to (iv), something we also saw in table 6.

The conclusion after looking at the results for non-educated farmers is that having access to reliable and up-to date market information (proxied by owning a radio) has a causal effect on farm-gate prices. Specification (vi) shows that these results are robust.

Table 9 shows the effects of market information for *educated farmers*.

Table 9: Effects of market information on the price educated farmers receive

Dep. variable	Farm-gate price per kilogram of maize					ln(price)
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Specification						
Sample	All	MIS	Non-MIS	All	No radio	All
Radio	19.01	21.67	17.83	18.44		0.0815
	(9.74)	(17.10)	(11.75)	(12.10)		(0.08)
Radio * MIS				1.58		-0.0192
				(19.98)		(0.13)
MIS					25.15	
					(14.70)	
Constant	192.58*	251.61*	148.76*	192.48*	193.72*	5.1350*
	(17.71)	(29.25)	(22.57)	(17.78)	(58.23)	(0.11)
District fixed effects	Yes	Yes	Yes	Yes	No	Yes
Household controls	Yes	Yes	Yes	Yes	Yes	Yes
Districts	42	17	25	42	53	42
Observations	529	227	302	529	100	529

Note Standard errors in parenthesis. * Significant at 1 % level.

Looking at specification (i) we see that the effect of radio on prices is larger than for non-educated and for the full sample. The effect is however not significant at any of the normal significance levels. This means that for farmers with education we do not observe an effect significantly different from zero, meaning that radio does not affect the farm-gate price of maize. The constant term, which is the price received without controlling for anything else, is however a lot larger than for uneducated farmers. This indicates that educated households are receiving a higher farm-gate price than their uneducated neighbours, and this is in accordance with the summary statistics presented in table 6.

When we split the sample into MIS and non-MIS districts we see that the effect is similar

in the two samples, a large positive, but insignificant effect. The big difference here is the constant. Whilst MIS-districts have a constant of more than 250 USh, non-MIS-districts have a constant of less than 150 USh. This illustrates that there is a large difference between the farm-gate prices received for maize in MIS-districts compared to non-MIS-districts. As radio is not a significant explanatory variable, there must be other reasons for this difference. Because radio does not make a difference for farm-gate prices, one should expect the prices in districts to be the same whether they are part of the MIS project or not. This is clearly not the case here, as we observe much higher prices in MIS districts. It is therefore reasonable to believe that the MIS project in some way or another is the cause of this big difference.

The fourth specification also shows different results than before. The radio coefficient is large, whilst it was close to zero in the full sample and for non-educated households. The estimate is however still not significant, meaning that radio does not affect prices significantly. Looking at the difference-in-differences estimate we see that this is very small, and also insignificant. This indicates that getting price and market information through radio broadcasts does not have a significant effect on the farm-gate prices received by educated households. The educated households in MIS-districts are still receiving a higher farm-gate price than the ones in districts not partaking in the project, and even though we cannot show that radio has a significant effect it is likely that the MIS project in some way contributes to this large difference between educated households in different districts. According to Foodnet's websites they do not only disseminate information through radio broadcasts, but also in newspapers. Since educated people most likely are literate this can be part of the explanation. If these farmers seek market and price information in newspapers, there will not be a difference between the households that own radios and the ones that don't, as both can access the information. If this is the case, radio does not work as a proxy for access to price information when we look at households with education. In addition, the information in local newspapers is the same information that is broadcast on the radio. Hence it is reasonable to assume that educated people living in

non-MIS districts cannot make use of this information even if they read the newspapers, as there are such large differences between individual marketplaces.

To see if the results above are robust I change the dependent variable to log price. As mentioned before, this will put less weight on outliers and will therefore change the results if they are based on a few extreme observations. Using a logarithmic dependent variable does not change any of my conclusions. Changing the dependent variable of specification (ii) and (iii) shows that the large gaps in prices between MIS districts and non-MIS districts are still present (the results are not reported in the table). The different estimates are not the result of outliers. Further, specification (vi) show that the effect of radio is still relatively large, but insignificant, as found in specification (iv). The interaction term is also insignificant, but the direction of the effect is opposite from before. As we cannot say that the effect is statistically different from zero that does not matter. As we have seen both in table 6 and 8, the constant is smaller when we use log price, illustrating that there are some outliers in the dataset that are now being given less weight.

After looking closer at educated households we can conclude that radio does not seem to have a significant effect on the farm-gate price received. We do however see that prices in MIS districts are higher than in non-MIS districts.

4.2.5 Conclusion

As seen in table 6, access to market information is consistent with higher farm-gate prices. This means that owning a radio causes higher farm-gate prices in MIS districts, whilst the effect of radio is non-existent for districts that are not part of the project. Svensson and Yanagizawa (2009) had a hypothesis that market information improves farmers' relative bargaining position vis-à-vis local traders, and the results above support this hypothesis.

I further show that getting access to price information via radio broadcasts has a large and significant effect on uneducated households. For educated households on the other hand, I do not find this effect. These results confirm my hypothesis that non-educated

farmers have more to gain from the MIS project's radio broadcasts than their educated counterparts, as the latter is more likely to be able to access such information in other ways.

4.3 The impact of radio in the developing world

As we have seen from the discussion and analysis above, radio is contributing to development in several ways. Radio is to many people their main source of information and has therefore proven to be a powerful tool in increasing knowledge and raising awareness about issues that affect poor people. As we saw in the analysis, radio is having a large impact on the prices received, and hence the income, of uneducated farmers. As they cannot seek information from other sources, radio is helping to close the information gap between sellers and buyers. In general it can be said that radio has the potential to help development in poor countries substantially because it has such a wide reach and makes information accessible to isolated and illiterate people.

5 Internet

The mainstream use of the Internet exploded in the 1990s, and by the end of 2009 more than 1.7 billion people were online. This amounts to approximately 26 % of the world's population, up from 11 % in 2002 (Engeler 2010). There are however large gaps between the different continents. Whilst Europe and America had Internet penetration rates of 43 and 44 % in 2007, only 1 in 20 was online in Africa, and Asia also lagged far behind with 15 % online (Tryhorn 2009). The number of fixed broadband subscribers has been increasing steadily across the globe, and over the last five years there has been more than a threefold increase, from 150 million to more than 500 million subscribers. As for mobile broadband there was 335 million subscribers by the end of 2008, which is less than 1 % of the world's population (Tryhorn 2009). This number is increasing rapidly and has now surpassed fixed broadband. Whilst access to fixed broadband often is limited to urban areas meaning that large parts of the population is left without access to Internet, mobile broadband is becoming more and more accessible as telephone networks are being upgraded to facilitate mobile Internet in the form of GPRS, EDGE, 3G etc. (ITU 2010).

The large divide between rich and poor countries is even clearer when it comes to Internet, compared to radio and mobile phones. In 2009 80 % of the developing world was still excluded from using the Internet (ITU 2010). Regardless of the fact that prices of computers have gone down significantly during the last few years, they are still too expensive for large parts of the world's population. Even if people could afford to buy a computer, poor people have more pressing concerns such as food, health and education, and in addition illiteracy is a large obstacle in many poor countries (Economist 2005b).

In the report "Towards A Connected World" (BCG-Telenor 2009), BCG¹³ explores the socio-economic impact of Internet in emerging economies. The aim of the study is to estimate how the Internet will impact three countries (Bangladesh, Thailand and Serbia), both economically and socially over the next ten years. As for mobile phones, the Internet

¹³Boston Consulting Group

has the potential to increase productivity a lot. This is expected to be the most important contribution that the Internet has. As the Internet makes communication easier it reduces the need to travel, and makes it easier for entrepreneurs to establish new businesses. This is expected to be a key driver of job creation. The Internet allows for new businesses to reach larger groups of potential customers and it also opens up new markets such as website design, online stores, software development, e-commerce etc. Such businesses can help people in rural parts of developing countries diversify their incomes, and reduce the amount of poor people that rely 100 % on agriculture for income.

As mentioned before, developing countries often suffer in areas such as education, health care and rural development. With the introduction of Internet such issues can be addressed in new and innovative ways. Bangladesh is a country that suffers with high illiteracy rates, poor education and pupil-teacher ratio of 45:1. This has resulted in many rural areas lacking access to primary education, and as much as 55 % of students never finish grade 5. A project in Gramjyoti seeks to face these challenges by providing distance learning at three local schools. Lessons are broadcast to students via wireless broadband, and being interactive they allow for students to ask questions. The project has proven a success, even in difficult subjects such as maths and chemistry. This illustrates how Internet as a source for learning has a lot of potential. People can do online courses, video conference classes and it can help raise the overall quality of education available to poor people.

The lack of trained medical personnel is also a pressing issue in Bangladesh, not only does the country have a doctor-to-patient ratio of 4000:1, but rural clinics suffer from chronic absenteeism of doctors. A project called Alokito e-health aims at making health care available to larger parts of the population. Nurses go out in the field using a specially equipped van to meet patients and perform basic procedures. All vans have a wireless broadband connection that makes it possible for nurses to link with doctors in the main hospitals. This way they can talk to patients and offer diagnoses. Through this project the number of patients that each doctor can serve has been significantly increased, and it is also tackling the fact that most doctors prefer to stay in urban areas where life is a lot

more comfortable than on the countryside.

In Thailand, the possible environmental gains that the Internet can bring have been emphasized. Carbon emission is a large problem in many urban areas, but as Internet is becoming more normal, there is less need for car trips. Paying bills and shopping can be done online, information can be easily shared via e-mail, and offices are looking into letting staff work from home some days of the week. This could potentially reduce emissions by up to 10 %, improving the environment significantly according to the BCG-Telenor report.

There are however many obstacles to achieving widespread Internet adoption. First of all, as mentioned earlier, many developing countries have high rates of illiteracy, especially amongst the poor. The illiteracy rates are much higher when it comes to English, which limits the gains from using the Internet considerably. Younger generations do however have higher levels of literacy than older, and can help their families in using the technology. Secondly there is the issue of coverage. Fixed lines only reach a very limited amount of people, and are expensive to extend to cover everyone. The growth of mobile broadband might solve this problem. As shown in part 3, mobile phones are widespread even in the developing world, and being able to access Internet via your phone will make the Internet accessible for much larger portions of the world's population. Another obstacle is awareness. Many people in developing countries are simply not aware of the Internet and the potential benefits it can bring. In order to achieve the potential gains from Internet use, people need to be educated on how to use the technology. The largest obstacle is however the simple fact that most poor people have more urgent concerns than being online, such as food, health and schooling, and simply cannot afford using computers and the Internet.

One initiative that is trying to overcome the fact that most people cannot afford to buy computers is the Community Information Centre (CIC) project initiated by Grameenphone (Deloitte & Touche 2008). Currently there are 560 such centers around Bangladesh providing customers with access to Internet, printing and scanning services, and content

on agriculture, health and education. These centers does however not deal with the issue of illiteracy.

It is not likely that Internet will become as widespread as mobile phones in the developing world because of the obstacles mentioned above. This is especially the case for poor people. Mobile Internet probably has the largest potential as it does not require that one buys a computer. As mobile networks are upgraded to facilitate Internet, Internet will become accessible to more people and can prove an important source of information around the developing world (ITU 2010). However, even if poor people cannot use the Internet themselves it will impact their lives through projects such as the Gramjyoti teaching project and Alokito e-health project. I therefore conclude that the Internet has the potential to promote development and improve the lives of people in the developing world.

6 Conclusion

Mobile telephony

Mobile phones are being used in innovative ways to overcome obstacles to development in the developing world. Services that we take for granted in the developed world, such as health care, education and bank services, are made available to people that have previously been excluded from such services, which can potentially have a large impact on development. Poor health and illiteracy are two of the main obstacles to people improving their lives, and the lack of opportunities to save money results in many people falling back into poverty in the case of emergencies. Further, I have shown through a case study that mobile phones contribute to making markets more efficient; reducing price dispersion across markets, price volatility within markets and eliminating waste through arbitrage opportunities. In addition, the use of mobile phones has the potential to greatly improve productivity by cutting travel time and making it easier to communicate and share information.

Radio

Radio reaches a large part of the world's population and is an inexpensive information channel. Radio is proving to play an important role in extending knowledge and raising awareness of important topics such as health, the environment and agriculture in developing countries. Its ability to reach rural, illiterate populations makes it an even more important source of information. In the case study I show how radio broadcast price information is giving farmers the information they need to gain a better bargaining position vis-à-vis local traders. This raises farmer's income and also helps make markets more efficient. I show that radio broadcast information has a higher value for non-educated farmers than for educated farmers.

Internet

Internet is still nowhere near as widespread as the two other technologies discussed but has an enormous potential to improve productivity through information sharing, online

marketplaces, online teaching etc. The largest potential for the Internet is through Internet on mobile phones, but there are still two important obstacles to the adoption of Internet: illiteracy and knowledge of how to use it.

As I have tried to show throughout this paper, technology is contributing to development in many ways. Most importantly it is helping increase productivity and improving market efficiency as information as it becomes easier to access information. As large portions of the world's poor population are dependent on functioning markets for their income, making it easier to seek reliable market information or making it easier for sellers to find buyers has the potential to promote development and ultimately improve the standard of living in developing countries.

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