London School of Economics and Political Science

Essays on the Importance of Access to Information in Developing Countries

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Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others.

I declare that my thesis consists of 30,323 words in total.

Statement of Inclusion of Previous Work

I confirm that chapter 3 is the result of previous study for the degree of MRes I undertook at the London School of Economics and Political Science. That degree was awarded in 2008.

Abstract

The aim of my thesis is to investigate the importance of access to information for individuals in developing countries. In the first chapter, I describe an important channel through which improved access to market information could increase the prices that producers receive from middlemen. I develop a theoretical model of trade between a farmer and a middleman which allows for the existence of different types of middlemen and I provide an empirical test of the theory from an original framed field experiment carried out with farmers and middlemen in India. In chapter 2, I investigate the relationship between the decision to produce high-quality goods and two important characteristics of the product: the degree of observability of quality and the level of intermediation in the supply chain. I present a model which demonstrates that if quality is not perfectly observable, there will be a range of values of the price difference between high-quality and low-quality goods for which production of high-quality goods will occur with vertical integration but will not occur if the stages of production are carried out by separate agents. This chapter also presents some case studies of supply chains for various products in a number of developing countries that have characteristics which are consistent with the predictions of the model. In the final chapter, I try to understand how access to information could be improved for individuals in developing countries. I investigate the relationship between rates of mobile phone and Internet use and a number of geographic, institutional and economic variables in a sample of 164 countries from 1990 to 2009. The aim of this chapter is to identify the main characteristics of countries that have had success in adopting these new technologies in order to gain some insight into the barriers which may be faced by those countries that have been less successful.

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Introduction

In this thesis, I aim to address a number of questions relating to the importance of access to information for individuals in developing countries. The first two chapters describe situations where producers do not have access to perfect information regarding price or quality and investigate what effect this has on prices received and production decisions. The final chapter attempts to understand how access to information could be improved for individuals in developing countries.

In chapter 1, I investigate an important channel through which improved access to market information could increase the prices that producers receive from middlemen. I develop a theoretical model of trade between a farmer and a middleman which allows for the existence of different types of middlemen. The source of heterogeneity is attitudes towards fairness. I provide an empirical test of the theory from an original framed field experiment carried out with farmers and middlemen in India. The model predicts that there will be a non-monotonic relationship between the benefit of information and the cost of switching to a new middleman. The results of the experiment support the predictions of the model and demonstrate that actual middlemen differ in their attitudes towards fairness, middlemen make higher offers when the farmer is informed, and the benefit of information to the farmer varies with the cost of switching.

In chapter 2, I present a model of a supply chain for a good involving two stages of production. Effort must be exerted at both stages if a high-quality good is to be produced. Effort is not observable and the quality of the good is not perfectly observable. The model predicts that there will be a range of values of the price difference between high-quality and low-quality goods for which production of high-quality goods will occur with vertical integration but will not occur if the tasks are carried out by separate agents. The range of price values for which this occurs will be decreasing as the level of observability of quality increases and

will disappear as quality becomes perfectly observable. I also present some case studies of supply chains for various products in a number of developing countries that have characteristics which are consistent with the predictions of the model.

In the chapter 3, I use a logistic model of technology diffusion to investigate the relationship between rates of mobile phone and Internet use and a number of geographic, institutional and economic variables, in a sample of 164 countries from 1990 to 2009. The aim of this chapter is to identify the main characteristics of countries that have had success in adopting these new technologies in order to gain some insight into the barriers which may be faced by those countries that have been less successful.

Chapter 1

Middlemen, Bargaining and Price Information: Is Knowledge Power?

1.1 Introduction

The majority of the poor in developing countries depend on agriculture for their livelihoods. Moreover, high and volatile food prices can have severe negative consequences for the welfare of the poor. Improving the efficiency of agricultural markets is therefore a priority. Agricultural supply chains are often dominated by middlemen with substantial market power. Their high margins distort the market by driving a wedge between the price paid to farmers and by final consumers. One source of market power lies in the fact that middlemen are better informed about market conditions, especially the prices further down the supply chain. This raises the possibility that better access to market information can increase the prices that farmers receive from middlemen, thereby increasing their income and helping them to make better production decisions.

A number of recent empirical papers have investigated the effects of better market information on producer prices, although results are mixed. However, few of these studies are able to model explicitly how a farmer can use price information when bargaining with a middleman. It is normally assumed that the farmer receives a higher price when he is informed because he is risk averse. However, since the variability of the price that he receives will also be higher, it is not clear that the farmer will be better off when he is informed. In this paper, I develop a theoretical model to demonstrate how market information can lead to an increase in the price that a farmer receives from middlemen through a different

channel. The approach allows for the presence of different types of middlemen, and for farmers to switch to a different buyer between periods. The paper provides an empirical test of the theory from an original framed field experiment carried out with actual farmers and middlemen in Gujarat, India.[1]

In the basic two-period model, a farmer and a middleman trade with one another. The middleman is informed about the market price for the good that they are trading while the farmer knows only the distribution of prices. The farmer has an outside option to go to the market himself but faces high transport costs. He may encounter one of two types of middlemen. The 'good' type cares about fairness and splits the gains from trade equally with the farmer. The 'bad' type behaves strategically and aims to maximize the sum of his gains from the two periods. The field experiment reported on here is mapped closely on to the set-up of the model. It is used to investigate whether the posited heterogeneity among middlemen is observed in reality. Also, by exogenously varying the cost of switching to a different middleman it is possible to test the prediction that the benefit of information varies with the degree of competition between middlemen.

There are a number of different ways to model heterogeneity among middlemen, e.g. different transport costs, different outside options, and these will result in similar predictions to those of the model presented here. In this paper, I decided to model the different types as having different attitudes to fairness, as this seems to be something that is true in reality and the framed field experiment gives us an opportunity to investigate its importance. Interviews with farmers and information providers in India suggest that exploitation by dishonest middlemen is an important concern for farmers and that information can be used to protect against this. The idea that the honesty or integrity of the middleman can be hidden when the farmer is uninformed about prices has been alluded to by previous authors but until now has not been explicitly addressed.[2]

The model yields some intuitive predictions. The existence of different types of middlemen creates a new role for price information stressing selection as well as incentives. It is easier for the bad middleman to disguise his type if the farmer

[1] I believe that this experiment qualifies as a framed field experiment as described by Harrison and List (2004) as the participants bring relevant information with them from their daily experiences of interacting with other farmers and middlemen and they also have experience in the field that is relevant to the tasks that they must perform in the experiment.

[2] Eggleston, Jensen and Zeckhauser, (2002): "Although trust may develop over multiple transactions, the paucity of information continues to handicap the farmer since he cannot independently assess the integrity of the dealer, or the reasonableness of the price he offers"; Opening quote from Aker and Fafchamps (2011): "[With a mobile phone], no dishonest trader can cheat me when I buy and sell."

is uninformed about the market price. The model predicts that there will be a non-monotonic relationship between the benefit of information to the farmer and the cost of switching to a different middleman. If the degree of competition between middlemen is high (i.e. the switching cost is low) then the farmer does not need to be informed about the market price in order to get a good offer from the middleman. As the cost of switching becomes higher, the benefit to the farmer of being informed also increases. For this region of the switching cost, information and competition act as substitutes. Once the switching cost is high enough, however, the bad middleman no longer needs to disguise his type and once again price information will not help the farmer.

The results from the experiment show that middlemen do vary in their attitudes towards fairness and that 'bad' types tend to make lower offers in the second round of the game. In the first round, the 'bad' type of middleman also makes higher offers when the farmer is informed. For all levels of switching costs, the farmer receives a higher average offer when he is informed, with the benefit of information varying with the switching cost. These findings confirm the relevance of the theory in interpreting the data.

Taken together, the approach and results confirm the importance of institutional arrangements in the agricultural sector to the welfare of farmers. There is long-standing suspicion of the role that middleman play in monopolistic settings and it is instructive to see that information provision can have an impact in this setting.

The rest of this paper is organized as follows. Section 2 presents a review of the relevant literature. The theoretical model is presented in Section 3. Section 4 describes the experimental design. The experimental results are presented in Section 5. Section 6 briefly discusses the potential effects of an intervention to increase access to price information and Section 7 concludes.

1.2 Related Literature

The issue of exploitation of farmers by middlemen is not new and has been debated for decades.[3] The existing literature relating to middlemen has tended to view middlemen as either fulfilling an important role in the market or as being purely exploitative. This paper builds on this literature by allowing for the pres-

[3]Bauer and Yamey (1968).

ence of both types of middlemen in the same market. Biglaiser (1993), Biglaiser and Friedman (1994) and Li (1997) present models in which middlemen act as guarantors of quality in markets where the quality of the good being traded is uncertain and middlemen invest in becoming experts. Another important role that middlemen can play is in reducing the search costs in markets with frictions. Van Raalte and Webers (1997) present a model where intermediation is necessary for matching to occur, whereas Rubinstein and Wollinsky (1987) show how middlemen can shorten the time period between transactions because they increase the likelihood of matches occurring. Jori and Leach (2002) demonstrate how middlemen can improve efficiency by improving match quality in markets with heterogeneous buyers and sellers. Masters (2007 and 2008), on the other hand, assumes that middlemen are purely exploitative and shows how their presence can reduce the efficiency of markets. Finally, a number of studies investigate competition between middlemen and either 'market makers' or direct sales between consumers and producers.[4]

In terms of the empirical evidence, Hayami, Kikuchi and Marciano (1999) find that there is a high degree of competition between middlemen in the market for rice in the Philippines. They state that it is very easy for farmers to switch to a different trading partner if they are not satisfied with their current relationship and this means that farmers are not exploited in this market. Conversely, Mitra and Sarkar (2003) find that the potato market in West Bengal is controlled by a small number of traders who earn oligopolistic profits. Fafchamps and Hill (2008) investigate the transmission of increases in coffee prices in Uganda. They state that high search costs exist and farmers are not well informed about prices. As a result, increases in prices are not passed on to producers. Another important source of middlemen's market power can be high transport costs as shown by Minten and Kyle (1999) and Merel, Sexton and Suzuki (2009).

In recent years, a number of empirical studies have investigated the effect of price information on producer prices in developing countries and the results have been mixed. The theoretical framework presented in this paper could help us to interpret these results as they are consistent with the prediction that the effect of information will vary with the competitive environment. Svensson and Yanagizawa (2008) found that having access to regular market information via radio was associated with 15% higher farm gate prices in Uganda. The results from an experiment in Rwanda, on the other hand, found no effect of having a mobile phone on prices received by farmers, although the authors report that the ran-

[4]Rust and Hall (2005); Spulber (2002); Fingleton (1997); Vesala (2008).

domization mechanism was problematic and so the results should be interpreted with caution (Futch and McIntosh, 2009). A recent study by Fafchamps and Minten (2011) looks at the effect of SMS-based agricultural information on producer prices in India and finds that access to this information did not significantly increase the prices that they received, whereas Muto and Yamano (2009) found that in Uganda mobile phone coverage had a positive effect on farm-gate prices for bananas. They did not find a significant impact on prices for maize, however. Aker and Fafchamps (2011) also find that the effect of mobile phones varies by crop in Niger. They report that there is no significant effect on average producer prices but there is a reduction in the variability of prices for cowpea. They do not find the same effect for millet, however. Using examples from Tanzania, Molony (2008) argues that the ability of producers to use price information may be limited by the fact that they are tied in to relationships with particular middlemen and are dependent on them for credit. Since they do not have an option to trade with someone else if they are unhappy with the price they receive, being informed about the market price does not help them. These results give some support to the idea that the benefit of information to farmers will vary depending on what options are available to them. The perishability of the crop will be an important element of this, and so we would expect to see the results varying by crop.

This paper also draws on the large literature which focuses on bargaining with incomplete information. One strand of this literature has allowed for the preferences of one of the players to be unknown to the other, such as Rubinstein (1985) who presents a model where one of the players has incomplete information about the time preferences of the other player. Other authors address the issue of bargaining when the seller has incomplete information about the valuation of the buyer and investigate how players can use the cost of delay to communicate information.[5] This paper adds to this literature by allowing for two kinds of uncertainty and also allowing for the outside option of one of the players to be unknown to that player.

Finally, this paper builds on a number of experimental studies which have looked at the importance of fairness and deception in ultimatum games.[6] It contributes to this literature by investigating how the ability to deceive depends on how easy it is to find a new trading partner.

[5]Sobel and Takahashi (1983); Fudenberg, Levine and Tirole (1987); Cramton (1984); Blouin and Serrano (2001); Sen (2000); Grossman and Perry (1986); Srivastava, Chakravarti and Rapoport (2000).

[6]Boles, Cross and Murnighan (2000); Pillutla and Murnighan (1995); Croson, Boles and Murnighan (2003)

1.3 Model

1.3.1 Description of Economic Environment

There are a number of characteristics of the relationship between a farmer and a middleman that are specific to a developing country setting. The key characteristics that I will focus on in this paper are the following: (i) middlemen are better informed about market conditions than farmers, (ii) farmers face high transport costs to go to the market themselves, (iii) farmers often trade with the same middleman for multiple periods, and (iv) the existence of frictions in the market means it is not costless for the farmer to find a different middleman to trade with. The model presented in this section will aim to capture these characteristics in the simplest way possible.

The core intuition of the model is most easily demonstrated using a model where there are only two possible values of the price and that is what I will present in this section. However, it is reasonably straightforward to extend the model to allow for more than two prices and the key predictions of the model remain the same.[7] I will describe a two-period model of trade between a farmer and a middleman. At the start of the first period, a farmer and middleman are matched and have an opportunity to trade. The farmer has a good which has a market price, p. This price is independently and identically distributed in each period, with $p \in \{p_L, p_H\}$, $p_H > p_L$, and $Pr(p = p_H) = \lambda$. The middleman observes p_t in each period but the farmer knows only the distribution of p. The middleman makes a take-it-or-leave-it offer, x_t, to the farmer. The farmer can accept the middleman's offer or he can go to the market himself to sell the good but he must pay a transport cost, τ, in order to do so. The middleman's transport costs are normalized to zero. Gains from trade exist as the middleman's transport costs are lower than those of the farmer. The middleman's outside option is also normalized to zero.

I assume that the middleman may be one of two types, 'good' or 'bad', $i \in \{G, B\}$, with $Pr(i = B) = q$. The farmer does not know the type of a given middleman but he does know that the probability that he is a bad type is equal to q. A good middleman will always split the gains from trade equally, and so he will offer $p_t - \frac{1}{2}\tau$. A bad middleman will behave strategically and will choose x in order to maximize his expected payoff. At the end of the first period, the farmer

[7] The case with three prices is presented in the appendix.

may decide to stay matched with the same middleman for the second period, or he may pay a cost κ to be matched with a new middleman. The type of the second middleman is an independent draw from an identical distribution to that of the first middleman. If the farmer decides to switch to a new middlemen, then the first middleman will receive zero in the second period. In the second period, the middleman observes p_2 and makes an offer, x_2, to the farmer, which the farmer may accept or reject. There is no discounting and the farmer and the bad middleman aim to maximize the sum of their own payoffs from the two periods.

In this game, the farmer has two choices to make. Firstly, he may decide whether to accept the middleman's offer for that period or go to the market himself. Secondly, he must decide whether to stay matched with the same middleman for the second period or to pay the cost κ and be matched with a new middleman. His first decision simply depends on whether or not the middleman's offer is greater than his expected return from going to the market. The second decision depends on his beliefs about the middleman's type given the offer made in the first period. I assume that it is always better for a farmer to trade with a good middleman than a bad middleman. This requires the following assumption about the parameter values: $\tau > 2\lambda(p_H - p_L)$. Since a farmer always prefers to be matched with the good type in the second period, this means that it may be optimal for the bad middleman to give the impression that he is a good type in the first period to avoid losing the opportunity to trade with the farmer in the second period.

The bad middleman will choose x_1 in order to maximize the sum of his expected payoff from the two periods:

$$\max_{x_1} \rho(x_1)(p_1 - x_1) + \sigma(x_1)\rho(x_2)(E(p_2) - x_2)$$

where $\rho(x)$ is the probability that the farmer accepts the middleman's offer and $\sigma(x)$ is the probability that the farmer does not switch to a new middleman for the second period, given the middleman's offer in the first period.

1.3.2 Equilibrium

This is a two-period game of incomplete information between the farmer and the middleman and in what follows I will characterize the perfect Bayesian equilibrium of this game. Since I have already assumed that $\tau > 2\lambda(p_H - p_L)$, this means

that it is always possible for the middleman to offer the farmer the expected value of his outside option.[8]

1.3.2.1 Second period

In the second period, the bad middleman's only concern is whether or not the farmer will accept or reject his offer. As long as the middleman's offer is greater than or equal to the farmer's expected outside option given his beliefs about the market price, then it is optimal for the farmer to accept his offer. The pure strategy equilibrium of the game is as follows:[9]

The bad middleman always offers $x_2^* = \lambda p_H + (1-\lambda)p_L - \tau$, and the farmer's strategy is

$$\rho^*(x_2) = \begin{cases} 1 & x_2 \geq \lambda p_H + (1-\lambda)p_L - \tau \\ 0 & x_2 < \lambda p_H + (1-\lambda)p_L - \tau \end{cases}$$

The farmer's expected payoff if he is matched with a bad middleman in the second period is $E(p) - \tau$. The good middleman will offer $p_2 - \frac{1}{2}\tau$. The expected gain for a farmer from being matched with a good middleman rather than a bad middleman in the second period is, therefore, equal to $\frac{1}{2}\tau$. The expected payoff in the second period for a type B middleman, if the farmer continues to trade with him, is τ.

1.3.2.2 Decision to switch

Let μ_x denote the farmer's belief that the type of the middleman that he is currently matched with is B, given x_1. The farmer will therefore decide to switch to a new middleman if

$$(\mu_x - q)\,\frac{1}{2}\tau > \kappa$$

I assume that the farmer forms his beliefs according to Bayes' rule.

[8] In order for the middleman to be willing to offer the farmer the expected value of his outside option, the following must be true: $p_L > \lambda p_H + (1-\lambda)p_L - \tau$. This will be true if $\tau > \lambda(p_H - p_L)$.

[9] There is also a mixed strategy equilibrium but the expected payoff to the farmer is the same in both equilibria. The strategies of the mixed strategy equilibrium are as follows: $x_2^* = p_H - \tau$ if $p_2 = p_H$ and $p_L - \tau$ if $p_2 = p_L$, and $\rho^*(x_2) = 1$ if $x_2 \geq p_H - \tau$, $\frac{\tau}{p_H - p_L + \tau}$ if $x_2 = p_L - \tau$ and 0 if $x_2 < p_L - \tau$.

1.3.2.3 First period

In this section, I will describe the intuition behind the main results of the model. A formal proof can be found in the appendix. In the first period, the good middleman will offer either $x_L = p_L - \frac{1}{2}\tau$ or $x_H = p_H - \frac{1}{2}\tau$. It is therefore reasonable to assume that the farmer's posterior beliefs will assign probability zero to the good type for any other x. Given that this is the case, there are three possible equilibrium strategies for the bad type of middleman: x_L, x_H or x_B, where $x_B = \lambda p_H + (1-\lambda)p_L - \tau$. Given that any offer other than x_L or x_H will lead the farmer to believe that the middleman is type B with probability 1, x_B dominates any other $x' \notin \{x_L, x_H\}$. If the middleman offers $x' > x_B$, his payoff in the first period will be lower without changing the probability that the farmer will continue to trade with him in the second period and, if he offers $x' < x_B$, the farmer will reject his offer and take up his outside option instead.

In this period, the middleman has to worry about two things. Firstly, whether the farmer will accept or reject his offer for this period. Secondly, whether or not the farmer will continue to trade with him in the second period. He must weigh up the extra gain from offering a low price this period against the probability of losing the farmer's trade next period if the farmer's belief that he is a bad type is high enough for him to switch. The more costly it is for the farmer to switch, the less the middleman has to worry about disguising his type as even if the farmer's belief that he is type B is very high, he still might not be willing to pay the cost to switch. In the extreme case, when the cost of switching is high enough, the middleman can reveal his type and the farmer still won't switch. This leads us to Proposition 1.

Proposition 1: *If the level of competition in the market is low, i.e.* $\kappa > (1-q)\frac{1}{2}\tau$*, the bad type does not need to conceal his type. In this situation, improving the farmer's access to price information will not increase the expected price that he receives in the first period.*

If $\kappa > (1-q)\frac{1}{2}\tau$, it is too costly for the farmer to switch to a different middleman even if he knows for certain that the one he is matched with is type B. Given that this is true, the bad type has no incentive to pretend to be a good type and therefore will offer the lowest price that the farmer will be willing to accept, which is x_B. Since the bad type is already revealing his type, price information will not help the farmer to get a higher price.

If $\kappa < (1-q)\frac{1}{2}\tau$, on the other hand, the middleman must try to disguise his type. If the farmer does not know when the market price is high then the middleman can still appear to be a type G middleman by offering x_L when $p = p_H$. As long as κ is high enough, the farmer will not switch when he receives an offer of x_L as it is possible that the middleman could be a type G middleman and $p = p_L$.

Proposition 2: *For an intermediate level of competition, i.e.* $(1-q)\frac{1}{2}\tau > \kappa > \frac{\lambda q(1-q)}{q+(1-q)(1-\lambda)}\frac{1}{2}\tau$*, the bad type of middleman will need to disguise his type or else the farmer will switch to a new trading partner for the second period. For this level of competition, the expected price that the farmer receives in the first period will be higher with price information.*

Since $\kappa < (1-q)\frac{1}{2}\tau$, if the farmer knows that the middleman's type is B with certainty, then he will switch to a different middleman for the second period. The middleman cannot offer x_B, therefore, without losing the farmer's trade in the second period. κ is high enough, however, that even if the type B middleman always offers x_L, the farmer will not switch when he receives an offer of x_L. This is because the probability that the middleman is a type G middleman with a low price is high enough that the farmer does not want to pay the cost of switching. If, on the other hand, the farmer knows that the price is high, the type B middleman can no longer get away with offering him the low price as this will reveal his type. Now, the type B middleman must always offer x_H when the price is high and so the expected price that the farmer receives is higher when he is informed about the market price.

Proposition 3: *As the level of competition in the market increases, the benefit to the farmer of being informed about the market price decreases.*

If $\kappa < \frac{\lambda q(1-q)}{q+(1-q)(1-\lambda)}\frac{1}{2}\tau$, the farmer will prefer to switch to a new middleman when he receives a low offer if the type B middleman's strategy is to always offer x_L. That means that this can no longer be an equilibrium. Now, the middleman must sometimes offer x_H in order for the farmer to remain indifferent between staying matched with him and switching to a new middleman. The farmer will stay matched with the middleman when he receives an offer of x_L with the probability $\sigma^*(x_L)$ which makes the middleman indifferent between offering x_H and x_L:

$$\sigma^*(x_L) = \frac{\tau - (p_H - p_L)}{\tau}.$$

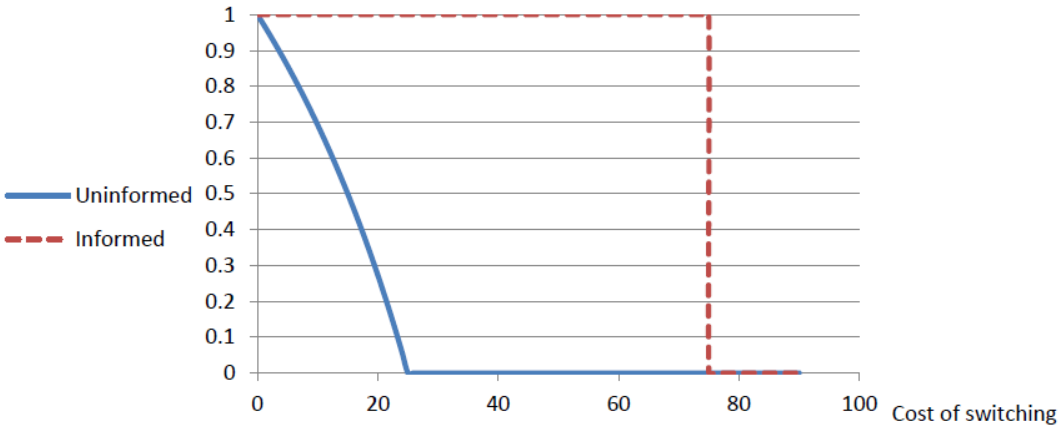
The probability that the type B middleman offers x_L when the price is high (γ_H) decreases as κ decreases:

$$\gamma_H^* = \frac{(1-\lambda)\kappa}{\lambda[\frac{1}{2}q(1-q)\tau - q\kappa]},$$

which means that the benefit to the farmer of being informed about the price also decreases.

In each case, the key variable that determines the expected payoff to the farmer is the probability that the middleman offers x_H when the price is high. If the level of competition is very low, then this probability is zero with or without price information as the middleman never needs to disguise his type. For an intermediate level of competition, the probability that the type B middleman makes a high offer when the price is high is zero if the farmer is uninformed about the price but 1 if the farmer is informed. This is the situation where information is most valuable to the farmer. As the level of competition increases (i.e. κ decreases), however, the probability that the middleman makes a high offer when the farmer is uninformed also increases and thus price information becomes less valuable to the farmer. This is demonstrated in Figure 1, assuming $q = \frac{1}{2}$ and setting $\tau = 300$, $p_H = 550$, $p_L = 350$ and $\lambda = \frac{1}{2}$, which were the values used in the experiment.

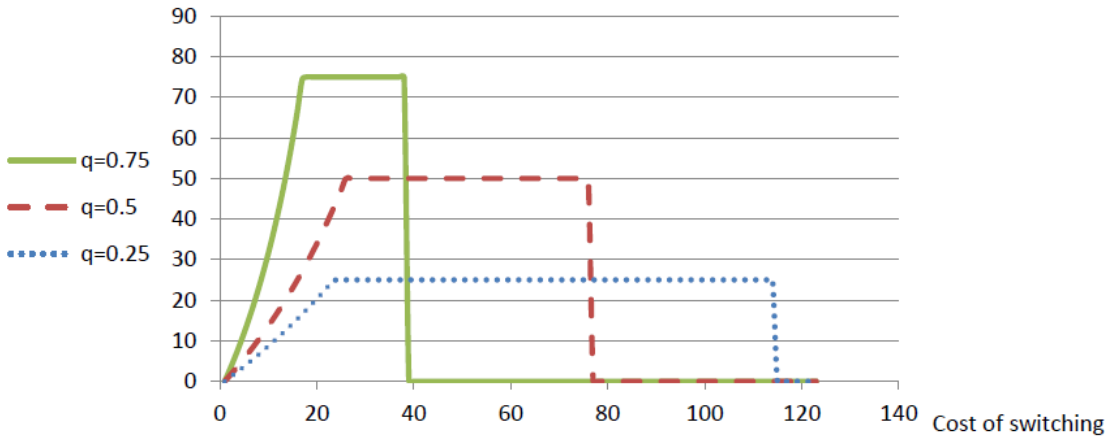
Figure 1.1: The probability that type B offers x_H when $p = p_H$.



The benefit to the farmer of being informed comes entirely through the first

period offer. Price information does not cause bad types to be pushed out of the market, it just forces them to behave like good types in the first period. Figure 2 shows how the benefit of information to the farmer varies with κ and with the share of type B middlemen in the population, q, for the same parameter values as in the previous figure. As q increases, the point at which information stops being useful decreases, as the farmer will be less inclined to switch if there are more bad types in the population. For the region of κ over which he would be willing to switch, however, information is more valuable if the proportion of bad types in the population is higher.

Figure 1.2: Expected offer in the first round with price information minus the expected offer without price information.



As these figures show, as long as the cost of switching is low enough that the bad type must try to appear like a good type, information and competition act as substitutes. Price information forces the bad type to always behave like a good type, achieving the same outcome that we would have if κ were equal to zero. Of course, the benefit of this to the farmer depends on how far away we were from this outcome without information.

1.4 Experimental design and procedures

In this section, I will describe the details of a framed field experiment which I carried out with farmers and middlemen in Gujarat, India. The experiment was designed to map as closely as possible onto the set-up of the model. A key assumption of the model is that there are different types of middlemen who have

different attitudes towards fairness, which cause them to make different offers to farmers. Carrying out an experiment with actual farmers and middlemen means that we can investigate whether or not this is the case in reality. There is of course a trade-off between being able to precisely estimate the causal effects of information through one channel and having to abstract away from other factors. A framed field experiment allows us to exogenously vary the degree of competition between middlemen and the amount of information that farmers have, while controlling for everything else. This gives us the opportunity to isolate one mechanism through which information could affect the prices that farmers receive from middlemen but it also retains relevance for the real world as participants can draw on their experiences from real bargaining situations when making decisions in the experiment.

The participants were recruited by Reuters Market Light, an organization that runs an SMS-based agricultural information service for farmers in India. RML have strong links with APMCs (Agricultural Produce Marketing Committee) across Gujarat and so were able to facilitate the recruitment of participants through the markets. The majority of participants were not RML customers. Sessions were carried out at various agricultural markets across Gujarat. Each session had an average of 20 participants,[10] half of whom were farmers and half of whom were middlemen, and there were 15 sessions in total. The participants were all from the local area where the session was being carried out but we were assured that individual farmers and middlemen who participated did not have strong personal relationships with one another outside of the experiment. Sessions began with all of the participants together. An explanation of what we were going to do was given and participants were asked to sign a consent form. Each participant was then given a questionnaire to fill out and some short games designed to elicit participants' preferences regarding fairness were played. This was followed by the bargaining game.

1.4.1 Middleman type

The key dimension of heterogeneity addressed in the model is attitudes towards fairness and so it is important that we obtain a measure for this in the experiment. With this in mind, the participants were asked to play two games at the beginning of the experimental session which were designed to elicit their attitudes towards fairness. The first game was a simple dictator game. The participants were told

[10] A number of sessions had 22 or 24, one session had 18 and one session had 14.

that they would each be given Rs.50. They were also told that they had been randomly and anonymously matched with another participant to whom they could give some of this money. They were asked how many rupees they would like to give to the other participant[11].

The participants were then asked to play a game designed to test their interpersonal orientation. This test requires participants to make a choice between three possible allocations of points to themselves and an anonymous 'other'. The options consist of one choice which maximizes the points allocated to oneself, another that equalizes the payoffs to both but gives a lower payoff to oneself than the first choice and a final choice which maximizes the relative payoff to oneself but gives a lower absolute payoff than the first choice. Each option corresponds to a different personality type: individualistic, prosocial or competitive. The instructions for the game are provided in the appendix. In the example given there, A is the 'competitive' choice, B is the 'prosocial' choice and C is the 'individualistic' choice. The participants are required to make nine such choices with different payoff values. If they make six or more choices consistent with one of the types then they are classified as that type. It has been shown in previous studies that participants' offers in ultimatum games, and whether or not they behave strategically, are correlated with this measure of personality type (van Djik, de Cremer and Handgraff (2002) and Carpenter (2003)).

The results from these games provide us with a number of different potential measures of a 'bad' type of middleman. In what follows, I construct a number of alternative measures and investigate how the results differ depending on the measure used.

1.4.2 Bargaining game

The experiment had six different treatment cells: there were two information treatments (informed and uninformed) combined with three costs of switching (Rs.10, Rs.40 and Rs.90). These costs of switching were chosen to map on to the different regions of κ described in the model, assuming that q was equal to $\frac{1}{2}$. The values for the parameters of the game were chosen to match the assumptions of the model as closely as possible and to give the participants a

[11] It is important to note that this is not a standard dictator game as in this game all participants receive some money and can choose how much to give away. We wanted to elicit the preferences of all participants, however, so it was decided that this was the best way to do this. The results are therefore not comparable to a standard dictator game but they do generate an ordinal measure of fairness which can be used in the empirical analysis.

large enough expected payoff that they would care about the outcome of the game. There were five possible values for the price, ranging from Rs.350 to Rs.550. The farmer's transport costs were set equal to Rs.300. In the set-up of the model, the middleman's outside option was normalized to zero. However, piloting showed that participants strongly dislike the possibility of getting a payoff of zero and this affects their choices in the game, so it was decided to give them a small, non-zero outside option instead. A summary of the parameter values can be found in Table 1.

Table 1.1: Parameter values in experiment

Parameter	Value (Rs.)
price	350, 400, 450, 500, 550
τ	300
κ_H	90
κ_M	40
κ_L	10
Outside option for middleman	40

Since there were likely to be significant differences between participants in different sessions and there were only 15 sessions in total, it was decided that all of the participants should each play all 6 types of game. This allows individual fixed effects to be calculated. The order in which the games were played was varied across sessions. The rules of the game were explained to the participants in detail with the use of examples. They were asked questions to make sure that they understood how the game would work. After the explanation, the farmers and middlemen were separated.[12] A space was kept between each participant to ensure that they could not influence each other or look at each other's responses. In each session, the participants played six games, consisting of two rounds each. At the start of each game, the participants were reminded of the conditions of the game i.e. the cost of switching and whether or not the farmers were informed about the market price. Each farmer was randomly and anonymously matched with a different middleman at the start of each game.

At the start of the round, the market price for the round was chosen. There were five possible values for the price: Rs.350, Rs.400, Rs.450, Rs.500, Rs.550. A middleman was asked to select a ball from a bag containing five balls, one corresponding to each of the five prices. The middlemen were told the market price and in the full-information games, the farmers were also told the price. In

[12]For most of the sessions they were put in separate rooms. For a few sessions, they were at opposite ends of a large hall.

the uninformed games, the farmers knew the possible values that the price could take, and that each one was equally likely. Each middleman was then given a form and asked to write down the offer that they would like to make to the farmer. Each form had a code on it to match the offer to the relevant middleman and farmer but this code changed between games and the participants could not identify their trading partner from this code. Once the middleman had written down an offer, the form was passed to the farmer with whom he had been matched. The farmer was then asked if he wanted to accept this offer and circled either 'yes' or 'no' on the form. If the farmer chose 'yes', then his payoff from that round was equal to the offer and the middleman's payoff was equal to the market price minus the offer. If the farmer chose 'no', then his payoff was the market price minus Rs.300 (representing transport costs) and the middleman's payoff was Rs.40.

After all of the farmers had decided whether or not to accept the middleman's offer, they were given another form asking them whether they would like to switch to a different middleman for the second round. They were reminded of the cost that they would have to pay if they said 'yes'. If a farmer decided to switch, then the first middleman only received Rs.40 for the second round. Once all farmers had made this choice, the second round began. A new price was chosen and the middlemen were given an offer form. If some farmers had decided to switch, then some middlemen received two forms in the second period as they were then matched with two farmers. They were told that they should make offers to two farmers but they would only get paid for one of the offers, which would be selected randomly. If a farmer chose to switch to a different middleman, then the first middleman did not receive a form in the second round, unless he was rematched with a different farmer who had also chosen to switch. In this case, the middleman was told that he would get paid the outcome for one of the rounds that would be chosen randomly and would receive only Rs.40 for the other round. Once all the middlemen had made offers, the forms were passed to the farmers who again chose to accept or reject. The game then ended.

The participants were paid for both rounds of one of the games which was selected randomly at the end. In general, middlemen tend to be wealthier than farmers and results from piloting suggested that the amounts of money involved were not as significant for the middlemen. In order to get them to care more about the game, therefore, one middleman was chosen randomly at the end of each session and that middleman's payoff from the game was tripled. Participants were informed of this before the game was played.

A summary of the timing of the bargaining game is as follows:

1. Farmers and middlemen are matched into pairs for Game 1.

2. All participants are told the cost of switching for that game and whether the farmers will be informed or uninformed about the price.

3. Round 1 begins. The price for Round 1 is chosen and told to the middlemen and also to the farmers in the informed treatments.

4. Each middleman writes down his offer on the offer sheet. This sheet is passed to the farmer that he has been matched with. Each farmer chooses to accept or reject the middleman's offer.

5. Each farmer is given a sheet of paper which asks him if he wants to stay matched with the same middleman for the second round or pay a cost to be matched with a new middleman. He chooses to switch or not to switch.

6. Farmers who choose to switch are matched with a different middleman for the second period. This means that some middlemen are matched with two farmers for the second period.

7. Round 2 begins. The price for Round 2 is chosen and told to the middlemen and also to the farmers in the informed treatments.

8. Each middleman who is playing in this round writes down his offer on the offer sheet (or two offer sheets if he is matched with two farmers). This sheet is passed to the farmer that he has been matched with. Each farmer chooses to accept or reject the middleman's offer.

9. Game 1 ends.

10. Each farmer is matched with a different middleman for Game 2.

11. The above steps are repeated 5 times, once for each treatment type, i.e. 6 games are played in total.

1.5 Experimental Results

This section will present the results from the experiment following the order in which the model was presented. Firstly, I will discuss the results for the second period offers. I will investigate the effect of being informed in the second round and, using the exogenous measures of 'bad' obtained from the tests of fairness, I will present results which demonstrate that these types of middlemen do actually make lower offers in the second round. Secondly, I will present the results for the farmer's decision to switch and show that they are consistent with the predictions of the model. Finally, I will discuss the results for the first period offers which show that farmers receive higher offers when they are informed but that the magnitude of this effect varies with the cost of switching. I will also present results which demonstrate that bad types are forced to make higher offers in the first round when the farmer is informed.

1.5.1 Second period offers

1.5.1.1 Effect of information

The model predicts that the offer that the middleman makes in the second period should not be affected by whether or not the farmer is informed. However, we can see from the results in Table 3 that even in the second round, the average offer that the farmer receives is around Rs.20 higher when he is informed about the market price. The most likely explanation for this result is that farmers are risk averse, which would mean that they would be willing to accept a lower offer rather than face the uncertainty of going to the market themselves.

1.5.1.2 Middleman characteristics

According to the assumptions of the model, the 'bad' type of middleman will make a lower offer in the second period. As mentioned earlier, we have a number of different measures of 'bad' type available to us, based on the results of the dictator game and test of interpersonal orientation. The different measures used are as follows: (i) classified as 'competitive' on the test of interpersonal orientation, (ii) classified as 'competitive' or 'individualistic' on the test of interpersonal orientation, (iii) gave less than Rs.15 in the dictator game, (iv) gave less then Rs.25

on the dictator game, and (v) classified as 'competitive' or gave less than Rs.15 on the dictator game. Table 4 presents results using these different measures. The variable 'bad' is a dummy equal to one if the middleman was classified as a 'bad' type according to the particular measure used.

The results of these regressions clearly show that certain types of middlemen make lower offers in the second round. The only measure of 'bad' type that does not make a significantly lower offer in the second round is the measure that includes those middlemen who were classified as 'individualistic' on the test of interpersonal orientation. For the other measures of the 'bad' type, these middlemen make offers that are Rs.17-38 lower than the other middlemen. These results demonstrate that differences in attitudes towards fairness do exist among actual middlemen and these differences translate into significantly lower offers for farmers.

1.5.2 Decision to switch

Table 5 presents results from the following regression:

$$\begin{aligned} S_{it} &= \alpha + \beta_1 \text{Informed}_t + \beta_2 \text{medium cost}_t + \beta_3 \text{high cost}_t \\ &\quad + \beta_4 \text{medium cost}_t * \text{Informed}_t + \beta_5 \text{high cost}_t * \text{Informed}_t \\ &\quad + \beta_6 \ln(\text{price})_t + \beta_7 \ln(\text{price})_t * \text{Informed}_t + \epsilon_{it} \end{aligned}$$

where S_{it} is a dummy equal to 1 if farmer i decided to switch in period t, Informed_t is a dummy equal to 1 if the farmers knew the market price in round t, medium cost_t is a dummy equal to one if the cost of switching in round t was Rs.40 and high cost_t is a dummy equal to 1 if the cost of switching in round t was equal to Rs.90.[13]

The results support the predictions of the model. The farmer is more likely to switch if he is uninformed about the price. If he is uninformed, he is less likely to switch as the cost of switching increases but since β_2 and β_4 are similar in magnitude and of opposite sign, as are β_3 and β_5, it seems that when the farmer is informed, he is equally likely to switch at any cost. If the farmer is informed about the price, then he is more likely to switch when the market price

[13]The offer was not included in the regression as it is endogenous to the switching decision.

is higher. The negative coefficient on ln(price) is most likely picking up the positive correlation between the offer and the price (since in this case the farmer does not observe the price, he only observes the offer), suggesting that the higher the offer, the less likely the farmer is to switch. These results suggest not only that different types of middlemen exist and make different offers, but also that the farmers are aware of this. If there were no differences in middlemen types then there would be no reason for the farmer to pay a cost to switch to a different middleman for the second period.

1.5.3 First period offer

1.5.3.1 Effect of information

Table 6 presents the results for the first period offer. A 'low cost' dummy equal to one when the cost of switching was Rs.10 is included. As can be seen from the results in the table, the benefit of information is higher in the low cost treatment, although there is still a benefit of information in the other treatments. As was shown in the previous table, the probability that the farmer switched was very similar when the cost of switching was Rs.40 and when it was Rs.90 which supports the idea that participants did not behave differently in these two treatments. It was found that there was no difference in the effect of information between the medium and high cost of switching treatments and these results are not reported. This result could be consistent with the model if the actual cut-off point for κ, above which we should see no effect of information, was less than Rs.40. The costs were chosen based on the assumption that the proportion of 'bad' middlemen in the population was equal to 50%. In reality, it was less than this and, depending on the measure of 'bad' that we use, could have been as low as 10%. This should actually increase the value of the highest cut-off for κ, however, rather than reduce it. The results from Table 3 could give us an indication of what else is going on. These results suggest that the difference between the offer made by the 'bad' type and the 'good' type is much lower than initially assumed. The highest estimate that we get for this difference is Rs.38.43. If this is the expected gain from being matched with a good type rather than a bad type, then we shouldn't expect to see any switching when the cost of switching is Rs.40 or above and the benefit of information should disappear at this point. As mentioned before, we still find a positive effect of information for the Rs.40 and Rs.90 treatments but the magnitude of this effect is similar to that found in the case of second round offers.

1.5.3.2 Middleman characteristics

Table 7 presents the results from the first round including the various measures of a 'bad' type. The results are comparable to those found for second round offers. Depending on the measure of 'bad' used, the results show that the 'bad' middlemen make offers that are Rs.13-48 lower than other middlemen.

1.5.3.3 Effect of information on the offers made by 'bad' types

According to the model, only some middlemen should use the farmer's lack of information to make lower offers in the first round. This means there should be a greater advantage to being informed when matched with one of these middlemen. Table 8 reports the results of regressions which include an interaction between 'bad' and 'informed' for three of the measures of 'bad' used in the previous table. The coefficient on bad*informed is positive and significant in the first column where the measure of 'bad' is whether or not the middleman was classified as 'competitive'. Column 2 shows that this result is robust to clustering the standard errors at the session level. Columns 3 and 4 present results from the same regression with a middleman classified as 'bad' if he gave Rs.15 or less on the dictator game. The coefficient on bad*informed is still positive in this case although it is not significantly different from zero. In the final two columns, the 'bad' dummy is equal to 1 if the middleman was classified as 'competitive' on the test of interpersonal orientation or if he gave less than Rs.15 on the dictator game. Once again, the coefficient on the interaction term is positive and significant.

The size of the coefficient on the 'bad' dummy in these regressions ranges from -40.97 to -66.98 and the coefficient on the interaction term ranges from 19.70 to 38.03. These results clearly demonstrate that 'bad' types make significantly lower offers in the first round when farmers are uninformed but they increase their offers when the farmer knows the exact value of the market price.

1.5.4 Summary of results

It is clear from the results of the experiment that actual middlemen differ in their attitudes towards fairness and this has relevance for the offers that they make to farmers. Farmers are better off with information in both rounds but there is an additional benefit of being informed in the first round if the cost of switching is

low. This is driven by the result that 'bad' middlemen will offer lower prices if the farmer is uninformed, but are forced to offer higher prices if the farmer is informed in order to prevent the farmer from switching away from him. These results are consistent with reports from farmers who state that dishonest middlemen can no longer take advantage of them when they have better information about market prices.

1.6 Implications

The results from the model and the experiment suggest that even when a farmer's options of who to trade with in a given period are constrained, informing farmers about market prices can lead to an increase in the offer that the farmer receives from the middleman. A full analysis of the general welfare effects of this increase in producer prices is beyond the scope of this paper. It is helpful, however, to briefly discuss the potential ways in which welfare could be affected by this change and the possible magnitude of these effects.

In the experiment, the average share of the surplus received by the farmer in the first round increased from 60% to 69% in the case where the cost of switching was Rs.40 or Rs.90 and to 74% when the cost of switching was Rs.10. We can see that even in the case where the farmer was uninformed, the share of the surplus that he received was quite high. This reflects the fact that most middlemen believed that it was right for the farmer to receive a higher share of the surplus because in general the farmer must also pay for the cost of production, and middlemen earn income from trading with many farmers so the total amount that they earn will be higher. This norm that farmers should receive a higher share of the surplus seemed to affect decisions made in the game, which supports the idea that the participants drew on their experiences from the real world when making choices in the experiment.

A potential concern about interpreting the results from this experiment is the likelihood that there was selection bias in the sample of participants. RML decided to organize sessions in the areas where they thought it would be easiest to recruit participants, which automatically introduces a bias. In addition, there were two sessions where, part way through, the middlemen decided that they did not want to participate in the experiment and they walked out of the session. It would not be difficult to imagine that the type of middleman who would be more willing to participate in a research project might also be the type of middleman

who would offer higher prices, which means that the sample in the experiment is probably not representative of the general population of middlemen in Gujarat. If it is true that the 'good' types are the ones that are more likely to participate in the experiment, however, then the bias created by this problem should work against finding an effect of information. This means that the results from the experiment should give us a lower bound on this effect.

The most direct effect of an increase in the farmer's share of the surplus is a simple transfer from middlemen to farmers. Even if there were no general welfare effects from this, this is still an important result since, in general, farmers are significantly poorer than middlemen. According to the World Development Report (2008), Agriculture for Development: "Of the developing world's 5.5 billion people, 3 billion live in rural areas, nearly half of humanity. Of these rural inhabitants an estimated 2.5 billion are in households involved in agriculture, and 1.5 billion are in smallholder households". Even a small increase in the income of these households could significantly improve their welfare.

In addition, however, an increase in farmers' income is likely to have more general welfare effects. It may lead to farmers being able to better manage risk and therefore start producing more valuable but riskier crops or it may allow them to save up in order to invest in better production technologies. This could lead to an increase in overall agricultural productivity, which could have significant effects on the economy.

If the average price that farmers receive increases, this may have an effect on their production decisions which in turn could have a positive impact on consumers. There are two ways in which production might change as a result of increased prices for farmers. The first is a direct increase in supply as a response to an increase in the price received. Farmers may decide to use inputs more intensively since the return from production is higher. Getting a precise estimate of the magnitude of this effect is difficult as good data on farm gate prices, cost of production and middlemen margins are hard to find. In what follows, however, I will present some back-of-the-envelope calculations to give an idea of the possible magnitude of the effect of improving access to information for farmers for two different crops in India. Table 2 presents data on the cost of production, wholesale prices and farm gate prices for rice and soya bean from 2004-05.[14]

A number of assumptions are made in order to calculate the potential change

[14]Data on cost and wholesale prices from indiastat.com; data on producer prices from FAOstat.

Table 1.2: Costs and prices for rice and soya bean in India, 2004-05 (Rs. per quintal)

	Cost of Production	Producer price	Wholesale Price
Paddy/Rice	530.94	898	1090
Soya bean	881.86	1010	1334

in price received as a result of better information. Firstly, the outside option of the farmer is not known so it is not possible to work out the surplus from trade. I will look instead at the total surplus from production which I assume is equal to the sum of the profits earned by the farmer and the trader. According to Acharya (2005), on average 20% of gross marketing margins go to the middleman as profit. I will therefore assume that the middleman's profit is 20% of the difference between the wholesale price and the price paid to the producer. In line with the results from the experiment, I will assume that the farmer's share of the surplus increases by 12 percent for soya bean. As the farmer's share of the surplus for rice is already 90%, it cannot increase by 12 percent, so I will assume that it increases by 7 percentage points.

Using these assumptions, the implied increase in producer prices would lead to a 7.7% increase in income for rice farmers and a 12% increase in income for soya bean farmers. Using supply elasticities estimated in previous studies,[15] this suggests that this increase in prices could lead to an increase in the amount of rice produced of between 423,000 and 619,000 tons and an increase in soya bean production of between 30,000 and 50,000 tons.

The second effect of an increase in producer prices could come through the composition of crops that farmers choose to produce, as suggested by Jensen (2010). Since having access to price information should lead to a greater increase in the prices received for crops where the level of competition is lower (as long as we are above the level where there is no effect), this could lead to farmers switching to producing more of these crops once they are informed. Since these were the crops for which the greatest distortions existed prior to farmers becoming informed, this should improve efficiency. Without detailed data on demand and supply, however, it is not possible to say how these efficiency gains will be distributed between producers and consumers.

The results presented in this paper have important policy implications. If we want to increase the prices that farmers receive from middlemen because we

[15] Kumar et al. (2010); Mythili (2006).

believe that middlemen have too much market power, then we have a couple of options. Firstly, we could try and intervene directly in the market to reduce their power. This has been tried before and has led to the setting up of agricultural marketing boards, minimum price supports and the fair trade movement. There are a number of reasons why we might not like this option. First of all, it might be extremely costly. Secondly, we might create distortions that are as bad or worse than the ones we are trying to fix. Finally, we might just end up transferring market power from one group to another (such as the agricultural marketing boards) and not having any effect on the prices that farmers receive. A second option for achieving the goal of higher prices for farmers could be to provide them with information about market prices. This might be a preferable option as it still allows the market to do the work, it just makes sure that the agents in the market have the best information possible to help them make decisions.

1.7 Conclusion

This paper presented a theoretical model outlining an important channel through which better access to market information could increase the prices that farmers receive from middlemen. The model introduced the idea of different types of middlemen and demonstrated how price information constrains the ability of bad types to offer lower prices to farmers and forces them instead to behave like good types. The model also predicts that the relationship between the benefit of information to the farmer and the degree of competition in the market will be non-monotonic. This could explain why the results from empirical studies investigating the impact of information on producer prices have been mixed.

The paper provided empirical support for the predictions of the model from a framed field experiment carried out with actual farmers and middlemen in India. The results from the experiment demonstrate that attitudes towards fairness do vary among actual middlemen. By obtaining an exogenous measure of the middlemen's attitudes towards fairness it was possible to show that middlemen who cared less about fairness also made lower offers to farmers in the second round. Providing farmers with information about prices was able to counteract this effect in the first round as it forced the bad middlemen to make higher offers, demonstrating that this is an important channel through which information could benefit farmers. In addition, the results from the experiment showed that the benefit of information varied with the cost of switching to a different middleman.

In general, the literature has tended to either view middlemen as purely exploitative or as fulfilling a necessary role in the market. The results in this paper suggest that we should take a more nuanced view and allow not just for the possibility that the truth lies somewhere in between but also that different types of middlemen may exist in the same market and some may be more exploitative than others. It is important to bear this in mind when carrying out empirical studies.

In the model presented in this paper, I have assumed that the cost of switching to a new middleman is exogenous. A potentially interesting avenue for future research could be to investigate how the competitive environment itself could be affected by information in the longer-term. The source of heterogeneity that I have focused on in this paper is attitudes towards fairness but there are many other possible ways in which middlemen could differ. In the model presented here, bad types are not pushed out of the market but instead are forced to behave like good types. If the difference between middlemen types comes through differences in costs, then efficiency could be improved if the high cost types were forced out of the market. The model presented in this paper could easily be extended to allow for this effect and to investigate how effective price information could be at changing the composition of middleman types in the market.

The focus of this paper has been on middlemen in agricultural markets in developing countries. The idea of competition and information acting as substitutes could be relevant to any number of situations, however.[16] I believe that it is applicable to any situation where one agent is tied in to a relationship with a particular trading partner for some period of time, some trading partners may be preferable to others and there is a cost to switching to a different partner, e.g. telephone provider, bank etc.

The agricultural sector is hugely important in developing countries and is a source of livelihoods for approximately 86 percent of rural people.[17] Improving efficiency in agricultural markets could have a major impact on the welfare of the poor. The structure of the middleman market in this sector is extremely complicated and much research remains to be done. The results from this paper are encouraging, however, as they highlight one important channel through which providing farmers with price information could help to counteract the market

[16] Although it looks at a very different context, the model in this paper is similar in spirit to that presented in Besley and Smart (2007) which looks at the role of fiscal restraints on politicians in a model with both moral hazard and adverse selection.

[17] World Development Report, 2008.

power of intermediaries.

Table 3: Second period offer

VARIABLES	(1) offer	(2) offer
Price	0.673***	0.673***
	(0.0262)	(0.0321)
Informed	20.04***	20.04***
	(3.367)	(5.437)
Constant	19.99	19.99
	(24.71)	(17.00)
Observations	942	942
R-squared	0.793	0.793
Clustered SE	No	Yes

Notes:

(1) Middlemen fixed effects are included.

(2) Standard errors in parentheses.

(3) When clustered, standard errors are clustered at the session level.

(4) *** p<0.01, ** p<0.05, * p<0.1

(5) Informed is a dummy equal to 1 if the farmer knows the market price.

Table 4: Second period offer with bad type

VARIABLE	(1) offer	(2) offer	(3) offer	(4) offer	(5) offer
Price	0.674***	0.672***	0.672***	0.672***	0.675***
	(0.0382)	(0.0386)	(0.0384)	(0.0384)	(0.0380)
Informed	17.45***	17.40***	17.50***	17.33***	17.42***
	(4.902)	(4.945)	(4.921)	(4.922)	(4.869)
Bad	-38.43***	-1.827	-23.83***	-17.17***	-36.14***
	(9.488)	(5.592)	(7.800)	(5.685)	(6.658)
Constant	53.71**	53.31**	52.78**	52.87**	52.96**
	(21.34)	(21.55)	(21.42)	(21.43)	(21.20)
Observatic	942	942	942	942	942
R-squared	0.469	0.459	0.465	0.464	0.476

Notes:

(1) Standard errors in parentheses.

(2) *** p<0.01, ** p<0.05, * p<0.1

(3) Session fixed effects included in all columns

(4) Bad is a dummy equal to 1 if the middleman is classified as a 'bad' type.

The classification in each column is as follows: Column 1: 'bad' if 'competitive' on test of interpersonal orientation; Column 2; 'bad' if classified as 'individualistic' or 'competitive'; Column 3: 'bad' if gave less than Rs.15 on the dictator game; Column 4: 'bad' if gave less than Rs.25 on the dictator game; Column 5: 'bad' if classified as 'competitive' or gave less than Rs.15 on the dictator game.

Table 5: Decision to switch

VARIABLES	(1) switch	(2) switch
Informed	-2.178**	-2.178*
	(0.926)	(1.234)
medium cost	-0.108***	-0.108**
	(0.0341)	(0.0387)
high cost	-0.144***	-0.144***
	(0.0344)	(0.0453)
medium cost*informed	0.103**	0.103*
	(0.0487)	(0.0526)
high cost*informed	0.113**	0.113*
	(0.0485)	(0.0621)
ln(price)	-0.262**	-0.262*
	(0.107)	(0.132)
ln(price)*informed	0.344**	0.344
	(0.151)	(0.201)
Constant	1.689**	1.689*
	(0.666)	(0.821)
Observations	942	942
R-squared	0.232	0.232
Clustered SE	No	Yes

Notes:

(1) Farmer fixed effects are included.

(2) Standard errors in parentheses.

(3) When clustered, standard errors are clustered at the session level.

(4) *** p<0.01, ** p<0.05, * p<0.1.

(5) medium cost is a dummy equal to 1 if the cost of switching is Rs. 40.

(6) high cost is a dummy equal to 1 if the cost of switching is Rs. 90.

Table 6: First period offer

VARIABLES	(1) offer	(2) offer
Price	0.761***	0.761***
	(0.0294)	(0.0348)
Informed	23.37***	23.37**
	(4.423)	(8.413)
low cost	3.304	3.304
	(5.421)	(7.169)
low cost*informed	13.50*	13.50*
	(7.684)	(6.836)
Constant	-25.70	-25.70
	(25.73)	(14.67)
Observations	942	942
R-squared	0.736	0.736
Clustered SE	No	Yes

Notes:

(1) Middlemen fixed effects are included.

(2) Standard errors in parentheses.

(3) When clustered, standard errors are clustered at the session level.

(4) *** p<0.01, ** p<0.05, * p<0.1.

Table 7: First period offer with bad type

VARIABLES	(1) offer	(2) offer	(3) offer	(4) offer	(5) offer
Price	0.760***	0.760***	0.760***	0.760***	0.760***
	(0.0405)	(0.0410)	(0.0407)	(0.0409)	(0.0402)
Informed	23.36***	23.36***	23.36***	23.36***	23.36***
	(6.084)	(6.161)	(6.114)	(6.148)	(6.047)
low cost	3.298	3.298	3.298	3.298	3.298
	(7.459)	(7.555)	(7.497)	(7.538)	(7.414)
low cost*informed	13.49	13.49	13.49	13.49	13.49
	(10.58)	(10.71)	(10.63)	(10.69)	(10.51)
bad	-47.96***	-5.716	-31.13***	-13.09**	-40.74***
	(9.650)	(5.725)	(7.943)	(5.878)	(6.755)
Constant	-9.857	-14.26	-16.71	-16.71	-10.89
	(22.05)	(22.42)	(22.11)	(22.24)	(21.89)
Observations	942	942	942	942	942
R-squared	0.410	0.395	0.404	0.397	0.417

Notes:

(1) Standard errors in parentheses.

(2) *** p<0.01, ** p<0.05, * p<0.1.

(3) Session fixed effects included in all columns.

(4) bad is a dummy equal to 1 if the middleman is classified as a 'bad' type.

The classification in each column is as follows: Column 1: 'bad' if 'competitive' on test of interpersonal orientation; Column 2: 'bad' if 'competitive' or 'individualistic'; Column 3: 'bad' if gave less than Rs.15 on the dictator game; Column 4: 'bad' if gave less than Rs.25 on the dictator game; Column 5: 'bad' if 'competitive' or 'gave less than Rs.15 on the dictator game.

Table 8: First period offer with bad type and informed interaction.

VARIABLES	(1) offer	(2) offer	(3) offer	(4) offer	(5) offer	(6) offer
Price	0.761***	0.761***	0.765***	0.765***	0.766***	0.766***
	(0.0404)	(0.0315)	(0.0408)	(0.0330)	(0.0402)	(0.0321)
Informed	20.45***	20.45**	20.73***	20.73**	18.30***	18.30**
	(6.239)	(7.777)	(6.420)	(8.339)	(6.476)	(8.429)
low cost	3.291	3.291	3.253	3.253	3.245	3.245
	(7.447)	(6.602)	(7.493)	(6.610)	(7.399)	(6.624)
low cost*informed	13.51	13.51*	13.61	13.61**	13.63	13.63**
	(10.56)	(6.300)	(10.63)	(6.325)	(10.49)	(6.336)
bad	-66.98***	-66.98***	-40.97***	-40.97***	-54.45***	-54.45***
	(13.41)	(16.62)	(10.83)	(9.488)	(9.271)	(11.66)
bad*informed	38.03**	38.03**	19.70	19.70	27.40**	27.40***
	(18.67)	(16.61)	(14.72)	(13.74)	(12.73)	(9.044)
Constant	-8.762	-8.762	-17.67	-17.67	-11.09	-11.09
	(22.02)	(15.52)	(22.12)	(14.77)	(21.85)	(15.09)
Observations	942	942	942	942	942	942
R-squared	0.413	0.413	0.405	0.405	0.420	0.420
Clustered SE	No	Yes	No	Yes	No	Yes

Notes:

(1) Standard errors in parentheses.

(2) *** p<0.01, ** p<0.05, * p<0.1.

(3) Session fixed effects included in all columns.

(4) bad is a dummy equal to 1 if the middleman is classified as a 'bad' type.

The classification in each column is as follows: Columns 1 and 2: 'bad' if 'competitive' on test of interpersonal orientation; Column 3 and 4: 'bad' if gave less than Rs. 15 on the dictator game; Column 5 and 6: 'bad' if 'competitive' or gave less than Rs. 15 on the dictator game.

Appendix

Farmer's beliefs and strategy

It is not possible to have an equilibrium where, when the farmer receives an offer of x_L, his belief that the middleman is a bad type is lower than his prior belief. If this were the case, then he would never switch when he received a low offer, which means that it would always be optimal for the strategic middleman to make a low offer, which means that the farmer's belief that the middleman is more likely to be good when he receives a low offer could not be correct. Let γ_H denote the probability that B offers x_L when $p = p_H$ and γ_L denote the probability that B offers x_L when $p = p_L$. The farmer's posterior beliefs for each x observed in equilibrium will be:

$$\mu_B = 1$$

$$\mu_H = \frac{q[\lambda(1-\gamma_H) + (1-\lambda)(1-\gamma_L)]}{q[\lambda(1-\gamma_H) + (1-\lambda)(1-\gamma_L)] + \lambda(1-q)} \in [0, q]$$

$$\mu_L = \frac{q[\lambda\gamma_H + (1-\lambda)\gamma_L]}{q[\lambda\gamma_H + (1-\lambda)\gamma_L] + (1-\lambda)(1-q)} \in [q, \frac{q}{q + (1-q)(1-\lambda)}]$$

Let σ_x denote the probability that the farmer continues to trade with the same middleman in the second period, given the middleman's offer in the first period. If the farmer receives an offer of x_B, then his optimal strategy will depend on the value of κ.

$$\text{If } \kappa > (1-q)\tfrac{1}{2}\tau, \text{ then } \sigma_B^* = 1$$

$$\text{If } \kappa = (1-q)\tfrac{1}{2}\tau, \text{ then } \sigma_B^* \in [0, 1]$$

$$\text{If } \kappa < (1-q)\tfrac{1}{2}\tau, \text{ then } \sigma_B^* = 0$$

Likewise, if the farmer receives an offer of x_L, his optimal strategy will be as follows

$$\text{If } \kappa > (\mu_L - q)\tfrac{1}{2}\tau, \text{ then } \sigma_L^* = 1$$

$$\text{If } \kappa = (\mu_L - q)\tfrac{1}{2}\tau, \text{ then } \sigma_L^* \in [0, 1]$$

$$\text{If } \kappa < (\mu_L - q)\tfrac{1}{2}\tau, \text{ then } \sigma_L^* = 0$$

Finally, since $\mu_H < q$, $\sigma_H^* = 1$, regardless of the value of κ.

Proof of Proposition 2:

Proposition 2: *For an intermediate level of competition, i.e.* $(1-q)\frac{1}{2}\tau > \kappa > \frac{\lambda q(1-q)}{q+(1-q)(1-\lambda)}\frac{1}{2}\tau$*, the bad type of middleman will need to disguise his type or else the farmer will switch to a new trading partner for the second period. For this level of competition, the expected price that the farmer receives in the first period will be higher with price information.*

Proof: (i) If the middleman makes an offer of x_B the farmer will know that the middleman's type is B with certainty. If $\kappa < (1-q)\frac{1}{2}\tau$, the farmer will switch to a new middleman with probability 1. Suppose $p_1 = p_H$. If the middleman chooses to offer x_B, his payoff will be:

$$p_H - \lambda p_H - (1-\lambda)p_L + \tau$$

if he offers x_H, his expected payoff will be:

$$p_H - p_H + \frac{1}{2}\tau + \tau$$

As long as $\tau > 2(1-\lambda)(p_H - p_L)$, the middleman will always prefer to offer x_H if offering x_B will cause the farmer to switch with certainty. I will assume that this condition holds[18]. If it is not optimal for him to offer x_B when $p = p_H$ then it will not be optimal for him to offer x_B when $p = p_L$.

(ii) If $\kappa > \frac{\lambda q(1-q)}{q+(1-q)(1-\lambda)}\frac{1}{2}\tau$, then the cost of switching is high enough that even if the farmer knows that the bad type always offers x_L, he still will not switch when he receives an offer of x_L as the probability that he is matched with a good type (but the market price is low) is high enough that it is not worth paying the cost to switch. Since the farmer will never switch when he receives an offer of x_L, it is not optimal for the middleman to ever make a higher offer.

Proof of Proposition 3

Proposition 3: *As the level of competition in the market increases, the benefit to the farmer of being informed about the market price decreases.*

[18] I have already assumed that $\tau > 2\lambda(p_H - p_L)$. As long as the distribution of p is fairly even, then it is not unreasonable to assume that this condition also holds

Proof: If the middleman offers x_H, his expected return will be:

$$p - p_H + \frac{1}{2}\tau + \tau$$

If he offers x_L, his expected return will be:

$$p - p_L + \frac{1}{2}\tau + \sigma_L^*\tau$$

He will, therefore, be indifferent between offering x_H and x_L if $\sigma_L = \frac{\tau-(p_H-p_L)}{\tau}$.

Assume $\gamma_L = 1$.[19] The farmer will be indifferent between switching to a new middleman and staying with the same one if:

$$\kappa = \left(\frac{q[\lambda\gamma_H + (1-\lambda)]}{q[\lambda\gamma_H + (1-\lambda)] + (1-\lambda)(1-q)} - q\right)\frac{1}{2}\tau$$

which implies

$$\gamma_H^* = \frac{(1-\lambda)\kappa}{\lambda[\frac{1}{2}q(1-q)\tau - q\kappa]}$$

which is increasing in κ.

Model with three prices

It is reasonably straightforward to extend the model to allow for the price to take three values instead of two: p_H, p_M, and p_L. Now, there will be four possible prices that the type B middleman could offer in equilibrium:

$$x_H = p_H - \frac{1}{2}\tau$$

$$x_M = p_M - \frac{1}{2}\tau$$

$$x_L = p_L - \frac{1}{2}\tau$$

$$x_B = E(p) - \tau$$

[19] This equilibrium is not unique. As the condition that makes the middleman indifferent between offering x_H or x_L is independent of the value of the market price, it will hold for both $p = p_H$ and $p = p_L$. It is not necessary that $\gamma_L = 1$ but the following must hold:

$$\lambda\gamma_L + (1-\lambda)\gamma_H = \frac{(1-\lambda)[(1-q)\kappa + q(1-q)\frac{1}{2}\tau]}{q(1-q)\frac{1}{2}\tau - q\kappa}$$

The expected return for the farmer in the first round, however, is the same for all of the possible equilibria.

For each offer made, the condition for whether or not the farmer decides to switch is the same as before:

$$\text{If } \kappa > (\mu_x - q)\,\tfrac{1}{2}\tau, \text{then } \sigma_x^* = 1$$

$$\text{If } \kappa = (\mu_x - q)\,\tfrac{1}{2}\tau, \text{ then } \sigma_x^* \in [0,1]$$

$$\text{If } \kappa < (\mu_x - q)\,\tfrac{1}{2}\tau, \text{then } \sigma_x^* = 0$$

For simplicity, assume that it is equally likely for the market price to take any of the three values. Let γ_i denote the probability that type B offers x_L, given p_i, and let α_i denote the probability that type B offers x_M, given p_i, $i = H, M, L$.

Proposition 1*: *If the level of competition in the market is low, i.e.* $\kappa > (1-q)\,\frac{1}{2}\tau$*, the bad type does not need to conceal his type. In this situation, improving the farmer's access to price information will not increase the expected price that he receives in the first period.*

As in the case with two prices, if $\kappa > (1-q)\,\frac{1}{2}\tau$, the farmer will never switch and the middleman will always offer x_B.

Proposition 2*: *For an intermediate level of competition, i.e.* $(1-q)\,\frac{1}{2}\tau > \kappa > \frac{q(1-q)\frac{2}{3}}{q+(1-q)\frac{1}{3}}\frac{1}{2}\tau$*, the bad type of middleman will need to disguise his type or else the farmer will switch to a new trading partner for the second period. For this level of competition, the expected price that the farmer receives in the first period will be higher with price information.*

If $(1-q)\,\frac{1}{2}\tau > \kappa > \frac{q(1-q)\frac{2}{3}}{q+(1-q)\frac{1}{3}}\frac{1}{2}\tau$, the middleman will always offer x_L and

$$\sigma_B^* = 0$$

$$\sigma_L^* = 1$$

$$\sigma_M^* = 1$$

$$\sigma_H^* = 1$$

Proposition 3*: *As the level of competition in the market increases, the benefit to the farmer of being informed about the market price decreases.*

Suppose $\frac{q(1-q)\frac{2}{3}}{q+(1-q)\frac{1}{3}}\frac{1}{2}\tau > \kappa > \frac{q(1-q)}{2-q}\frac{1}{2}\tau$.[20] For this value of κ, it is no longer possible for the bad type to always offer x_L, as if he did, then $(\mu_L - q)\frac{1}{2}\tau > \kappa$, and the farmer would switch when he received an offer of x_L. Assume $\gamma_L = 1$.[21] In order for the middleman to be indifferent between offering x_L and x_M, the farmer must sometimes switch when he receives the lower offer. We must have $(\mu_L - q)\frac{1}{2}\tau = \kappa$, which implies:

$$\gamma_M^* + \gamma_H^* = \frac{\kappa}{q(1-q)\frac{1}{2}\tau - q\kappa}$$

As long as $\kappa > \frac{q(1-q)}{2-q}\frac{1}{2}\tau$, it is not optimal for the farmer to switch when he receives an offer of x_M, even if the middleman never offers x_H. Therefore, the following will be an equilibrium:

$$\alpha_M^* = 1 - \gamma_M^*$$

$$\alpha_H^* = 1 - \gamma_H^*$$

$$\sigma_B^* = 0$$

$$\sigma_L^* = \frac{\tau - (p_M - p_L)}{\tau}$$

$$\sigma_M^* = 1$$

$$\sigma_H^* = 1$$

As κ decreases, $\gamma_M^* + \gamma_H^*$ must fall so that the farmer remains indifferent between switching or staying when he receives an offer of x_L. Since $\alpha_M^* + \alpha_H^* = 2 - (\gamma_M^* + \gamma_H^*)$, $\alpha_M^* + \alpha_H^*$ must rise. This will happen up until the point where

$$\kappa = (\mu_M - q)\frac{1}{2}\tau$$

$\mu_M = \frac{q(\alpha_M^* + \alpha_H^*)}{q(\alpha_M^* + \alpha_H^*) + (1-q)} = \frac{q(1-q)}{2-q}\frac{1}{2}\tau$, since $\gamma_M^* + \gamma_H^* = \frac{\kappa}{q(1-q)\frac{1}{2}\tau - q\kappa}$must still hold. At this point, the middleman must start occasionally offering x_H in order for the farmer to remain indifferent to switching when he receives an offer of x_M. We

[20] This is possible as long as $q < \frac{3}{4}$

[21] As in the case with two prices, this is not the only equilibrium as the middleman is indifferent between offering x_L and x_M regardless of the value of the market price. As the expected payoff to the farmer is the same for all of the equilibria, however, I will focus on this one for simplicity.

then have

$$\gamma_M^* + \gamma_H^* = \frac{\kappa}{q(1-q)\frac{1}{2}\tau - q\kappa}$$

$$\alpha_M^* + \alpha_H^* = \frac{(1-q)\kappa - q(1-q)\frac{1}{2}\tau}{q(1-q)\frac{1}{2}\tau - q\kappa}$$

$$\sigma_B^* = 0$$

$$\sigma_L^* = \frac{\tau - (p_H - p_L)}{\tau}$$

$$\sigma_M^* = \frac{\tau - (p_M - p_L)}{\tau}$$

$$\sigma_H^* = 1$$

As κ decreases, $\gamma_M^* + \gamma_H^*$ and $\alpha_M^* + \alpha_H^*$ must also decrease, meaning that the benefit to the farmer of being informed also decreases.

An Instrument to Measure Interpersonal Orientation

In this task we ask you to imagine that you have been randomly paired with another person, whom we will refer to simply as the "Other." This other person is someone you do not know and that you will not knowingly meet in the future. Both you and the "Other" person will be making choices by circling either the letter A, B, or C. Your own choices will produce points for both yourself and the "Other" person. Likewise, the other's choice will produce points for him/her and for you. Every point has value: the more points you receive, the better for you, and the more points the "Other" receives, the better for him/her.

Here's an example of how this task works:

	A	B	C
You get	500	500	550
Other gets	100	500	300

In this example, if you choose A you would receive 500 points and the other would receive 100 points; if you chose B, you would receive 500 points and the other 500; and if you chose C, you would receive 550 points and the other 300. So, you see that your choice influences both the number of points you receive and the number of points the other receives. Before you begin making choices, please keep in mind that there are no right or wrong answers -- choose the option that you, for whatever reason, prefer most. Also, remember that the points have value: the more of them you accumulate the better for you. Likewise, from the "other's" point of view, the more points s/he accumulates, the better for him/her.

1.8 Chapter 1 References

1. Acharya, S.S. (2005), "Agriculture marketing and rural credit: Status, Issues and Reform agenda, Area, Production and Yield of Principal Crops in India", Directorate of Economics and Statistics, Ministry of Agriculture.

2. Aker, Jenny and Marcel Fafchamps, (2011), "How Does Mobile Phone Coverage Affect Farm-Gate Prices? Evidence from West Africa. Unpublished mimeo.

3. Bauer, P.T. and B.S. Yamey (1968), "Markets, Market Control and Marketing Reform", Garden City Press Ltd.

4. Bayes, Abdul, Joachim von Braun and Rasheda Akhter (1999), "Village Pay Phones and Poverty Reduction: Insights from a Grameen Bank Initiative in Bangladesh," Center for Development Research (ZEF), Universitat Bonn, Discussion Papers on Development Policy No. 8.

5. Besley, Timothy and Michael Smart (2007), "Fiscal restraints and voter welfare," *Journal of Public Economics*, 91, 755-773.

6. Biglaiser, Gary (1993), "Middlemen as Experts," *The RAND Journal of Economics*, 24 (2), 212-223.

7. Biglaiser, Gary and James W. Friedman (1994), "Middlemen as guarantors of quality," *International Journal of Industrial Organization*, 12 (4), 509-31.

8. Blouin, Max R., and Serrano, Roberto (2001), "A Decentralized Market with Common Values Uncertainty: Non-Steady States," *Review of Economic Studies*, 68, 323-346.

9. Boles, Terry, Rachel Croson and J. Keith Murnighan (2000), "Deception and Retribution in Repeated Ultimatum Bargaining," *Organizational Behavior and Human Decision Processes*, 83 (2), 235-259.

10. Carpenter, Jeffrey (2003), "Is fairness used instrumentally? Evidence from sequential bargaining," *Journal of Economic Psychology*, 24, 467-489.

11. Cramton, Peter (1984), "Bargaining with Incomplete Information: An Infinite-Horizon Model with Two-Sided Uncertainty," *Review of Economic Studies*,

51, 579-593.

12. Croson, Rachel, Terry Boles and J. Keith Murnighan (2003) "Cheap talk in bargaining experiments: lying and threats in ultimatum games," *Journal of Economic Behavior and Organization*, 51, 143-159.

13. van Djik, Eric, David de Cremer and Michel J.J. Handgraaf, (2002), "Social value orientations and the strategic use of fairness in ultimatum bargaining," *Journal of Experimental Social Psychology*, 40 (6), 697-707.

14. Eggleston, Karen, Robert Jensen and Richard Zeckhauser, (2002) "Information and Communication Technologies, Markets and Economic Development," *Global Information Technology Report*, 62-76.

15. Fafchamps, Marcel, Ruth Vargas Hill (2008), "Price Transmission and Trader Entry in Domestic Commodity Markets," *Economic Development and Cultural Change*, 56 (4), 729-66.

16. Fafchamps, Marcel and Bart Minten, (2011), "Impact of SMS-Based Agricultural Information on Indian Farmers," *World Bank Economic Review* (forthcoming).

17. Ferris, Shaun (2004), "FOODNET: Information is Changing Things in the Marketplace", *ICT Update*, Issue 18, CTA, The Netherlands.

18. Fingleton, John (1997), "Competition Among Middlemen When Buyers and Sellers Can Trade Directly," *The Journal of Industrial Economics*, 45 (4), 405-427.

19. Fudenberg, Drew, David K. Levine and Jean Tirole (1985), "Infinite-Horizon Models of Bargaining with One- Sided Incomplete Information," in Alvin Roth (ed), Game Theoretic Models of Bargaining, Cambridge, England: Cambridge University Press.

20. Futch, Michael and Craig McIntosh (2009), "Tracking the Introduction of the Village Phone Product in Rwanda," *Information Technologies and International Development.*

21. Grossman, Sanford J. and Motty Perry (1986b), "Sequential Bargaining Under Asymmetric Information," *Journal of Economic Theory*, 39(1), 120-154.

22. Harrison, G. and John A. List (2004), "Field Experiments," *Journal of Economic Literature*, 42 (4), 1009-1055.

23. Hayami, Y., M. Kikuchi and E. B. Marciano (1999), "Middlemen and peasants in rice marketing in the Philippines," *Agricultural Economics*, 20 (2), 79-93.

24. Jensen, Robert (2007), "The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector," *Quarterly Journal of Economics*, 122 (3), 879-924.

25. Jensen, Robert (2010), "Information, Efficiency and Welfare in Agricultural Markets," *Agricultural Economics*.

26. Johri, Alok and John Leach (2002) Middlemen and the Allocation of Heterogeneous Goods," *International Economic Review*, 43 (2), 347-61.

27. Kumar, Praduman, P. Shinoj, S.S. Raju, Anjani Kumar, Karl M. Rich and Siwa Msangi (2010), "Factor Demand, Output Supply Elasticities and Supply Projections for Major Crops of India," *Agricultural Economics Research Review*, 23, 1-14.

28. Li, Yiting (1998), "Middlemen and private information," *Journal of Monetary Economics*, 42 (1), 131-59.

29. Masters, Adrian (2007) "Middlemen in Search Equilibrium," *International Economic Review*, 48 (1), 343-62.

30. Masters, Adrian (2008), "Unpleasant Middlemen," *Journal of Economic Behavior and Organization*, October 2008, 68 (1), 73-86.

31. Merel, Pierre R., Richard J. Sexton and Aya Suzuki (2009) "Optimal Investment in Transportation Infrastructure When Middlemen Have Market Power: A Developing-Country Analysis," *American Journal of Agricultural Economics*, 91 (2), 462-76.

32. Minten, Bart and Steven Kyle (1999), "The effect of distance and road quality on food collection, marketing margins, and traders' wages: evidence from the former Zaire", *Journal of Development Economics*, 60 (2), 467-95.

33. Mitra, Sandip and Abhirup Sarkar (2003), "Relative Profitability from Pro-

duction and Trade. A Study of Selected Potato Markets in West Bengal," *Economic and Political Weekly*, November, 4694-4699.

34. Molony, Thomas (2008), "Running Out of Credit: The Limitations of Mobile Phone Telephony in a Tanzanian Agricultural Marketing System," *Journal of Modern African Studies*, 46(4), p. 637-58.

35. Muto, Megumi and Takashi Yamano (2009), "The Impact of Mobile Phone Coverage Expansion on Market Participation: Panel Data Evidence from Uganda," *World Development*.

36. Mythili, G. (2006), "Supply Response of Indian Farmers: Pre and Post Reforms," Indira Gandhi Institute of Development Research, Mumbai.

37. Overa, Ragnhild (2006), "Networks, distance and trust: telecommunications development and changing trading practices in Ghana," *World Development*, 34 (7), 1301-15.

38. Pillutla, M. M., & Murnighan, J. K. (1995). Being fair or appearing fair: Strategic behavior in ultimatum bargaining. *Academy of Management Journal*, 38, 1408–1426.

39. Rubinstein, Ariel (1985), "A Bargaining Model with Incomplete Information about Time Preferences," *Econometrica*, 53, 1151-1172.

40. Rubinstein, Ariel and Asher Wollinsky (1985), "Equilibrium in a Market with Sequential Bargaining," *Econometrica,* 53, 1133-1150.

41. Rust, John and George Hall (2003), "Middlemen versus Market Makers," *Journal of Political Economy*, April 2003, 111 (2), 353-403.

42. Sen, Arijit (2000), "Multidimensional Bargaining under Asymmetric Information," *International Economic Review*, 41, (2), 425-50.

43. Sobel, Joel, and Ichiro Takahashi (1983), "A Multi State Model of Bargaining," *Review of Economic Studies*, 50, 411-426.

44. Spulber, Daniel F. (2002), "Market Microstructure and Incentives to Invest," *Journal of Political Economy*, 110 (2), 352-81.

45. Srivastava, Joydeep, Dipankar Chakravarti and Amnon Rapoport (2000),

"Price and Margin Negotiations in Marketing Channels: An Experimental Study of Sequential Bargaining Under One-sided Uncertainty and Opportunity Cost of Delay," *Marketing Science*, 19 (2), 163-84.

46. Svensson, Jakob and David Yanagizawa, (2009), "Getting Prices Right: the impact of the market information service in Uganda ," *Journal of the European Economic Association*, 7 (2-3), 435-45.

47. Van Raalte, Chris and Harry Webers (1998), "Spatial Competition with Intermediated Matching", *Journal of Economic Behavior & Organization*, 34, 477-488.

48. Vesala, Timo (2008), "Middlemen and the adverse selection problem," *Bulletin of Economic Research*, 60 (1), 1-11.

49. World Bank, World Development Report 2008: Agriculture for Development.

Chapter 2

Quality Observability and Vertical Integration in Supply Chains

2.1 Introduction

A low level of production of high-quality agricultural goods is a major problem for many developing countries. The World Development Report 2008, Agriculture for Development, highlighted the opportunities for farmers to increase their profits by supplying rapidly growing urban and export markets which demand goods of higher quality. In addition, the availability of better-quality food products which are more hygienic and higher in nutritional value could lead to improved health outcomes for consumers. This paper will investigate the relationship between the decision to produce high-quality goods and two important characteristics of the product: the degree of observability of quality and the level of intermediation in the supply chain.

Supply chains for agricultural goods in most developed countries are characterised by a high level of integration. Farmers generally sell directly to processors or through agricultural cooperatives. Supply chains in many developing countries, on the other hand, tend to involve a large number of intermediaries, such as collectors, middlemen or brokers, who perform a variety of functions. It is possible that this higher level of intermediation could lead to a lower level of production of high-quality goods, especially if each actor in the supply chain must exert effort in order to maintain the quality of the good.

Not all quality attributes are easily observable and in some cases it is necessary

to carry out tests in order to know whether or not a good is of high quality. A middleman may be unwilling to pay a farmer a high price for a good that may not be of high quality, especially if the effort of the farmer is also not observable and so a moral hazard problem exists. Moral hazard is not a problem in this situation if the quality of the good is perfectly observable as then the middleman can just pay the farmer a higher price when he successfully produces a high-quality good. However, if the quality of the good is not perfectly observable, in some cases the farmer may receive a high price even when he did not exert high effort and the good is of low quality. This means that if he is to exert effort, his incentive to produce high-quality goods must be increased by offering him a higher price for goods that appear to be of higher quality, thereby increasing the cost to the middleman. A middleman may also be unwilling to exert the necessary effort to maintain the quality of the good if he is not certain that it is of high quality. Vertical integration could overcome some of these problems.

This paper will present a model of a supply chain for a good involving two stages of production. Effort must be exerted at both stages if a high-quality good is to be produced. Effort is not observable and the quality of the good is not perfectly observable. The model predicts that there will be a range of values of the price difference between high-quality and low-quality goods for which production of high-quality goods will occur with vertical integration but will not occur if the tasks are carried out by separate agents. The range of price values for which this occurs will be decreasing as the level of observability of quality increases and will disappear as quality becomes perfectly observable. The paper will also present some case studies of supply chains for various products in a number of developing countries that have characteristics which are consistent with the predictions of the model.

Much of the existing literature related to quality focuses on the use of reputation to incentivise firms to produce goods of high quality. These papers describe models where consumers cannot immediately observe the quality of the good that they purchase but once they consume the good they learn the quality and they are able to punish firms who produce goods of lower quality than stated by refusing to buy from them in the future. Firms receive a price premium for producing high-quality goods.[1] Dana and Fong (2011) present a model which predicts that concern about loss of reputation can lead firms to produce higher-quality goods in oligopolistic markets but not monopolistic or competitive markets. Kranton (2003) argues that competition can eliminate the price premium for reputation

[1]Shapiro (1983); Allen (1984); Riordan (1986); Gale and Rosenthal (1994).

needed to induce production of high quality. Esfahani (1989) argues that it is harder for reputation to sustain a high-quality equilibrium in developing countries because of the high rate of seller turnover, high idiosyncratic cost fluctuations and low entry costs.

Fafchamps, Vargas-Hill and Minten (2007) also suggest that reputation and repeated interaction cannot overcome the problem of poor quality in developing countries because producers are very far removed from consumers because of the large number of actors in the supply chain. They investigate the extent to which information about crop attributes is conveyed along the supply chain by examining evidence from supply chains for non-staple food crops in India. They find that while price premiums exist for observable product characteristics, no information is circulated about unobservable characteristics. As a result, growers have no incentive to invest in unobservable quality characteristics. This paper will abstract away from the question of reputation and focus on a situation where it is not possible for repeated purchases to act as an incentive for producing high-quality goods. It will demonstrate how, even in the absence of reputational concerns, vertical integration could lead to increased production of higher-quality goods.

A number of other papers have also discussed the issue of low-quality agricultural goods in developing countries. Robinson and Kolavalli (2010) describe the problems involved in maintaining quality in tomato markets in Ghana. They state that sales are based on quantity rather than quality. Quality can be difficult to assess as farmers often put poor-quality tomatoes on the bottom of the crate and better-quality tomatoes on the top. Middlemen exacerbate this problem by stacking crates on top of each other thereby further reducing the quality of tomatoes at the bottom of the crate. Fafchamps and Gabre-Madhin discuss the problem of assessing quality in agricultural markets in Benin. They report that inspecting quality is challenging and time consuming and traders do not want to delegate this task to others. This increases their costs and limits their ability to expand their operations.

This paper adds to the literature by presenting a model where effort needs to be exerted at each stage in the production process in order to maintain quality. This set-up is similar in spirit to Kremer's O-Ring theory.[2] The model presented in this paper does not allow for heterogeneity in levels of skill, however. Instead, it investigates how the degree of observability of quality affects the decision of

[2]Kremer (1993).

agents later in the chain about whether or not to exert effort.

The rest of this paper is organised as follows. Section 2 presents the theoretical model. Characteristics of a number of supply chains which are consistent with the predictions of the model are presented in Section 3, and Section 4 concludes.

2.2 Model

2.2.1 Description of economic environment

I will describe the supply chain of a good which involves two stages of production. I will use the example of a farmer and middleman in this paper but this model could apply to a number of other situations. There are two possible quality levels that the good can have, high or low, $Q \in \{H, L\}$. The final market price for a high-quality good is p^H and the price for a low-quality good is p^L. The quality of the good is perfectly observable to the final purchaser (e.g. a large processing company who has the technology to test for quality) but it is not perfectly observable at the intermediate production stage. A higher level of effort is required at both stages of the production process in order to produce a good of high quality. This effort is costly. The timing of the production process is as follows:

1. The decision is made about whether or not to exert high effort in the first stage of production. The cost of this effort is c^F. If high effort is exerted, the probability that the good that is produced will be of high quality is γ. If low effort is exerted, the good will be of low quality with certainty.

2. A signal, $s \in \{H, L\}$, regarding the quality of the good is received. $s = Q$ with probability ρ, $1 \geq \rho > \frac{1}{2}$. ρ gives us a measure of the observability of quality. If ρ is close to $\frac{1}{2}$, then it is very difficult to observe quality. If $\rho = 1$, then quality is perfectly observable.

3. The decision is made about whether or not to exert high effort in the second stage of production in order to maintain the quality of the good. The cost of this effort is c^M. If effort is exerted at this stage, the quality of the good will be preserved with certainty. If effort is not exerted, the quality of the good will be low.

4. The quality of the good is perfectly observed in the final stage and p^H will be received for the good if $Q = H$ and p^L will be received if $Q = L$.

The following sections will present the predictions of the model both for the case where each stage of production is carried out by a separate agent and for the vertically integrated case where one agent carries out both tasks.

2.2.2 Separate agents

Suppose there are two agents, a farmer and a middleman. Both agents are assumed to be risk neutral. The farmer carries out the first stage of production and the middleman carries out the second stage. The middleman cannot observe the farmer's effort level and cannot perfectly observe the quality of the good. His payment to the farmer can therefore only be based on the signal of quality that he receives. The middleman must decide whether or not to offer the farmer a contract such that the farmer has an incentive to exert effort.

2.2.2.1 Farmer's problem

Suppose the farmer receives h from the middleman if $s = H$ and l if $s = L$. If the farmer exerts high effort, his expected payoff will be:

$$\gamma\left(\rho h + (1-\rho)\, l\right) + (1-\gamma)\left((1-\rho)\, h + \rho l\right) - c^F$$

If he does not exert high effort, his expected payoff will be:

$$(1-\rho)\, h + \rho l$$

The farmer will therefore exert effort if

$$h - l \geq \frac{c^F}{(2\rho - 1)\,\gamma}$$

I will assume that a limited liability constraint applies so that $l \geq 0$. This assumption is important but not unreasonable. It means that we assume that the middleman cannot force the farmer to pay him if he receives a low signal. It is reasonable to assume that the worst that the middleman could do to the farmer would be to refuse to purchase the good. The farmer must also be willing to participate in the contract. I will assume that the value of the farmer's outside

option is zero. The following condition must hold:

$$\gamma\left[\rho h + (1-\rho)\, l\right] + (1-\gamma)\left[(1-\rho)\, h + \rho l\right] - c^F \geq 0$$

Given the above constraints, from the point of view of the middleman, the optimal h and l which will induce the farmer to exert effort will be:

$$h^* = \frac{c^F}{(2\rho - 1)\,\gamma}$$

$$l^* = 0$$

2.2.2.2 Middleman's problem

The middleman has two decisions to make. He must decide whether or not to exert effort himself in the second stage and he must decide whether or not to induce the farmer to exert effort in the first stage. His decision about whether or not to induce the farmer to exert effort will depend on his own willingness to exert effort in the second stage.

Second Stage

The middleman will only exert effort in the second stage of production if he believes that effort was exerted in the first stage. If he has set $h \geq h^*$ in the first stage, then he will believe that the farmer exerted effort in the first stage with probability one. If he has set $h < h^*$ in the first stage, then he will believe that the farmer exerted effort in the first stage with probability zero.

In the second stage, a signal will be received about the quality of the good, which the middleman will use to form his beliefs about quality. If he believes that no effort was exerted in the first stage then he will believe that the good is of low quality with probability one, regardless of the signal. If he believes that effort was exerted in the first stage, then his beliefs about the quality of the good will be formed as follows:

$$\mu^H = Prob(Q = H \mid s = H) = \frac{\gamma\rho}{\gamma\rho + (1-\gamma)\,(1-\rho)}$$

$$\mu^L = Prob(Q = H \mid s = L) = \frac{\gamma(1-\rho)}{\gamma(1-\rho) + (1-\gamma)\rho}$$

The middleman will then decide whether or not to exert effort. Once he is in the second stage, the costs from the first stage are sunk, so his decision will only depend on his belief about the quality of the good, the cost of effort required to preserve the quality of the good, and the difference between the price for a good of high quality and that for a good of low quality. Let $\widetilde{p} = p^H - p^L$.

If the following condition holds, the middleman will exert effort in the second stage when he receives a signal that the good is of high quality:

$$\widetilde{p} \geq c^M \left(\frac{\gamma\rho + (1-\gamma)(1-\rho)}{\gamma\rho} \right). \tag{2.1}$$

He will exert effort in the final stage when he receives a signal that the good is of low quality if the following condition holds:

$$\widetilde{p} \geq c^M \left(\frac{\gamma(1-\rho) + (1-\gamma)\rho}{\gamma(1-\rho)} \right). \tag{2.2}$$

The second condition is stronger so if the middleman is willing to exert effort when he receives a low signal, he will also be willing to exert effort when he receives a high signal.

First stage

Given that the middleman knows the choices that he will make in the second stage if effort is exerted by the farmer, he must use this to decide whether or not to induce the farmer to exert high effort in the first stage.

Proposition 1: *If* $c^M \left(\frac{\gamma(1-\rho)+(1-\gamma)\rho}{\gamma(1-\rho)} \right) \geq \widetilde{p} \geq c^M \left(\frac{\gamma\rho+(1-\gamma)(1-\rho)}{\gamma\rho} \right)$*, the middleman will induce the farmer to exert high effort if the following condition holds:*

$$\widetilde{p} \geq \frac{\gamma\rho + (1-\gamma)(1-\rho)}{\gamma\rho} \left(\frac{c^F}{(2\rho-1)\gamma} + c^M \right) \tag{2.3}$$

Otherwise, only low-quality goods will be produced.

For these parameter values, the middleman is only willing to exert effort in the final stage if he receives a signal that the good is of high quality. Given this, the

probability of successfully producing a good of high quality is $\gamma\rho$. He will only be willing to induce the farmer to exert high effort if his expected gain is greater than the expected cost that he will have to pay. The middleman will only pay h and c^M if a high signal is received.

Proposition 2: *If* $\widetilde{p} \geq c^M \left(\frac{\gamma(1-\rho)+(1-\gamma)\rho}{\gamma(1-\rho)}\right)$, *the middleman will induce the farmer to exert high effort if the following condition holds:*

$$\widetilde{p} \geq \frac{\gamma\rho + (1-\gamma)(1-\rho)}{\gamma}\left(\frac{c^F}{(2\rho-1)\gamma}\right) + \frac{c^M}{\gamma} \tag{2.4}$$

Otherwise, only low-quality goods will be produced.

In this case, $\widetilde{p}$ is large enough relative to c^M that the middleman will always be willing to exert effort in the second stage if effort has been exerted in the first stage, regardless of the value of the signal that he receives. Given this, the probability of producing a good of high quality is now γ. In this case, however, the middleman will always pay c^M.

The middleman's decision regarding the level of effort to exert will therefore depend on the relative parameter values. The possible effort levels that the middleman could choose are as follows:

1. Full effort: the middleman induces the farmer to exert high effort and always exerts effort himself.

2. Partial effort: the middleman induces the farmer to exert high effort and exerts effort himself when he receives a high signal.

3. No effort: the middleman does not induce the farmer to exert high effort and the farmer always produces low-quality goods.

Proposition 3: *Suppose* $\frac{c^M}{c^F} \geq \frac{\gamma\rho+(1-\gamma)(1-\rho)}{(2\rho-1)\gamma}\left(\frac{1-\rho}{(2\rho-1)(1-\gamma)}\right)$. *If* $\widetilde{p}$ *is such that Constraint 2.3 is not satisfied, no effort will be exerted. If* $\widetilde{p}$ *is such that Constraint 2.3 is satisfied but Constraint 2.2 is not satisfied, then partial effort will be exerted. If Constraint 2.2 is satisfied, then full effort will be exerted.*

If $\frac{c^M}{c^F} \geq \frac{\gamma\rho+(1-\gamma)(1-\rho)}{(2\rho-1)\gamma}\left(\frac{1-\rho}{(2\rho-1)(1-\gamma)}\right)$, then c^M is relatively more important than c^F. This means that the middleman will be willing to induce the farmer to exert

high effort at values of $\widetilde{p}$ which are lower than the value at which he himself would be willing to exert full effort. In this scenario,

$$c^M\left(\frac{\gamma\left(1-\rho\right)+\left(1-\gamma\right)\rho}{\gamma\left(1-\rho\right)}\right)>\frac{\gamma\rho+\left(1-\gamma\right)\left(1-\rho\right)}{\gamma}\left(\frac{c^F}{\left(2\rho-1\right)\gamma}\right)+\frac{c^M}{\gamma}$$

$$>\frac{\gamma\rho+\left(1-\gamma\right)\left(1-\rho\right)}{\gamma\rho}\left(\frac{c^F}{\left(2\rho-1\right)\gamma}+c^M\right)>c^M\left(\frac{\gamma\rho+\left(1-\gamma\right)\left(1-\rho\right)}{\gamma\rho}\right),$$

which means that Constraint 2.2 is the hardest constraint to satisfy. Once this has been satisfied, full effort will be exerted and the high quality good will be produced with probability γ.

Proposition 4: *Suppose* $\frac{c^M}{c^F}<\frac{\gamma\rho+(1-\gamma)(1-\rho)}{(2\rho-1)\gamma}\left(\frac{1-\rho}{(2\rho-1)(1-\gamma)}\right)$. *If Constraint 2.4 is not satisfied, no effort will be exerted. If Constraint 2.4 is satisfied, then full effort will be exerted.*

If $\frac{c^M}{c^F}<\frac{\gamma\rho+(1-\gamma)(1-\rho)}{(2\rho-1)\gamma}\left(\frac{1-\rho}{(2\rho-1)(1-\gamma)}\right)$, then c^F is relatively more important than c^M. The middleman would always be willing to incur c^M in the final stage (conditional on effort being exerted in the first stage) at values of $\widetilde{p}$ which are lower than the value at which he is willing to pay enough to induce the farmer to exert high effort. This means that Constraints 2.2 and 2.4 will be satisfied more easily than Constraint 2.3 and therefore partial effort will never be exerted in this case.

2.2.3 Vertically integrated firm

Now, suppose there is just one agent who carries out both tasks. As with the case with two agents, his decision about whether or not to exert effort in the first stage will depend on his willingness to exert effort in the second stage.

2.2.3.1 Second stage

The agent will know whether or not he exerted effort in the first stage. If he did not exert effort in the first stage then he will not exert effort in the second stage as he knows that the good is of low quality. If he did exert effort in the first stage, then his decision to exert effort in the second stage will depend on his beliefs regarding the quality of the good. These beliefs will be formed based on the signal that he receives in the same way that the beliefs were formed by

the middleman in the case with two agents. He will exert effort in the second stage when he receives a signal that the good is of high quality if Constraint 2.1 is satisfied and will exert effort when he receives a signal that the good is of low quality if Constraint 2.2 is satisfied.

2.2.3.2 First stage

The conditions that need to be satisfied in order for effort to be exerted in the first stage will be different from the case with two agents, as there will no longer be a moral hazard problem.

Proposition 5: *If* $c^M \left(\frac{\gamma(1-\rho)+(1-\gamma)\rho}{\gamma(1-\rho)}\right) \geq \widetilde{p} \geq c^M \left(\frac{\gamma\rho+(1-\gamma)(1-\rho)}{\gamma\rho}\right)$*, the agent will exert effort in the first stage if the following condition holds:*

$$\widetilde{p} \geq \frac{c^F}{\gamma\rho} + \left(\frac{\gamma\rho + (1-\gamma)(1-\rho)}{\gamma\rho}\right) c^M \tag{2.5}$$

Otherwise, only low-quality goods will be produced.

As in the case with two agents, for this value of $\widetilde{p}$, the agent is only willing to exert effort in the second stage if he receives a high signal. The probability of success will therefore be $\gamma\rho$. The cost that he has to pay for effort to be exerted in the first stage is now smaller, however, as he does not have to pay a premium to overcome the moral hazard problem.

Proposition 6: *If* $\widetilde{p} \geq c^M \left(\frac{\gamma(1-\rho)+(1-\gamma)\rho}{\gamma(1-\rho)}\right)$ *, the agent will exert effort in the first stage if the following condition holds:*

$$\widetilde{p} \geq \frac{c^F + c^M}{\gamma} \tag{2.6}$$

Otherwise, only low-quality goods will be produced.

In this case, the agent is always willing to exert effort in the second stage if effort is exerted in the first stage. Therefore, it is as if there is just one task to be carried out and the cost is $c^F + c^M$. The probability of success will be γ.

The agent again must choose between three possible effort levels: full effort, partial effort and no effort.

Proposition 7: *Suppose* $\frac{c^M}{c^F} \geq \frac{1-\rho}{(2\rho-1)(1-\gamma)}$. *If* $\widetilde{p}$ *is such that Constraint 2.5 is not satisfied, no effort will be exerted. If* $\widetilde{p}$ *is such that Constraint 2.5 is satisfied but Constraint 2.2 is not satisfied, then partial effort will be exerted. If Constraint 2.2 is satisfied, then full effort will be exerted.*

This situation is comparable to that in Proposition 3. The condition on the parameter values is different, however. As $\frac{\gamma\rho+(1-\gamma)(1-\rho)}{(2\rho-1)\gamma}\left(\frac{1-\rho}{(2\rho-1)(1-\gamma)}\right) > \frac{1-\rho}{(2\rho-1)(1-\gamma)}$, this situation will apply for a lower value of $\frac{c^M}{c^F}$ than in the case with two agents. This is because the actual cost of making sure that effort is exerted in the first stage is greater in the case with two agents.

Proposition 8: *Suppose* $\frac{c^M}{c^F} < \frac{1-\rho}{(2\rho-1)(1-\gamma)}$. *If* $\widetilde{p}$ *is such that Constraint 2.6 is not satisfied, then no effort will be exerted. If* $\widetilde{p}$ *is such that Constraint 2.6 is satisfied then full effort will be exerted.*

In this situation, c^F is relatively more important and so either no effort will be exerted or full effort will be exerted. This is comparable to Proposition 4 in the two agent case but again the constraint necessary for high-quality production to take place is easier to satisfy in this case.

2.2.4 Comparison of two agent case with vertical integration

2.2.4.1 Case 1: $\frac{c^M}{c^F} \geq \frac{\gamma\rho+(1-\gamma)(1-\rho)}{(2\rho-1)\gamma}\left(\frac{1-\rho}{(2\rho-1)(1-\gamma)}\right) > \frac{1-\rho}{(2\rho-1)(1-\gamma)}$

For low values of $\widetilde{p}$, no effort will be exerted with or without integration. As $\widetilde{p}$ increases, we will hit the partial effort constraint. This happens for lower values of $\widetilde{p}$ in the integrated case than in the two-agent case, as

$$\frac{\gamma\rho+(1-\gamma)(1-\rho)}{\gamma\rho}\left(\frac{c^F}{(2\rho-1)\gamma}+c^M\right) \geq \frac{c^F}{\gamma\rho}+\left(\frac{\gamma\rho+(1-\gamma)(1-\rho)}{\gamma\rho}\right)c^M$$

If $\widetilde{p}$ lies between these values, high-quality goods will not be produced in the two-agent case but will be produced in the integrated case. From now on I will refer to this range of value of $\widetilde{p}$ as the 'production gap'. Once $\widetilde{p}$ becomes greater than $c^M\left(\frac{\gamma(1-\rho)+(1-\gamma)\rho}{\gamma(1-\rho)}\right)$, full effort will be exerted regardless of the structure of the supply chain.

2.2.4.2 Case 2: $\frac{\gamma\rho+(1-\gamma)(1-\rho)}{(2\rho-1)\gamma}\left(\frac{1-\rho}{(2\rho-1)(1-\gamma)}\right) > \frac{c^M}{c^F} \geq \frac{1-\rho}{(2\rho-1)(1-\gamma)}$

For these parameter values, the agent will be willing to exert partial effort for some values of the price in the integrated case but not in the two-agent case. If the following is true

$$c^M\left(\frac{\gamma\left(1-\rho\right)+\left(1-\gamma\right)\rho}{\gamma\left(1-\rho\right)}\right) > \widetilde{p} \geq \frac{c^F}{\gamma\rho}+\left(\frac{\gamma\rho+\left(1-\gamma\right)\left(1-\rho\right)}{\gamma\rho}\right)c^M$$

partial effort will be exerted in the integrated case but no effort will be exerted in the two-agent case. As $\widetilde{p}$ increases, we will reach the following situation:

$$\frac{\gamma\rho+\left(1-\gamma\right)\left(1-\rho\right)}{\gamma}\left(\frac{c^F}{\left(2\rho-1\right)\gamma}\right)+\frac{c^M}{\gamma} > \widetilde{p} \geq c^M\left(\frac{\gamma\left(1-\rho\right)+\left(1-\gamma\right)\rho}{\gamma\left(1-\rho\right)}\right)$$

where full effort will be exerted in the integrated case but still no effort will be exerted in the two-agent case. Once $\widetilde{p}$ becomes large enough that it is greater than $\frac{\gamma\rho+(1-\gamma)(1-\rho)}{\gamma}\left(\frac{c^F}{(2\rho-1)\gamma}\right)+\frac{c^M}{\gamma}$, full effort will be exerted in the two-agent case.

2.2.4.3 Case 3: $\frac{\gamma\rho+(1-\gamma)(1-\rho)}{(2\rho-1)\gamma}\left(\frac{1-\rho}{(2\rho-1)(1-\gamma)}\right) > \frac{1-\rho}{(2\rho-1)(1-\gamma)} \geq \frac{c^M}{c^F}$

For these parameter values, partial effort is never exerted so we only need to compare the conditions for full effort to be exerted. As before, this condition will be satisfied for lower values of $\widetilde{p}$ in the integrated case than in the two-agent case, as

$$\frac{\gamma\rho+\left(1-\gamma\right)\left(1-\rho\right)}{\gamma}\left(\frac{c^F}{\left(2\rho-1\right)\gamma}\right)+\frac{c^M}{\gamma} \geq \frac{c^F+c^M}{\gamma}$$

If $\widetilde{p}$ lies between these values then high-quality goods will be produced in the integrated case but not in the two-agent case.

2.2.5 Comparative Statics

2.2.5.1 Degree of observability, ρ

As ρ increases, the range of values of $\widetilde{p}$ over which it is profitable to produce at all increases. However, as the price that the middleman must pay to the farmer in the two-agent case is decreasing in ρ, this range of values increases faster in the two-agent case than in the integrated case and therefore the production gap becomes smaller.

For a given $\frac{c^M}{c^F}$, if ρ is small we will be in Case 3 above where only full effort or no effort will be exerted. The production gap will be equal to:

$$\frac{1-\rho}{\gamma^2(2\rho-1)}c^F$$

which is decreasing in ρ. As ρ continues to increase, we will move to Case 2, where partial effort will be exerted for some values of $\widetilde{p}$. In this case the production gap will be equal to

$$\left[\frac{\rho(\gamma\rho+(1-\gamma)(1-\rho))-\gamma(2\rho-1)}{\gamma^2\rho(2\rho-1)}\right]c^F+\frac{(2\rho-1)(1-\gamma)}{\gamma\rho}c^M$$

Since in this case $\frac{c^M}{c^F}<\frac{1-\rho}{(2\rho-1)(1-\gamma)}$, this gap will be smaller than when we were in Case 3 and will still be decreasing in ρ. Eventually we will move to Case 1, where the production gap will be equal to:

$$\frac{1-\rho}{\gamma^2\rho(2\rho-1)}c^F$$

Again, given the value of ρ in this case, this gap will be smaller than in the previous case and will continue to decrease as ρ increases. If $\rho=1$, the difference will disappear and there will be no loss in efficiency from not having an integrated supply chain.

2.2.5.2 The middleman's cost, c^M

For a given ρ and c^F, if c^M is sufficiently high we will be in Case 1 above. As long as we remain in this case, the production gap will remain constant as c^M falls. However, eventually c^M will become small enough that we will move to Case 2, where for this range of parameter values, the gap will be smaller than it was in Case 1. Also, the gap will now depend on c^M and will continue to fall as c^M falls. Finally, if c^M continues to fall, we will move to Case 3. Once again, in this case the size of the gap will be smaller than in the previous cases. It will no longer depend on c^M, however, so it will remain constant from now on as c^M falls.

2.2.5.3 The farmer's cost, c^F

As with c^M and ρ, as c^F falls, the production gap falls. For a given c^M and ρ, if c^F is high, we will be in Case 3. As c^F falls we will move from Case 3 to Case

2 and eventually to Case 1. In each successive case, the production gap will be smaller and within each of these cases it will be decreasing in c^F. As c^F goes to zero, the production gap will also go to zero.

2.2.6 Summary of findings

The decision to produce high-quality goods will depend on the costs of production, the degree of observability of quality and the price difference between goods of high and low quality. If quality is not perfectly observable, it is more costly to the middleman to overcome the problem of the farmer's moral hazard. He will therefore need a larger price difference between high- and low-quality goods in order to convince him to induce effort in the farmer and exert effort himself. The lack of observability of quality increases the cost of production of high-quality goods in the first stage when the two stages are carried out by different agents but not in the vertically integrated case. This creates a 'production gap' as there is a range of values of the price difference between high- and low-quality goods for which high-quality goods are produced in the vertically integrated case but not in the case with two agents. In addition to increasing the first-stage cost of producing high-quality goods, a lower ρ also decreases the likelihood that partial effort will be exerted as this will only happen when the expected cost paid to the farmer is low relative to c^M. This also increases the production gap.

2.3 Empirical Observations

This section will discuss the structure of supply chains for a number of different products. It will present two examples of products where the degree of observability of quality is low: milk and cocoa. It will also present two examples of products with a higher degree of observable quality: chilli and rice. In the case of the first two products, we will see that high-quality goods are only produced in situations where the supply chain is short. However, in the second two cases, we will see that it is possible to produce higher-quality products even when there is a high degree of intermediation in the supply chain.

2.3.1 Milk

There is a significant difference between the structure of dairy supply chains in developed countries and those in a number of developing countries. In developed countries, the supply chain for dairy tends to be very short. Most milk is produced through cooperatives who deliver the milk directly to a processor. Farmers who do not sell their milk through cooperatives sell directly to processors themselves. The milk that is produced is rigorously tested and of high quality.[3] In the case of the developing countries discussed in this section, the situation is quite different. The supply chain for milk in these countries involves many actors and is plagued by problems of low quality. The vast majority of milk that is sold is raw, unprocessed milk which must be boiled before use and is often adulterated with water.[4] A report by TechnoServe Rwanda (2008) estimates that 96% of milk marketed in Rwanda is through the informal channel even though the price of processed milk is 2-2.5 times that of fresh raw milk. A similar situation can be found in Pakistan:

> Dairying in Pakistan is labour-intensive and engages a large number of agents along the value chain, including 6.8 million farmers, and thousands of milk collectors, transporters, processors, distributors and retailers. ... In the absence of checks and balances, adulteration is rampant, as each agent in the marketing chain seeks to maximize profits. (Zia, Mahmood and Ali, 2011; p. 10-11)

Much of the adulteration is attributed to intermediaries in the chain who try to keep the milk cool during transport by adding ice or who add washing powder and maize flour to try and enhance volume and whiteness. Adulteration by farmers is also common as they try to increase the volume by adding water since milk tends to be bought on the basis of quantity rather than quality.[5]

Observing the quality of milk can be very challenging. A basic level of quality in milk can be observed by sight, smell and taste but testing for most of the characteristics of high-quality milk, such as the presence of bacteria and fat content, involves more sophisticated equipment and cannot be carried out by local middlemen.[6]

[3] Smith and Thanassoulis (2008) and DairyCo (2011).
[4] Faye and Loiseau (2002) and SNV Netherlands Development Organisation (2008).
[5] Zia, Mahmood and Ali (2011).
[6] Kibiego (2010).

According to a report by the SNV Netherlands Development Organisation (2008):

> The present system in Ethiopia for testing of raw milk and dairy products (with the exception of some research testing laboratories like ILRI) does not stimulate the production of good quality, biologically pure milk with high technological quality that meets the national/ international standards. Currently there are no proper means for collecting and processing of information concerning the milk and milk products quality for marketing. (p. v)

In terms of the model presented in the previous section, this would correspond to a very low value of ρ. In addition to the low level of observability of quality, it is costly for middlemen to try and preserve the quality of milk during transportation as the handling and storage of the milk must be carried out with care in order to prevent contamination. The milk can be contaminated by storage material that has not been properly disinfected or by transporting the milk for too long without proper cooling equipment.[7] Rota and Sperandini (2010) report that transportation and handling costs make up the largest portion of marketing costs of fresh milk. The combination of high costs to the middleman and low observability of quality means that middlemen have little incentive to pay farmers a higher price in order to encourage them to produce higher-quality milk.

This is not to suggest that no high-quality milk is produced in these countries. In general, however, the value chain for high-quality milk is much shorter and looks more like the supply chains for dairy that we see in developed countries. In Pakistan, there are a number of formal processors who produce processed, fresh milk. They usually buy milk directly from farmers rather than through middlemen and they provide the transport themselves using refrigerated tanks. They have also set up farm cooling tanks in the villages where they collect the milk.[8]

In Ethiopia, the Adaa Dairy Cooperative which has 813 members has managed to start producing higher-quality milk which is then delivered directly to one of 12 collection points where the milk is tested for quality.[9] TechnoServe Rwanda (2008) reports a similar situation in Rwanda where a number of farmers in the region around Kigali are vertically integrated into the dairy market and many of

[7] Faye and Loiseau (2002) and SNV Netherlands Development Organisation (2008).
[8] Zia, Mahmood and Ali (2011).
[9] SNV Netherlands Development Organisation (2008).

the owners of dairy farms also own a processor or retailer.

Finally, much of the production of high-quality milk in developing countries is supported by large multi-national corporations, such as Nestlé, who work directly with farmers to source the milk and provide the necessary infrastructure for safely transporting the milk without it being contaminated. In addition, these companies provide training to farmers to help them improve their production techniques so that they can produce high-quality milk.[10]

2.3.2 Cocoa

This section will compare the structure of the supply chain for cocoa in two major cocoa producing countries: Indonesia and Ghana. The quality of cocoa produced in Indonesia is generally quite poor. In contrast, Ghana has a reputation for producing high-quality cocoa. The supply chains for cocoa in these two countries have quite different structures. There are many actors involved in the supply chain for cocoa in Indonesia. Farmers generally sell to local collectors at the farm gate who then sell on to village collectors who sell to processors or other intermediaries.

The supply chain in Ghana is much shorter. The cocoa industry in Ghana is strictly regulated by the Cocoa Marketing Board, Cocobod. Farmers either sell directly to Licensed Buying Companies (LBCs) or to farmers' associations, both of whom sell directly to Cocobod.

Observing the quality of cocoa beans is not quite as difficult as in the case of milk but it still poses a number of challenges. In order to meet international standards, high-quality cocoa beans should possess the following characteristics:

> Cocoa beans of good quality are free from insect holes, smoky and flat beans. They are not excessively acidic, bitter or astringent, and they have uniform sizes. They should also be well fermented, have a moisture content of maximum 7.5 %, a free fatty acid content maximum 1.5 % and a cocoa butter content between 45 and 60 %. Finally, too high levels of foreign matters, insects, harmful bacteria and pesticides residues are not allowed ... International standards are made to measure quality of cocoa beans. This is performed via a cut test where the cocoa beans are cut lengthwise and visually divided after quality.

[10] Zia, Mahmood and Ali (2011) and http://www.nestle.com/Brands/Dairy/Pages/DairyCSV.aspx

> Purple beans, slaty beans and beans with all other defectiveness are grouped. Defectiveness among cocoa beans includes flat, moldy and germinated beans" (Mikkelsen, 2010; p.19)

Mikkelsen (2010) outlines the steps involved in identifying and handling high-quality beans. Many of the problems with the cocoa beans can be detected by sight via a cut test. However, to ensure that the batch of cocoa beans is generally of good quality, this must be carried out with a significant sample of the beans which is time-consuming. In addition, specialised equipment is necessary to measure the moisture content of the beans and a sample of the beans must be weighed and counted in order to determine bean size.

If the middleman is willing to buy high-quality beans, then he must exert effort in order to maintain the quality of the beans. High-quality cocoa beans must be stored with care in order to preserve quality. Sacks must be secure and tight to protect from insect infestation. They also need to be kept dry and protected from high temperatures.[11] Most importantly, they should not be mixed with beans of lower quality.

Cocoa beans in Indonesia are generally purchased on the basis of quantity rather than quality. Collectors do not differentiate on the basis of quality in terms of the price that they pay the farmer. In addition, they mix beans of different quality with each other and sometimes also with waste material in an effort to increase volume:[12]

> The common practice has been for the first buyer (local collector) to pay the same price per kilogram for both good and poor quality cocoa, 'mixing' the beans and forwarding these mixed beans on to the next buyer (village collector). When the cocoa beans eventually arrive at the warehouse of the international exporter they then need to be cleaned or 'unmixed' to meet the international buyer's specifications. (Badcock, Matlick, and Bako Baon, 2007; p. 3).

There are a number of actions that farmers can take in order to produce high-quality cocoa beans. A major cause of low quality in cocoa beans is infestation by the cocoa pod borer. The farmer could exert effort to protect his crops from infestation. He could also improve the quality of his beans by fermenting them. However, these actions are costly for the farmer and he has no incentive to carry

[11] Mikkelsen (2010).
[12] Panlibuton, Henry, and Lusby (2006).

them out as the collector is not willing to pay a higher price for beans that appear to be of higher quality.

In general, there is little cooperation between cocoa farmers in Indonesia, and associations or cooperatives do not exist. A few local processors have begun to set up 'up-country' buying stations in order to try and source high-quality beans directly from farmers.[13] A number of international organisations have also started to work directly with farmers in order to increase the level of quality in the beans that they purchase. Armajaro and Olam have both established buying stations that are located close to farmers where quality control is carried out and farmers are paid a premium for high-quality beans.[14]

Cocoa production in Ghana follows a very different model which is focused on producing high-quality cocoa beans. The cocoa marketing board in Ghana (Cocobod) plays a major role in ensuring that the quality of cocoa is high. Farmers either sell cocoa to Licensed Buying Companies (LBCs) or farmer associations.[15] Cocoa is strictly graded and checked for quality at a number of stages in the chain. Low-quality cocoa is rejected by Cocobod, providing a strong incentive to the LBCs to perform quality checks at an early stage in the supply chain:

> Because cocoa is graded early in the marketing chain and identified by farming society, farmers are motivated to present high quality cocoa and are also instantly aware (and penalised, by not being able to sell their cocoa) when their cocoa is sub standard (Shepherd and Onumah 1997: 46; Bank of Ghana 2003: 10). By contrast, in other cocoa producing countries cocoa is generally graded much later in the chain and not always traced back to its origin, giving farmers little information about their cocoa's quality and few incentives to improve it. (Williams, 2009; p. 25)

As was the case with the dairy supply chain we only see high-quality goods being produced when the supply chain is highly integrated.

[13] Panlibuton, Henry, and Lusby (2006).
[14] Badcock, Matlick, and Bako Baon (2007) and VECO (2011).
[15] Mohammed, Asamoah, and Asiedu-Appiah (2012).

2.3.3 Chillies

This section will discuss the supply chain for chilli in Indonesia. As was the case for cocoa, the supply chain for chilli involves a number of different actors: local collectors, wholesalers, retailers, supermarkets. However, in the case of chilli, quality is much more easily observable. Most of the characteristics of chilli that differentiate quality can be judged by sight such as size, shape and colour.

In South Sulawesi in Eastern Indonesia, two main types of chilli are produced: large chilli and small chilli. Large chilli is considered to be of higher quality and sells for a higher price. However, the production of large chilli is also more costly. Different inputs and techniques are used:

> In South Sulawesi there are a number of key differences between small chilli and Large chilli producers: Small chilli producers do not use high quality certified seed, whereas farmers in the same province producing Large chilli are using certified seed. The use of certified seed is used due to stronger market demand and greater intensity of cultivation. Small chilli cultivation appears to be less intensive and uses less chemical inputs compared to large chilli farming. (White, Morey, Natawidjaja, and Morgan, 2007; p.26)

Collectors and wholesalers must also exert some effort to sell high-quality chilli to supermarkets such as sorting, grading and packaging the chilli.

Even though the supply chain for large chilli is quite long, there is a market for it. Large chilli is produced and farmers receive a higher price for producing it. In 2005, 62% of chilli production was large chilli and 38% was small chilli.[16] The most common form of supply chain for chilli in Indonesia is for farmers to sell to local collectors who then sell to wholesalers or retailers. The wholesalers may sell to small retailers or to supermarkets. Collectors pay a higher price for higher-quality chilli.

An exception to the long supply chain is the case of chillies produced to make chilli sauce. ABC is a processor of chilli sauce in Indonesia and buys at least half of its chilli directly from growers. The company needs the farmers to grow a particular variety of chilli in order for it to have the right flavour, which is a characteristic that is more difficult to observe than the size of the chilli.

[16] White, Morey, Natawidjaja, and Morgan (2007).

2.3.4 Rice

The final product that will be discussed is rice. This section will describe the production of rice in Vietnam and Thailand. In both of these countries many actors are involved in the supply chain for rice: producers, assemblers, middlemen/brokers, wholesalers, millers/polishers and retailers. Similarly to the case of chilli, the quality characteristics of rice are easily observable:

> In general, there is a broad range of rice qualities available in the market place in the Mekong River Delta, Vietnam. The difference in the qualities are based on the rice variety, the way of milling the rice influences to what extent the grains are broken (broken level), the period the rice has been in storage, and the purity of the rice. (Hai, 2002; p.82)

Most rice traders in Vietnam differentiate rice into two types, long and medium/short. Long-grain rice is higher quality and the growers receive a higher price. Of paddy sold at the farm gate in the Mekong Delta, approximately 60% is long grain paddy and 40% is short grain. In Thailand, two types of rice are also produced: glutinous and non-glutinous. Non-glutinous rice is of higher quality and growers receive a higher price from traders for this type of rice but must also use more intensive technology in order to produce it.[17] Glutinous rice is grown for own consumption or sold locally and non-glutinous rice is grown commercially.

We can see that in the case of chilli and rice, where quality characteristics are easily observable, high-quality products are produced even where there are many agents participating in the supply chain.

2.4 Conclusion

This paper presented a model of a supply chain which demonstrated that the decision to produce low-quality goods can be explained by a combination of low observability of quality and a high level of intermediation in the supply chain. The model predicts that if the quality of the good is not perfectly observable, then a 'production gap' will exist. This means that there will be a range of values for the price difference between high- and low-quality goods for which high-quality goods will be produced if the supply chain is vertically integrated,

[17] Agrifood Consulting International (2005).

but will not be produced if the different tasks are performed by separate agents. The paper also discussed examples of supply chains in a number of developing countries that have characteristics which are consistent with the predictions of the model. The analysis in this paper has taken the degree of integration of the supply chain as exogenous in order to better understand one side of the problem. In reality, the decision of whether or not to vertically integrate may be endogenous. Incorporating this into the model could be an important avenue for future research.

The model presented in this paper predicts that the size of the production gap will be decreasing in the degree of observability of quality and increasing in the cost to the farmer of producing a high-quality good and the cost to the middleman of preserving the quality of the good. This means that, from a policy perspective, there are a number of ways in which the production of high-quality goods could be encouraged. Firstly, the government could support the formation of farmers' associations which could perform some of the tasks of the middleman by transporting the goods to the processor. Secondly, processors could be encouraged to establish operations 'up country' in order to buy directly from farmers and test for quality earlier in the supply chain. Thirdly, the costs to farmers could be reduced by training them to use more efficient production techniques or, once again, by encouraging farmers to work together in a cooperative in order to reduce costs. Finally, investing in better roads could reduce the middleman's costs and the cost to the farmer of sourcing inputs.

Chapter 2 References

1. Agrifood Consulting International, (2005), "Northeast Thailand Rice Value Chain Study", Project Brief Series, Agrifood Consulting International, Maryland.

2. Allen, Franklin, (1984), "Reputation and Product Quality", *The RAND Journal of Economics*, Vol. 15, No. 3, pp. 311-327.

3. Badcock, Simon, B. Matlick, and J. Bako Baon, (2007), *A Value Chain Assessment of the Cocoa Sector in Indonesia,* USAID.

4. DairyCo (2011), *Dairy Supply Chain Margins 2010/11,* Agriculture and Horticulture Development Board, Warwickshire.

5. Dana, James, and A. Fong, (2011), "Product Quality, Reputation, and Market Structure", *International Economic Review*, Vol. 52, No. 4, pp. 1059-1076.

6. Esfahani, Hadi Salehi, (1989), "Reputation and Uncertainty: Toward an Explanation of Quality Problems in Competitive LDC Markets", *Journal of Development Economics,* 35, pp. 1-32.

7. Fafchamps, Marcel and E. Gabre-Madhin, (2006), "Agricultural Markets in Benin and Malawi", African Journal of Agricultural and Resource Economics, 1(1): 67-85.

8. Fafchamps, Marcel, R. Vargas-Hill and B. Minten, (2007), "Quality Control in Non-Staple Food Markets: Evidence from India" in *Global Supply Chains, Standards, and the Poor*, Johan Swinnen (ed.), Cabi Publications.

9. Faye, B. and Loiseau, G. (2002), "Sources of Contamination in Dairy Supply Chains and Approaches to Quality Control" in Hanak, E., E. Boutrif, P. Fabre and M. Pineiro, (ed.), *Food Safety Management in Developing Countries. Proceedings of the International Workshop*, CIRAD-FAO, Montpellier, France.

10. Hai, Luu Thanh Duc, (2002), "The Organization of the Liberalized Rice Market in Vietnam", PhD thesis, University of Groningen, Groningen.

11. Gale, Douglas and R. Rosenthal, (1994), "Price and Quality Cycles for Experience Goods", *The RAND Journal of Economics*, Vol. 25, No. 4, pp. 590-607.

12. Kibiego, Michael (2010), *Training Manual for the Development of the Milk Marketing Chain,* Ministry of Livestock Development Smallholder Dairy Commercialization Programme.

13. Kranton, Rachel, (2003), "Competition and the Incentive to Produce High Quality", Economica, New Series, Vol. 70, No. 279, pp. 385-404.

14. Kremer, Michael, (1993), "The O-Ring Theory of Economic Development", *The Quarterly Journal of Economics,* Vol. 108, No. 3, pp. 551-575.

15. Mikkelsen, Laerke, (2010), "Quality Assurance along the Primary Processing Chain of Cocoa Beans from Harvesting to Export in Ghana", Dissertation, University of Copenhagen, Faculty of Life Sciences, Copenhagen.

16. Mohammed, Dawuni, D. Asamoah, and F. Asiedu-Appiah, (2012), "Cocoa Value Chain - Implication for the Smallholder Farmer in Ghana" in *2012 SWDSI Proceedings,* Southwest Decision Sciences Institute, Texas.

17. Nestle website: http://www.nestle.com/Brands/Dairy/Pages/DairyCSV.aspx

18. Panlibuton, Henry and F. Lusby, (2006), *Indonesia Cocoa Value Chain Case Study,* MicroReport No. 65, USAID.

19. Riordan, Michael, (1986), "Monopolistic Competition with Experience Goods", *The Quarterly Journal of Economics*, Vol. 101, No. 2, pp. 265-280.

20. Robinson, Elizabeth and S. Kolavalli, (2010), *The Case of Tomato in Ghana: Marketing*, GSSP Working Paper No. 20, IFPRI, Washington, D.C.

21. Rosenberg, David, M. Eckstein, and C. Brett, (2009), *Traders as agents of sustainability in coffee and cocoa supply chains,* Best Practices Series, The Dutch Sustainable Trade Initiative (IDH), Utrecht.

22. Rota, Antonio and S. Sperandini (2010), *Value chains, linking producers to the markets,* Livestock Thematic Papers: Tools for Project Design, IFAD, Rome.

23. Shapiro, Carl, (1983), "Premiums for High Quality Products as Returns to Reputations", *The Quarterly Journal of Economics*, Vol. 98, No. 4, pp. 659-680.

24. Smith, Howard and J. Thanassoulis (2008), *The Milk Supply Chain Project,* University of Oxford.

25. SNV Netherlands Development Organisation (2008), *Study on Dairy Investment Opportunities in Ethiopia*, TAM Consult, Addis Ababa.

26. TechnoServe Rwanda (2008), *The Dairy Value Chain in Rwanda,* East Africa Dairy Development Program, Rwanda.

27. VECO, (2011), *Increased incomes for Indonesian cocoa farmers in sustainable markets: NGO-private sector cooperation on Sulawesi island,* VECO, Leuven.

28. White, Benjamin, P. Morey, R. Natawidjaja, and W. Morgan (2007) *Vegetable value chains in Eastern Indonesia–a focus on chilli,* SADI-ACIAR research report, Australian Centre for International Agricultural Research, Canberra

29. Williams, Tracy, (2009), *An African Success Story: Ghana's Cocoa Marketing System,* IDS Working Paper 318, Institute of Development Studies at the University of Sussex, Brighton.

30. World Bank, (2008), *World Development Report: Agriculture for Development*, World Bank, Washington D.C.

31. Zia, Umm e, T. Mahmood and M.R. Ali (2011), *Dairy Development in Pakistan*, FAO, Rome.

Chapter 3

A Cross-Country Analysis of the Diffusion of Information and Communications Technology

3.1 Introduction

The potential of information and communications technology for development has received a lot of attention in recent years. While there is no doubt that mobile phones and the Internet are extremely useful in developed countries, these technologies are arguably even more important in developing countries where the information environment is generally poorer and older communications technologies, such as fixed line telephones, are less widely available. A number of studies have shown that ICTs can have a significant impact on the well-being of individuals in developing countries.[1] These technologies can reduce transaction costs, help markets to work more efficiently and provide access to important services, e.g., healthcare information and mobile banking.

However, while there has been rapid growth in the use of mobile phones and the Internet in developing countries over the past few years, a significant digital divide still exists, meaning that large portions of the population do not have access to technologies that could be very beneficial to them. Given the potential benefits of these technologies, it is important for us to try and understand what the main barriers to adoption are for developing countries.

The technology adoption process is made up of two parts. Firstly, the necessary infrastructure must be in place before anyone can use the technology. This usually

[1] Jensen (2007); Goyal (2010); Aker (2010).

involves a significant level of investment. The costs and benefits of this investment may depend on a number of factors including the physical geography of the region and the institutional environment. Secondly, individuals can choose whether or not to use the technology once it is available. This choice will depend on their economic circumstances and the expected gain to using the technology.

A number of studies have investigated the process of diffusion of ICTs and its relationship with a number of other variables. Many of these studies focus on particular countries or geographic areas, such as the EU or OECD.[2] The evidence on the relationship between rates of ICT use and income per capita is mixed. Some studies have found a positive relationship[3] while others have found no significant relationship between the two.[4] Previous studies have also come to different conclusions regarding the relationship between fixed line telephones and rates of ICT use. Some have found them to be complements[5] while others have found that they are substitutes.[6] A number of studies have investigated the relationship between competition in the mobile phone market and rates of mobile phone use and have generally found that increased competition leads to higher rates of mobile phone use.[7] Rouvinen (2006) differentiates between developed and developing countries to investigate whether or not there is a significant difference in the process of diffusion in poorer countries. He finds that the speed of adjustment is not too different between developed and developing countries but that population size and network effects are more important in poorer countries. Gumboa and Otero (2009) attribute the delayed installation of infrastructure in remote areas of Columbia to the diverse topography of the country. Hyytinen and Toivanenn (2011) find a positive relationship between inequality and mobile phone penetration rates.

This paper will add to this literature by using a logistic model of technology diffusion to investigate the relationship between rates of mobile phone and Internet use and a number of geographic, institutional and economic variables, in a sample of 164 countries from 1990 to 2009. The aim of this paper is to identify the main characteristics of countries that have had success in adopting these new technologies in order to gain some insight into the barriers which may be faced

[2]Gruber and Verboven (2000); Lee and Cho (2007); Frank (2004); Jang, Dai and Sung (2005).
[3]Lee and Cho (2007); Ding, Haynes and Li (2010); Bohlin, Gruber and Koutroumpis (2010); Lee, Marcu and Lee (2011); Gruber and Verboven (2001); Frank (2002).
[4]Rouvinen (2006); Chu, Wu, Kao and Yen (2009).
[5]Hwang, Cho and Long (2009); Gruber and Verboven (2001).
[6]Lee and Cho (2007); Jang, Dai and Sung (2005); Chu, Wu, Kao and Yen (2009).
[7]Koshi and Kretschmer (2005); Gruber and Verboven (2000); Bohlin, Gruber and Koutroumpis (2010); Lee, Marcu and Lee (2011); Gruber and Verboven (2001); Jang, Dai and Sung (2005); Chu, Wu, Kao and Yen (2009); Hwang, Cho and Long (2009).

by those countries that have been less successful.

The rest of this paper is organised as follows. Section 2 introduces the logistic model of technology diffusion. Section 3 describes the econometric specification and data used. The results are presented in Section 4 and Section 5 concludes.

3.2 Model of technology diffusion

3.2.1 Model

This section will present a logistic model of technology diffusion, as used by Gruber and Verboven (2001). Let y_{it} be the number of adopters of the technology in country i at time t and let y^*_{it} represent the total potential number of adopters. The fraction of adopters to potential adopters is given as follows:

$$\frac{y_{it}}{y^*_{it}} = \frac{1}{1 + exp(-a_{it} - b_{it}t)} \tag{3.1}$$

This function is an S-shaped curve, with an inflection point at $y_{it} = \frac{1}{2}y^*_{it}$. The shape of this curve makes it very appropriate for representing technology diffusion which tends to follow an S-shaped path, as the rate of adoption increases slowly initially, then much more rapidly, and then slows down again as it approaches the steady state level. This is the model most commonly used in the ICT diffusion literature.

The variable a_{it} is a location variable which shifts the curve forwards or backwards. The variable b_{it} relates positively to the growth rate in adoption of the technology:

$$\frac{\mathrm{d}y_{it}}{\mathrm{d}t}\frac{1}{y_{it}} = b_{it}\frac{y^*_{it} - y_{it}}{y^*_{it}}$$

At the inflection point, the growth rate is equal to $\frac{1}{2}b_{it}$. The variables a_{it} and b_{it} together give us information on the timing of adoption, e.g. the year at which penetration reaches 10% of the potential level can be calculated as:

$$t_{0.1} = \frac{(-2.2 - a_{it})}{b_{it}}$$

As most countries have not yet reached the steady state level of adoption of mobile phones or the Internet, it will not be possible to say very much about

what factors affect this steady state. This paper will focus on understanding which factors are related to the location variable, a_{it}, and the growth variable, b_{it}, both of which affect the transition to the steady state. In the empirical analysis, results will be presented for a number of different possible values of y^*_{it} in order to see how robust the results are to changes in this value. The following section will discuss some of the factors which could explain differences in a and b between countries.

3.2.2 Explanatory Variables

There is a large amount of variation in the rates of technology adoption in different parts of the world. Figure 1 presents data on the average rates of mobile phone use from 1990 to 2009 in different geographic regions of the world. Figure 2 presents the analogous data for Internet use. As can be seen from these graphs, some parts of the world have adopted these technologies at significantly higher rates than others. Figures 3 and 4 present the same data grouped into high income countries and the rest of the world. These graphs demonstrate that poorer countries still lag significantly behind richer countries in the use of ICTs. This gap is particularly stark for Internet use.

Even within regions there is still significant variation in rates of ICT use. Figures 5 and 6 present data on mobile phone and Internet use respectively for six different countries in sub-Saharan Africa. As can be seen from this graph, the gap between some of the most and least successful adopters is quite high. Figures 7 and 8 present similar data for a selection of countries in the Middle East and, once again, we can see that even within the same region there can be large differences in the rates of ICT adoption between countries.

The aim of this paper is to try and understand what the main differences are between countries who have successfully adopted ICTs and those who have not. In what follows, the discussion will be focused on three categories of variables which could play an important role in understanding these differences. These categories are as follows: geographic, institutional and economic.

3.2.2.1 Geographic Variables

The geographic variables which will be included in this study are an index of ruggedness, population density and the proportion of the population living in rural areas. Each of these variables could be related both to the cost of constructing ICT infrastructure and also to the benefit gained from using this technology.

The shape of the terrain can have an important influence on the cost of building the infrastructure necessary for ICT use. We would expect that countries where the terrain is more rugged would face higher costs of construction and this could lead to lower rates of adoption.

Since there is a high fixed cost component to putting this infrastructure in place in a particular area, the per capita cost should be lower in areas where population density is higher. This would lead us to expect to see a positive relationship between adoption rates and population density.

For a similar reason, the proportion of people living in rural areas could have an influence on the cost of providing access to ICT infrastructure to the majority of the population which would lead to a negative relationship between these two variables.

On the other hand, all of these variables also affect the cost of communicating with other people in the absence of ICTs which means that the benefit of using these technologies may be higher in cases where the cost of building the infrastructure is higher. This will work in the opposite direction to the cost effect described above.

3.2.2.2 Institutional Variables

Adopting ICTs involves a large fixed cost of investing in the infrastructure. This means that the institutional environment could have an important influence on whether or not private firms would be willing to undertake this investment and will also affect the government's decision or ability to carry out the investment itself.

An environment that is conducive to private investment but also ensures that services provided by private firms are affordable and reach most of the population is necessary in order to increase rates of technology use. A number of factors can

contribute to this. Usually, it would be wasteful to duplicate the underlying ICT infrastructure which means that the regulatory environment could be very important. This could be affected by the legal environment, the degree of competition between ICT providers and the quality of government regulation. In addition, the type of government regime could also have an influence both on the stability of government and on the incentives that the government faces to encourage the construction of ICT infrastructure.

3.2.2.3 Economic Variables

Using technology is costly both in terms of acquiring the initial infrastructure and using the product. Therefore, it would be natural to expect that richer countries will achieve higher rates of technology use sooner than poorer countries. New information and communications technologies can be particularly useful for individuals in developing countries, however, as they are substitutes for older technologies such as fixed line telephones which are not as widely available in poorer countries. Therefore, it is not clear that we will definitely see a positive relationship between GDP p.c. and rates of ICT adoption once we have controlled for other factors that influence the construction of the infrastructure.

The education level of the population will also affect their ability to use ICT. It is necessary to be literate in order to use the Internet and so we would definitely expect to see a positive relationship between rates of Internet adoption and literacy. This is less true for mobile phones although it is necessary for using SMSs which have become an important form of communication. However, as literacy is also a proxy for general level of education, we still may expect to see a positive relationship between mobile phone use and literacy.

The importance of communication varies across sectors of the economy. It is particularly important in the services sector. It is plausible that countries where the services sector forms a larger part of the economy will have a greater incentive to invest in adopting ICTs and will begin to adopt these technologies earlier. Therefore we would expect to see a positive relationship between the percentage of GDP coming from the services sector and rates of ICT adoption. There has been a lot of discussion recently about the importance of ICTs for agriculture so we might also expect to see a positive relationship between rates of ICT use and the percentage of GDP coming from agriculture.

Finally, the decision to adopt a new technology may depend on what other

alternatives are available. Fixed line telephones are a partial substitute for other forms of communications technology suggesting a negative relationship between the number of fixed line telephones and the rate of technology adoption. On the other hand, fixed line telephones can be necessary to use the Internet and may also be positively correlated with overall investment in telecommunications which could lead to a positive relationship.

3.3 Empirical methodology

3.3.1 Empirical specification

Equation (3.1) can be transformed as follows:

$$log\left(\frac{y_{it}}{y^*_{it} - y_{it}}\right) \equiv z_{it} = a_{it} + b_{it}t$$

It is assumed that y^*_{it} is proportional to the total population of country i at time t, i.e., $y^*_{it} = \gamma_i Population_{it}$, where γ_i is the fraction of the population which will eventually adopt the technology. In practice it is very difficult to estimate γ_i, as most countries have not yet reached a sufficiently high level of adoption. In what follows, it will be assumed that γ_i is known and results will be presented for different values of γ_i to see how sensitive they are to this value. The data on mobile phone penetration rates are based on the number of mobile phone subscriptions rather than mobile phone users which means that it is possible to have a value of this variable greater than 100. In fact, for many countries which are highly advanced in their use of this technology, the value of this variable is close to 200. However, the data for Internet penetration rates are based on the number of Internet users and so the maximum possible value for this variable is 100. In addition to using these values, some specifications will use predicted values of γ_i for each country. These values are based on estimates of the relationship between γ_i and different combinations of the other explanatory variables in a subset of countries who are at advanced stages in the technology adoption process.

The equation to be estimated is:

$$
\begin{aligned}
z_{it} &= \alpha_{it}^{o} + x_{it}^{G}\alpha^{\mathbf{G}} + x_{it}^{I}\alpha^{\mathbf{I}} + x_{it}^{E}\alpha^{\mathbf{E}} \\
&\quad +(\beta_{it}^{o} + x_{it}^{G}\beta^{\mathbf{G}} + x_{it}^{I}\beta^{\mathbf{I}} + x_{it}^{E}\beta^{\mathbf{E}})t + \varepsilon_{it} \qquad (3.2)
\end{aligned}
$$

where x_{it}^{G} is a vector of geographic variables, x_{it}^{I} is a vector of institutional variables and x_{it}^{E} is a vector of economic variables.

3.3.2 Data

The dataset covers 164 countries for the period 1990-2008. Data on GDP p.c., population density, rural population, services value added, agriculture value added, fixed telephone lines per 100 people and literacy are taken from the World Bank World Development Indicators. Data on literacy are not available on an annual basis. In order to deal with this, dummy variables were created and countries were assigned to the following categories based on the available data: low (0-20%), medium low (20-40%), medium (40-60%), medium high (60-80%) and high (80-100%). Data on literacy rates were not available for many of the OECD countries. However, as literacy is generally high in these countries, they have been assigned to the high literacy category.

Data on ruggedness and legal origins come from the dataset used by Nunn and Puga (2012). They have constructed a ruggedness index for each country which gives a measure of the average terrain ruggedness of the country's land area. The units for the terrain ruggedness index correspond to units used to measure elevation differences. Data on the level of competition in the ICT sector come from the International Telecommunications Union World Telecommunication Regulatory Database. Using this data, dummy variables were constructed for whether the type of competition in the ICT sector in a given year is a monopoly, partially competitive or competitive. The regulatory quality indicator comes from the Worldwide Governance Indicators database. The units in which it is measured follow a normal distribution with mean zero and standard deviation of one[8].

Data on the type of political regime come from the Polity IV database. As recommended by the Polity IV project, countries are characterised as 'autocracies' if they have a polity score between -10 and -6, 'anocracies' if they have a score of -5 to +5 or one of the special values of -66, -77 or -88, and 'democracies' if

[8]Kaufmann et al. 2008

they have a score of +6 to +10. Dummies were constructed to represent each of these categories. Regional dummies are also included in the regression but are not reported in the results.

3.4 Empirical results

When interpreting the results it is important to distinguish between the location parameters and the growth parameters. As mentioned in Section 2, the location parameters shift the diffusion curve. A larger location parameter is associated with an earlier date of initial adoption which means that rates of ICT use will be higher at any point in time, all other things being equal. Therefore, a positive location parameter for a particular variable means that higher values of that variable are associated with higher rates of ICT use and a negative location parameter means the opposite is true. The growth parameters determine the rate at which the use of ICTs increase over time. If the growth parameter for a particular variable has the opposite sign to that of the location parameter, this means that the initial effect of that variable on rates of ICT use will diminish over time. If, on the contrary, the sign of the growth parameter is the same as that of the location parameter, this means that the effect will be reinforced over time.

In what follows, results will be presented from regressions containing each category of variable separately and the full regression including all explanatory variables. As many of these variables are correlated with one another, the regressions containing a reduced number of variables will suffer from omitted variables bias. However, seeing how these estimates change when other variables are included may help us to interpret the relationship that we observe between these variables and the process of ICT adoption.

3.4.1 Mobile phone diffusion

The estimated location and growth parameters for mobile phone diffusion are presented in Tables 1-4. Tables 1-3 present results for each category of explanatory variables separately. Table 4 presents the results from the full regression containing all explanatory variables. In each table, the results in columns (1) and (2) are based on a value of γ equal to 205, which is the maximum value observed. The results in the other columns are based on a number of different

predicted values of γ_i for each country. The results for each of the categories of explanatory variables will now be discussed in turn.

3.4.1.1 Geographic Factors

Table 1 presents the results from a regression containing only the geographic variables. The location parameters are presented in the first part of the table and the growth parameters are presented in the second part. The location parameter on the ruggedness index is positive and significant in this regression. The location parameter for rural population is negative and significant and the location parameter for population density is not significantly different from zero. However, these results seem to be driven by omitted variable bias as the results change quite a bit when all of the variables are included. The results from the full regression are presented in Table 4, where the location and growth parameters are presented side by side. In particular, the geographic variables seem to be highly correlated with GDP p.c., fixed line telephones and literacy. As we can see from columns (2), (4), (6) and (8), when these variables are included the results are a lot closer to the results that we see in Table 4.

The location parameter on population density is negative in Table 4. If we think about this variable from a cost perspective, this is a surprising result as we would expect that a lower population density would add to the cost of constructing ICT infrastructure. However, from a benefit point of view, a lower population density also adds to the cost of communicating with others over distances which is something that mobile phones can help to overcome. Therefore the lower the population density, the greater the benefit of mobile phones. This could possibly explain the result that we see here. The sign of the growth parameter for population density is negative which means that the initial effect of this variable will diminish over time. The location parameters for the proportion of the population living in rural areas and for the ruggedness index are both positive in Table 4 but are not significantly different from zero.

3.4.1.2 Institutional Factors

Table 2 presents the results from a regression containing only the institutional variables. As was the case with the geographic variables these variables are correlated with a number of other variables and so the values of the parameters

change when all variables are included. As we can see from columns (2), (4), (6) and (8), including GDP p.c. and fixed line telephones in particular reduces the estimates of the location parameters for the democracy dummy and regulatory quality.

Looking at the results from the full regression in Table 4, we can see that the institutional variables seem to be strongly related to the rate of mobile phone adoption. The location parameters for the democratic dummy and the autocratic dummy are both positive and significantly different from zero. This could suggest that what is important for the adoption of mobile phones is to have a strong, stable government which is able to coordinate investment in mobile phone infrastructure. This does not necessarily mean that the government must be democratically elected. The growth parameters for these variables are both negative which would suggest that this effect should diminish over time. However, only the parameter for the autocratic dummy is significantly different from zero. The location parameter for regulatory quality is positive and significantly different from zero suggesting that countries with better regulation adopt ICTs earlier. The growth parameter for this variable is negative but is not significantly different from zero in any of the specifications. This means that the initial effect of earlier adoption by countries with better regulation could have a permanent effect on the rate of technology use as there is no evidence that countries with poorer regulation will catch up over time.

In order to investigate the relationship between the type of competition in the mobile phone market and rates of mobile phone use dummy variables have been included for the case of a monopoly and the case of partial competition. The omitted category is a competitive mobile phone market. The results suggest that countries where the mobile phone market is partially competitive adopt mobile phone technology earlier than countries where this sector is fully competitive as the location parameter for this variable is positive and significant. This could be because of the fixed costs involved in providing and maintaining the mobile phone infrastructure, meaning that companies will be more likely to invest if they are likely to earn a higher profit. The growth parameter for this variable is negative and significantly different from zero, suggesting that this effect diminishes over time. The location parameter for a monopoly is also positive but is only significantly different from zero in two of the specifications.

The final institutional variable that will be discussed is legal origins. Previous research suggests that differences in legal origin can have an effect on a number

of different aspect of the economic environment including the burden of entry regulation and regulation of labour markets[9]. A dummy variable is included which is equal to one for countries whose legal origins come from common law. In general civil law is associated with higher levels of government intervention than common law. The location parameter for this variable is negative but it is not significantly different from zero in any of the specifications.

3.4.1.3 Economic Factors

The results for the regression containing just the economic factors are presented in Table 3. Unlike with the other variables, these results do not change dramatically when other variables are included in the regression.

The location parameter for GDP p.c. in Table 4 is positive and significant and the growth parameter is negative and significant which is consistent with what we would expect. It suggests that richer countries are earlier adopters of mobile phone technology but that the rate of technology use in poorer countries will grow faster than that in richer countries, eliminating the initial effect over time.

There certainly seems to be evidence that education is positively correlated with mobile phone use. The omitted category for the literacy dummies is 'high' literacy, meaning over 80% of the population is literate. The coefficients on the lowest three literacy dummy variables are all negative and significant suggesting that countries with higher literacy rates are earlier adopters of mobile phone technology. The growth parameters for these variables have positive signs, which means that countries with lower literacy rates should catch up over time in terms of mobile phone use. However, the growth parameter for low literacy is not significantly different from zero so it is possible that the effect of very low literacy could be quite persistent over time.

We expected to find a positive relationship between the proportion of GDP from the services sector and rates of mobile phone use. The location parameter for this variable is positive and significantly different from zero. The location parameter for the proportion of GDP from the agricultural sector is negative which means that countries where agriculture is relatively more important are later adopters of mobile phone technology. This is somewhat surprising given

[9]La Porta et al. (2007)

the attention that has been given recently to the importance of mobile phones in agricultural markets. However, this parameter is only significantly different from zero in two of the specifications. The growth parameter for this variable is positive but is not significantly different from zero which means that this effect could be persistent over time.

Finally, the results suggest that there is a positive relationship between the number of fixed line telephones and early adoption of mobile phone technology. This goes against the story that mobile phones are being used as a substitute for fixed line telephones which would lead to a negative relationship. Given that we do not have a good measure of mobile phone infrastructure or investment in telecommunications, it is possible that this variable is picking this up as these variables are likely to be positively correlated. The growth parameter is negative but is only significantly different from zero in one of the specifications.

3.4.2 Internet diffusion

The results for Internet diffusion are presented in Tables 5-8 in a way analogous to those for mobile phone diffusion. The results in columns (1) and (2) are based on a value of γ equal to 100. The results in the other columns are based on the predicted values of γ_i for each country. Tables 5-7 present the results for each category of explanatory variable separately. The results from the full regression containing all explanatory variables are presented in Table 8. The results for each of the categories of explanatory variables will now be discussed in turn.

3.4.2.1 Geographic Factors

The results of the regressions containing only geographic variables are presented in Table 5. As was the case with mobile phones, these variables are correlated with a number of other variables, in particular GDP p.c. and fixed line telephones and the values of the estimates change when these variables are included. The results for the regression containing all explanatory variables are presented in Table 8. In this table, the location parameters for all of the geographic variables are negative but none are significantly different from zero suggesting that geographic variables are not that important in explaining rates of Internet adoption.

3.4.2.2 Institutional Factors

The results for the regression containing just institutional variables are presented in Table 6. However, as was the case with the geographic variables, the estimates change quite a lot when GDP p.c. and fixed line telephones are included so the following discussion will focus on the estimates from the full regression which are presented in Table 8.

As in the case of mobile phone diffusion, there is evidence that regulatory quality is important for Internet adoption. The location parameter is positive and strongly significant. The growth parameter is negative and significant suggesting that the initial effect diminishes over time.

However, the other institutional variables do not seem to be as important for Internet diffusion as they were for mobile phone diffusion. The location parameter for the democracy dummy is positive but not significantly different from zero. The equivalent parameter for the autocracy dummy is negative but is also not significantly different from zero in any of the specifications.

There is not strong evidence that the type of competition in the Internet market has an important effect on rates of Internet use as none of the location parameters are significantly different from zero. The growth parameter for internet services monopoly dummy is positive and significantly different from zero. The location parameter for this variable is negative suggesting that a monopoly in this sector could be associated with lower rates of Internet adoption. However, it is not significantly different from zero.

As was the case for mobile phones, the location parameter for legal origins that come from common law is negative but is not significantly different from zero. However, the growth parameter for this variable is positive and significantly different from zero suggesting that this variable may have an effect on Internet adoption.

3.4.2.3 Economic Factors

The economic variables seem to be the most important for understanding rates of Internet use. The results for the regression containing only economic variables are presented in Table 7. As can be seen from Table 8, these results do not change dramatically when other variables are included in the regression. The

location parameter for GDP p.c. is negative but is not significantly different from zero in the specifications presented in Table 8. This is somewhat surprising as we would expect this parameter to be positive. However, the results for GDP p.c. change significantly when the number of fixed line telephones is included. Table 9 presents results for regressions containing just GDP p.c. or GDP p.c and fixed line telephones.[10] As we can see from the results in this table, the location parameter for GDP p.c is positive if the number of fixed telephone lines is not included in the regression but becomes negative if this variable is included. The location parameter for fixed line telephones in Table 8 is positive and significantly different from zero. As the number of fixed telephone lines is positively related to GDP p.c. and also to the level of Internet use this suggests that the main way in which GDP p.c. is positively related to Internet use could be through investment in telecommunications infrastructure. If the inclusion of fixed telephone lines captures some of the effect of investment in telecommunications then it is less surprising that the location parameter for GDP p.c. becomes smaller and could be negative, as it is possible that poorer countries have more to gain from Internet use. The growth parameter for fixed telephone lines is negative which means that these effects become smaller over time.

The location parameters for the lower literacy dummies are negative and significant. This is consistent with what we would expect since it is necessary to be literate in order to use the Internet. The growth parameters for these variables are positive and significant suggesting that this effect diminishes over time.

As was the case with mobile phones, the location parameters for the proportion of GDP coming from the services sector and agriculture are positive and negative, respectively. The magnitude of the location parameter for agriculture is similar in magnitude to that for mobile phones and is significantly different from zero. However, the growth parameter is not significantly different from zero which could mean that this effect is persistent over time. The location parameter for the services variable is smaller than that for mobile phones and is not significantly different from zero.

3.4.3 Discussion

The results presented above suggest that the institutional environment can have a significant influence on the process of technology diffusion. This is perhaps not

[10] Regional dummies are also included in these regressions but the results are not reported.

surprising given the large investment costs required to provide the infrastructure necessary to use these technologies. Some degree of coordination at a national, or at least regional, level is required in order to make sure this infrastructure is in place. In particular, the quality of government regulation seems to be positively related to rates of mobile phone and Internet adoption. It is also necessary to have a population which is sufficiently well-educated that they are able to use the technology. Other institutional and geographic variables seem to be more strongly related to the process of diffusion of mobile phones than for the Internet. In particular, having a strong and stable government seems to be more important for mobile phone adoption. As the process of Internet adoption is still not that advanced in most countries, it could be that it is not yet possible to precisely estimate the relationship between these variables and rates of Internet adoption later in the diffusion process.

3.5 Conclusion

Although there has been a rapid increase in the use of ICTs in the past few years, a large portion of the world's population still do not have access to these technologies and we have reason to be concerned that some countries are being left behind. Given the huge potential that these technologies have for development, it is important for us to try and understand the main barriers to adoption of these technologies.

This paper used a logistic model of technology diffusion to investigate the relationship between rates of mobile phone and Internet use and a number of geographic, institutional and economic variables. The results suggest that countries with better regulatory quality, high literacy rates and a smaller agricultural sector have higher rates of mobile phone and Internet use. In addition, it seems that countries which have lower levels of fixed line telephones also have lower rates of use of other ICTs. The relationship between a number of institutional variables and income per capita and the process of ICT diffusion differs between mobile phones and the Internet and it is possible that these differences could be explained by the differences between these technologies both in terms of the cost involved in providing the infrastructure and the different ways in which these technologies are used.

Of course, all of these variables may be correlated with a number of other factors which may influence rates of ICT use and it is very difficult to know the

specific ways in which they affect the process of technology diffusion. However, the results from this paper do give us an idea of the main characteristics of countries which have been successful in adopting ICTs. Though perhaps unsurprising, the picture to emerge from this analysis is somewhat discouraging from a development perspective as it seems that the countries which have been most successful at adopting ICTs have also been more successful in a number of other ways. The unfortunate consequence of this could be that individuals who might benefit the most from ICTs are the ones who are least likely to have access to them.

Given that large scale investments in infrastructure are required to ensure access to these technologies, which often require coordination or oversight by governments, a deeper analysis of the policies implemented by governments in countries which have achieved high rates of ICT use could give us greater insight into how this process works. It would be particularly useful to understand why a few countries in sub-Saharan Africa have achieved great success in this regard while most are lagging far behind. Given the great potential that ICTs hold for development it is important for us to try and understand where these differences come from.

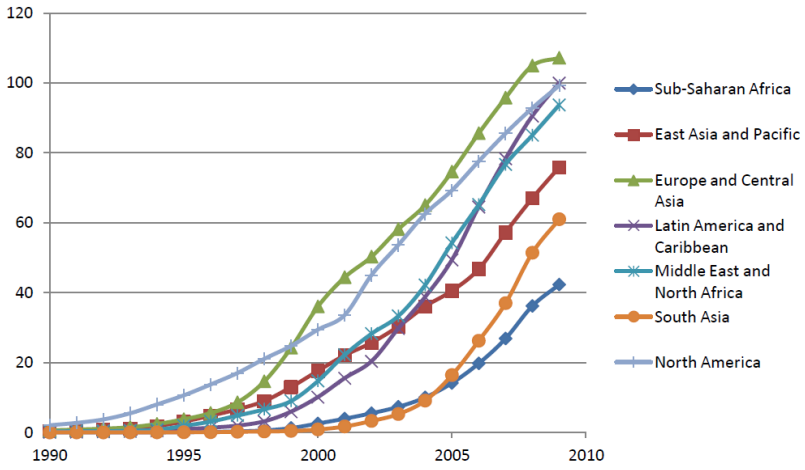


Figure 3.1: Mobile phone subscriptions per 100 by geographic region

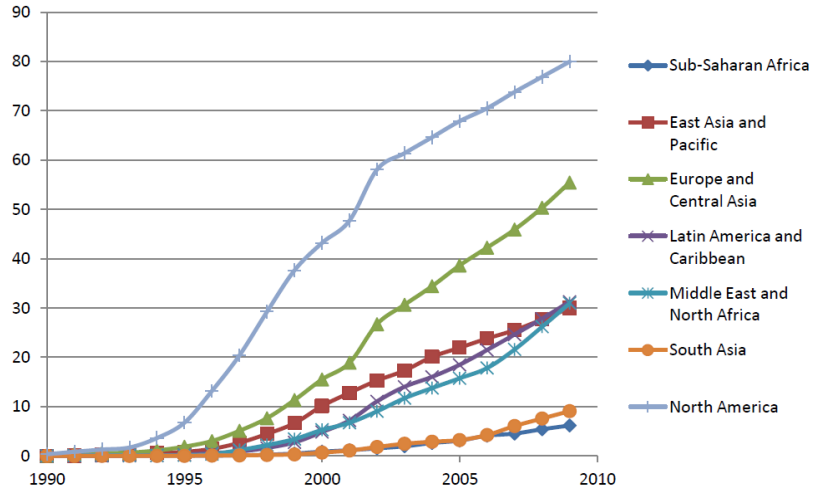


Figure 3.2: Internet users per 100 by geographic region

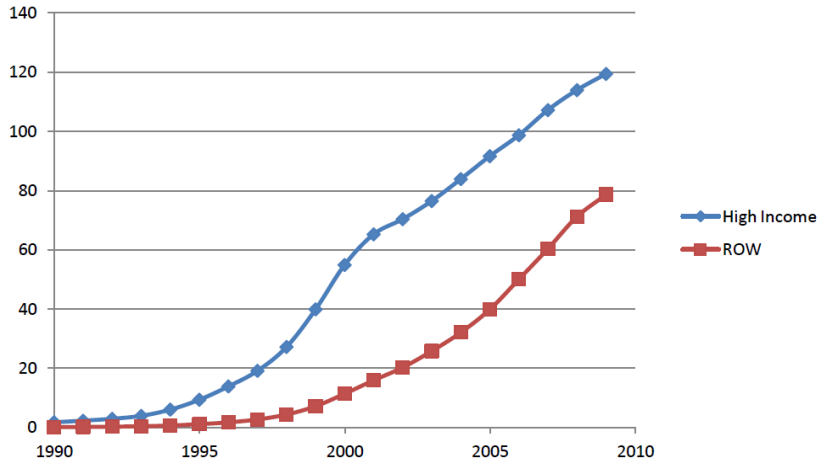


Figure 3.3: Mobile phone subscriptions per 100 by income level

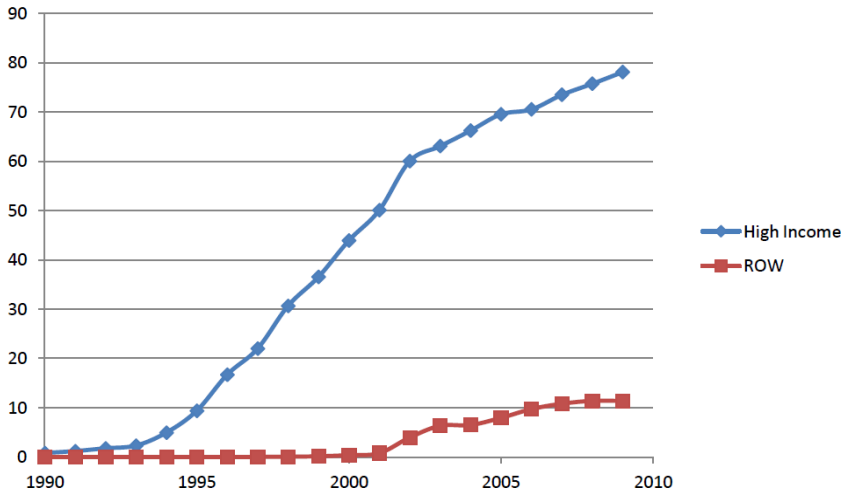


Figure 3.4: Internet users per 100 by income level

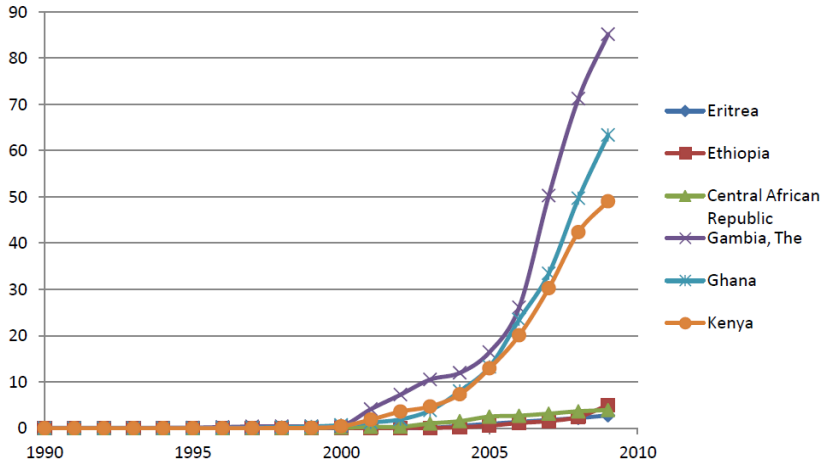


Figure 3.5: Mobile phone subscriptions per 100 for a selection of countries in Africa

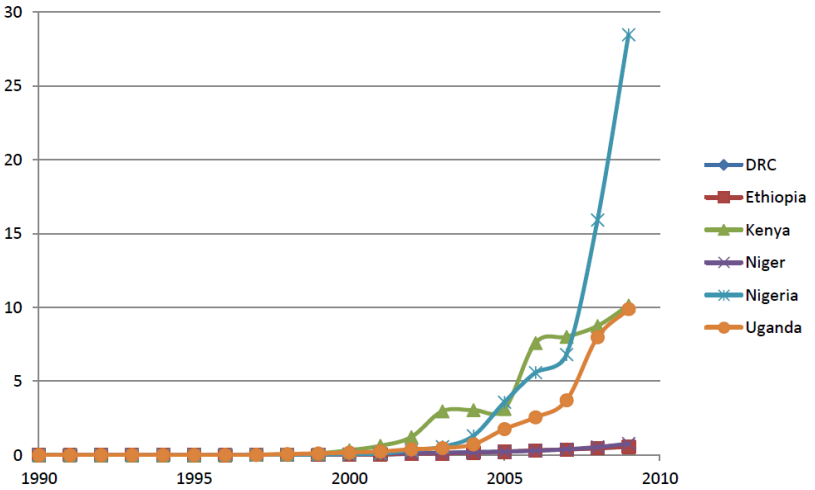


Figure 3.6: Internet users per 100 for a selection of countries in Africa

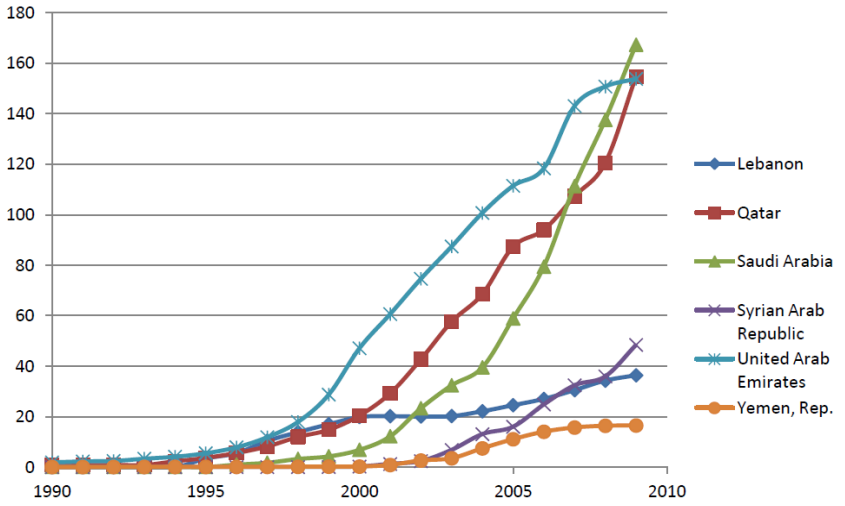


Figure 3.7: Mobile phone subscriptions per 100 for a selection of countries in the Middle East

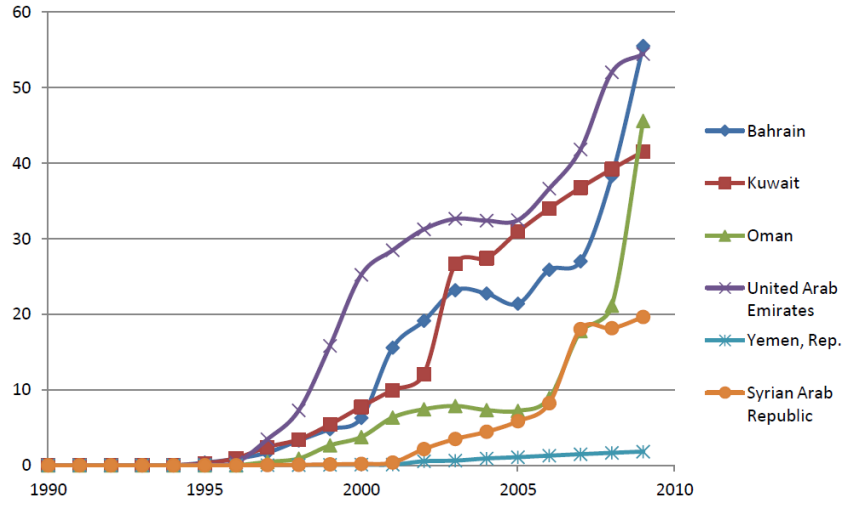


Figure 3.8: Internet users per 100 for a selection of countries in the Middle East

Table 1: Geographic variables and rates of mobile phone use

	γ=205		predicted γ1		predicted γ2		predicted γ3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOCATION								
Rugged	0.770***	0.0262	0.860***	0.121	0.853***	0.128	0.728***	0.00480
	(0.245)	(0.184)	(0.255)	(0.191)	(0.251)	(0.190)	(0.252)	(0.192)
Pop Density	-6.04e-05	-0.000473**	-2.28e-05	-0.000284	5.24e-05	-0.000266	-0.000214	-0.000539***
	(0.000472)	(0.000201)	(0.000474)	(0.000197)	(0.000466)	(0.000199)	(0.000437)	(0.000194)
Rural Pop	-0.144***	-6.53e-05	-0.122***	0.0130	-0.118***	0.0181	-0.121***	0.0152
	(0.0173)	(0.0139)	(0.0185)	(0.0150)	(0.0181)	(0.0151)	(0.0181)	(0.0152)
GDPpc		3.86e-05		2.25e-05		4.96e-05		3.76e-05
		(3.99e-05)		(4.20e-05)		(4.16e-05)		(4.13e-05)
Fixed Telephones		0.228***		0.210***		0.208***		0.215***
		(0.0266)		(0.0279)		(0.0282)		(0.0286)
Low Literacy		-7.025***		-6.640***		-6.335***		-6.492***
		(1.353)		(1.385)		(1.395)		(1.387)
Medium Low Literacy		-3.505***		-3.187***		-2.880***		-2.982***
		(0.898)		(0.925)		(0.942)		(0.938)
Medium Literacy		-2.979***		-2.745***		-2.414***		-2.440***
		(0.743)		(0.764)		(0.773)		(0.775)
Medium High Literacy		-0.498		-0.312		-0.0521		-0.0162
		(0.597)		(0.619)		(0.629)		(0.631)
GROWTH								
Rugged	-0.0292***	-0.00368	-0.0332***	-0.00849	-0.0329***	-0.00854	-0.0240**	0.000258
	(0.00927)	(0.00706)	(0.00981)	(0.00745)	(0.00964)	(0.00745)	(0.00971)	(0.00755)
Pop Density	7.47e-06	1.82e-05**	4.52e-06	7.09e-06	8.42e-07	6.49e-06	1.64e-05	2.24e-05***
	(1.95e-05)	(8.19e-06)	(1.98e-05)	(8.12e-06)	(1.94e-05)	(8.27e-06)	(1.82e-05)	(8.11e-06)
Rural Pop	0.00413***	-0.000600	0.00281***	-0.00135**	0.00265***	-0.00163***	0.00278***	-0.00149**
	(0.000677)	(0.000555)	(0.000742)	(0.000619)	(0.000727)	(0.000627)	(0.000727)	(0.000627)
GDPpc		-1.36e-06		-1.80e-07		-1.45e-06		-8.96e-07
		(1.52e-06)		(1.65e-06)		(1.63e-06)		(1.62e-06)
Fixed Telephones		-0.00729***		-0.00634***		-0.00639***		-0.00671***
		(0.00103)		(0.00112)		(0.00114)		(0.00116)
Low Literacy		0.226***		0.209***		0.195***		0.203***
		(0.0619)		(0.0635)		(0.0640)		(0.0636)

Table 1 (cont.): Geographic variables and rates of mobile phone use

	γ=205		predicted γ1		predicted γ2		predicted γ3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GROWTH								
Medium Low Literacy		0.116***		0.102***		0.0876**		0.0933**
		(0.0356)		(0.0370)		(0.0379)		(0.0377)
Medium Literacy		0.0827***		0.0727**		0.0568*		0.0585*
		(0.0292)		(0.0303)		(0.0308)		(0.0309)
Medium High Literacy		0.00370		-0.00355		-0.0159		-0.0175
		(0.0233)		(0.0246)		(0.0252)		(0.0253)
t	0.282***	0.523***	0.389***	0.601***	0.407***	0.638***	0.387***	0.616***
	(0.0459)	(0.0403)	(0.0497)	(0.0437)	(0.0493)	(0.0454)	(0.0492)	(0.0453)
Constant	-8.165***	-15.33***	-9.522***	-16.30***	-9.902***	-16.97***	-9.537***	-16.59***
	(1.191)	(1.036)	(1.259)	(1.090)	(1.247)	(1.126)	(1.246)	(1.124)
Observations	1266	1266	1266	1266	1266	1266	1266	1266
R-squared	0.756	0.851	0.770	0.860	0.776	0.859	0.775	0.857

Notes:

(i) Regression of $\ln(y_{it}/(y_{it}^{*}-y_{it}))$ on geographic variables.

(ii) $y_{it}^{*}=\gamma_i Population_i$

(iii) In the first specification, γ is constant and set equal to 205. In the following three specifications γ_{it} is a predicted value based on the results of regressions of the number of mobile phone subscriptions in 2009 on various explanatory variables for a subsample of countries that have achieved a high level of mobile phone penetration.

(iv) Regional dummies included in all regressions.

(v) Robust standard errors in parentheses

(vi) *** p<0.01, ** p<0.05, * p<0.1

Table 2: Institutional variables and rates of mobile phone use

	γ=205		predicted γ1		predicted γ2		predicted γ3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOCATION								
Democratic	2.565***	1.798***	2.606***	1.876***	2.643***	1.969***	2.481***	1.769***
	(0.618)	(0.564)	(0.643)	(0.591)	(0.648)	(0.606)	(0.641)	(0.598)
Autocratic	1.832**	1.189*	1.850**	1.336*	1.824**	1.298*	1.872**	1.294*
	(0.766)	(0.688)	(0.784)	(0.701)	(0.807)	(0.722)	(0.795)	(0.716)
Regulatory Quality	3.534***	1.444***	2.996***	1.127***	3.150***	1.297***	3.154***	1.230***
	(0.332)	(0.362)	(0.342)	(0.378)	(0.349)	(0.395)	(0.345)	(0.379)
Mobile Monopoly	-0.546	-0.221	-0.0858	0.259	0.213	0.541	0.117	0.457
	(0.640)	(0.561)	(0.659)	(0.580)	(0.668)	(0.594)	(0.667)	(0.591)
Mobile Partial Comp	0.622	0.936**	0.376	0.638	0.597	0.892*	0.643	0.944**
	(0.494)	(0.457)	(0.513)	(0.469)	(0.515)	(0.476)	(0.513)	(0.474)
Common Law	0.579	0.574	0.555	0.505	0.419	0.369	0.485	0.452
	(0.557)	(0.509)	(0.581)	(0.531)	(0.598)	(0.552)	(0.600)	(0.554)
GDPpc		0.000106***		9.52e-05**		0.000119***		0.000113***
		(3.80e-05)		(4.01e-05)		(4.25e-05)		(4.24e-05)
Fixed Telephones		0.121***		0.105***		0.0905***		0.101***
		(0.0238)		(0.0261)		(0.0297)		(0.0280)
GROWTH								
Democratic	-0.0883***	-0.0617***	-0.0904***	-0.0657***	-0.0928***	-0.0703***	-0.0857***	-0.0615**
	(0.0240)	(0.0221)	(0.0254)	(0.0236)	(0.0258)	(0.0244)	(0.0255)	(0.0240)
Autocratic	-0.0694**	-0.0477*	-0.0684**	-0.0543*	-0.0678**	-0.0528*	-0.0706**	-0.0534*
	(0.0303)	(0.0272)	(0.0314)	(0.0281)	(0.0327)	(0.0293)	(0.0320)	(0.0289)
Regulatory Quality	-0.0987***	-0.0255*	-0.0661***	-0.00651	-0.0751***	-0.0148	-0.0752***	-0.0120
	(0.0131)	(0.0144)	(0.0137)	(0.0153)	(0.0141)	(0.0162)	(0.0139)	(0.0154)
Mobile Monopoly	0.00422	-0.00897	-0.0174	-0.0313	-0.0322	-0.0453*	-0.0268	-0.0405
	(0.0268)	(0.0239)	(0.0280)	(0.0250)	(0.0286)	(0.0258)	(0.0285)	(0.0257)
Mobile Partial Comp	-0.0233	-0.0349**	-0.0128	-0.0208	-0.0234	-0.0331*	-0.0257	-0.0355*
	(0.0190)	(0.0177)	(0.0201)	(0.0185)	(0.0203)	(0.0189)	(0.0202)	(0.0188)
Common Law	-0.0189	-0.0183	-0.0185	-0.0158	-0.0117	-0.00894	-0.0149	-0.0128
	(0.0219)	(0.0202)	(0.0233)	(0.0215)	(0.0242)	(0.0226)	(0.0243)	(0.0227)

Table 2 (cont.): Institutional variables and rates of mobile phone use

	γ=205		predicted γ1		predicted γ2		predicted γ3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GROWTH								
GDPpc		-4.54e-06***		-3.64e-06**		-4.74e-06***		-4.41e-06***
		(1.45e-06)		(1.58e-06)		(1.70e-06)		(1.70e-06)
Fixed Telephones		-0.00377***		-0.00292***		-0.00239**		-0.00288**
		(0.000915)		(0.00105)		(0.00122)		(0.00114)
t	0.539***	0.582***	0.586***	0.615***	0.591***	0.622***	0.590***	0.623***
	(0.0262)	(0.0258)	(0.0285)	(0.0280)	(0.0299)	(0.0296)	(0.0292)	(0.0286)
Constant	-16.66***	-17.90***	-17.04***	-18.04***	-17.10***	-18.12***	-17.08***	-18.15***
	(0.659)	(0.643)	(0.703)	(0.685)	(0.729)	(0.715)	(0.716)	(0.696)
Observations	1,266	1266	1,266	1266	1,266	1266	1,266	1266
R-squared	0.855	0.876	0.866	0.885	0.861	0.879	0.862	0.880

Notes:

(i) Regression of $\ln(y_{it}/(y_{it}^{*}-y_{it}))$ on institutional variables.

(ii) $y_{it}^{*}=\gamma_i Population_i$

(iii) In the first specification, γ is constant and set equal to 205. In the following three specifications γ_{it} is a predicted value based on the results of regressions of the number of mobile phone subscriptions in 2009 on various explanatory variables for a subsample of countrie that have achieved a high level of mobile phone penetration.

(iv) Regional dummies included in all regressions.

(v) Robust standard errors in parentheses

(vi) *** p<0.01, ** p<0.05, * p<0.1

Table 3: Economic variables and rates of mobile phone use

	γ=205		predicted γ1		predicted γ2		predicted γ3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LOCATION	GROWTH	LOCATION	GROWTH	LOCATION	GROWTH	LOCATION	GROWTH
GDPpc	8.63e-05**	-3.32e-06**	7.02e-05*	-2.14e-06	9.70e-05**	-3.37e-06**	8.67e-05**	-2.81e-06*
	(3.92e-05)	(1.48e-06)	(4.19e-05)	(1.65e-06)	(4.28e-05)	(1.69e-06)	(4.27e-05)	(1.69e-06)
Low Literacy	-3.891*	0.128	-4.070*	0.138	-3.739*	0.121	-3.726*	0.116
	(2.128)	(0.0966)	(2.121)	(0.0963)	(2.135)	(0.0970)	(2.117)	(0.0962)
Medium Low Literacy	-3.407***	0.145***	-3.712***	0.163***	-3.461***	0.150***	-3.346***	0.142***
	(0.961)	(0.0387)	(0.993)	(0.0407)	(1.017)	(0.0420)	(1.000)	(0.0412)
Medium Literacy	-1.692**	0.0663**	-1.894**	0.0785**	-1.611**	0.0642*	-1.601**	0.0615*
	(0.773)	(0.0310)	(0.799)	(0.0326)	(0.810)	(0.0333)	(0.802)	(0.0329)
Medium High Literacy	-0.292	0.0121	-0.226	0.0112	0.0597	-0.00270	0.161	-0.00892
	(0.565)	(0.0226)	(0.593)	(0.0243)	(0.610)	(0.0252)	(0.604)	(0.0249)
Services	0.0658***	-0.00230**	0.0629**	-0.00212**	0.0734***	-0.00258**	0.0682***	-0.00231**
	(0.0247)	(0.000946)	(0.0256)	(0.000998)	(0.0258)	(0.00102)	(0.0256)	(0.00101)
Agriculture	-0.0637**	0.000484	-0.0360	-0.000940	-0.0298	-0.00120	-0.0333	-0.000965
	(0.0251)	(0.000992)	(0.0260)	(0.00105)	(0.0261)	(0.00106)	(0.0258)	(0.00105)
Fixed Telephones	0.129***	-0.00385***	0.116***	-0.00306**	0.108***	-0.00284**	0.117***	-0.00331***
	(0.0279)	(0.00108)	(0.0295)	(0.00119)	(0.0306)	(0.00125)	(0.0306)	(0.00124)
t_mobile		0.552***		0.590***		0.637***		0.622***
		(0.0520)		(0.0548)		(0.0565)		(0.0552)
Constant	-16.63***		-16.96***		-17.91***		-17.64***	
	(1.380)		(1.425)		(1.450)		(1.425)	
Observations		1266		1266		1266		1266
R-squared		0.874		0.878		0.875		0.875

Notes:

(i) Regression of $\ln(y_{it}/(y_{it}^{*}-y_{it}))$ on economic variables.

(ii) $y_{it}^{*}=\gamma_i Population_i$

(iii) In the first specification, γ is constant and set equal to 205. In the following three specifications γ_{it} is a predicted value based on the results of regressions of the number of mobile phone subscriptions in 2009 on various explanatory variables for a subsample of countries that have achieved a high level of mobile phone penetration.

(iv) Regional dummies included in all regressions.

(v) Robust standard errors in parentheses

(vi) *** p<0.01, ** p<0.05, * p<0.1

Table 4: All variables and rates of mobile phone use

	γ=205		predicted γ1		predicted γ2		predicted γ3	
	(1) LOCATION	(2) GROWTH	(3) LOCATION	(4) GROWTH	(5) LOCATION	(6) GROWTH	(7) LOCATION	(8) GROWTH
Rugged	0.107	-0.00533	0.197	-0.00975	0.188	-0.00901	0.0617	2.69e-05
	(0.161)	(0.00620)	(0.164)	(0.00639)	(0.165)	(0.00648)	(0.168)	(0.00668)
Pop Density	-0.000630**	2.53e-05**	-0.000495**	1.61e-05	-0.000493**	1.61e-05	-0.000787***	3.30e-05***
	(0.000246)	(9.96e-06)	(0.000242)	(9.93e-06)	(0.000245)	(1.01e-05)	(0.000230)	(9.48e-06)
Rural Pop	0.000828	-0.000346	0.00754	-0.000800	0.0144	-0.00116**	0.00995	-0.000946*
	(0.0133)	(0.000524)	(0.0137)	(0.000554)	(0.0140)	(0.000573)	(0.0139)	(0.000567)
Democratic	0.903*	-0.0259	0.897*	-0.0264	1.030*	-0.0330	0.942*	-0.0289
	(0.516)	(0.0202)	(0.529)	(0.0211)	(0.538)	(0.0216)	(0.537)	(0.0215)
Autocratic	1.173**	-0.0510**	1.286**	-0.0565**	1.269**	-0.0560**	1.423**	-0.0636**
	(0.595)	(0.0237)	(0.605)	(0.0245)	(0.621)	(0.0254)	(0.613)	(0.0250)
Regulatory Quality	1.271***	-0.0231	1.065***	-0.00907	1.248***	-0.0181	1.205***	-0.0166
	(0.389)	(0.0154)	(0.393)	(0.0159)	(0.413)	(0.0170)	(0.403)	(0.0165)
Mobile Monopoly	0.224	-0.0250	0.604	-0.0416*	0.910*	-0.0568**	1.069**	-0.0652***
	(0.514)	(0.0220)	(0.533)	(0.0233)	(0.547)	(0.0241)	(0.542)	(0.0238)
Mobile Partial Comp	1.230***	-0.0463***	0.986**	-0.0347**	1.255***	-0.0478***	1.218***	-0.0461***
	(0.412)	(0.0160)	(0.417)	(0.0166)	(0.422)	(0.0168)	(0.421)	(0.0168)
Common Law	-0.0260	0.00481	-0.158	0.0109	-0.330	0.0193	-0.282	0.0169
	(0.452)	(0.0177)	(0.460)	(0.0183)	(0.475)	(0.0191)	(0.479)	(0.0193)
GDPpc	0.000153***	-6.53e-06***	0.000150***	-6.06e-06***	0.000176***	-7.29e-06***	0.000164***	-6.69e-06***
	(3.43e-05)	(1.32e-06)	(3.53e-05)	(1.39e-06)	(3.85e-05)	(1.55e-06)	(3.86e-05)	(1.56e-06)
Low Literacy	-4.000**	0.114	-4.162**	0.122	-4.115**	0.119	-4.231**	0.126
	(1.783)	(0.0825)	(1.781)	(0.0827)	(1.773)	(0.0821)	(1.769)	(0.0819)
Medium Low Literacy	-2.385**	0.0895**	-2.233**	0.0843**	-1.947**	0.0703*	-2.041**	0.0752*
	(0.933)	(0.0376)	(0.944)	(0.0383)	(0.959)	(0.0390)	(0.953)	(0.0387)
Medium Literacy	-2.033***	0.0719**	-1.997***	0.0723**	-1.679**	0.0564*	-1.708**	0.0584**
	(0.725)	(0.0285)	(0.728)	(0.0287)	(0.732)	(0.0290)	(0.734)	(0.0292)
Medium High Literacy	-0.0366	-0.00396	0.111	-0.00876	0.385	-0.0218	0.445	-0.0246
	(0.499)	(0.0201)	(0.517)	(0.0211)	(0.536)	(0.0222)	(0.533)	(0.0220)
Services	0.0409*	-0.00200**	0.0421*	-0.00208**	0.0469*	-0.00227**	0.0477**	-0.00232**
	(0.0237)	(0.000915)	(0.0238)	(0.000931)	(0.0242)	(0.000955)	(0.0242)	(0.000952)

Table 4 (cont.): Rates of mobile phone use and all explanatory variables

	γ=205		predicted γ1		predicted γ2		predicted γ3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LOCATION	GROWTH	LOCATION	GROWTH	LOCATION	GROWTH	LOCATION	GROWTH
Agriculture	-0.0600**	0.00102	-0.0440*	0.000275	-0.0406	0.000135	-0.0404	0.000106
	(0.0257)	(0.00103)	(0.0257)	(0.00104)	(0.0258)	(0.00105)	(0.0257)	(0.00105)
Fixed Telephones	0.0635***	-0.00195**	0.0506**	-0.00132	0.0410	-0.00103	0.0510*	-0.00147
	(0.0231)	(0.000898)	(0.0254)	(0.00103)	(0.0286)	(0.00118)	(0.0281)	(0.00116)
t_mobile		0.580***		0.665***		0.716***		0.694***
		(0.0545)		(0.0557)		(0.0590)		(0.0582)
Constant	-15.90***		-16.96***		-17.97***		-17.57***	
	(1.424)		(1.433)		(1.493)		(1.477)	
Observations		1,266		1,266		1,266		1,266
R-squared		0.913		0.920		0.917		0.916

Notes:

(i) Regression of $\ln(y_{it}/(y_{it}^{*}-y_{it}))$ on all explanatory variables.

(ii) $y_{it}^{*}=\gamma_i Population_i$

(iii) In the first specification, γ is constant and set equal to 205. In the following three specifications γ_{it} is a predicted value based on the results of regressions of the number of mobile phone subscriptions in 2009 on various explanatory variables for a subsample of countrie that have achieved a high level of mobile phone penetration.

(iv) Regional dummies included in all regressions.

(v) Robust standard errors in parentheses

(vi) *** p<0.01, ** p<0.05, * p<0.1

Table 5: Geographic variables and rates of Internet use

	γ=205		predicted γ1		predicted γ2		predicted γ3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOCATION								
Rugged	0.0578	-0.0778	0.0889	-0.0375	0.0781	-0.0468	0.0543	-0.0691
	(0.164)	(0.123)	(0.167)	(0.125)	(0.169)	(0.124)	(0.189)	(0.131)
Pop Density	5.29e-05	-0.000133	-6.72e-05	-0.000197	-7.63e-05	-0.000190	-0.000120	-0.000219
	(0.000262)	(0.000137)	(0.000251)	(0.000133)	(0.000249)	(0.000133)	(0.000263)	(0.000145)
Rural Pop	-0.113***	-0.0380***	-0.109***	-0.0361***	-0.109***	-0.0365***	-0.119***	-0.0432***
	(0.0160)	(0.0113)	(0.0163)	(0.0114)	(0.0164)	(0.0114)	(0.0179)	(0.0127)
GDPpc		-7.17e-05**		-8.79e-05***		-9.07e-05***		-0.000115***
		(2.90e-05)		(3.04e-05)		(3.06e-05)		(3.02e-05)
Fixed Telephones		0.168***		0.167***		0.168***		0.182***
		(0.0196)		(0.0202)		(0.0202)		(0.0210)
GROWTH								
Rugged	-0.00243	0.00306	-0.00536	-0.00103	-0.00405	-5.77e-05	0.00261	0.00624
	(0.0102)	(0.00783)	(0.0105)	(0.00808)	(0.0107)	(0.00802)	(0.0122)	(0.00844)
Pop Density	5.74e-06	5.85e-06	1.99e-05	1.40e-05	2.09e-05	1.31e-05	2.97e-05*	1.97e-05**
	(1.66e-05)	(8.92e-06)	(1.61e-05)	(8.88e-06)	(1.59e-05)	(8.87e-06)	(1.68e-05)	(9.84e-06)
Rural Pop	0.00450***	0.00128*	0.00417***	0.00126*	0.00417***	0.00134*	0.00439***	0.00150*
	(0.000997)	(0.000709)	(0.00103)	(0.000720)	(0.00103)	(0.000717)	(0.00113)	(0.000793)
GDPpc		5.10e-06***		6.82e-06***		7.53e-06***		9.00e-06***
		(1.83e-06)		(1.96e-06)		(1.97e-06)		(1.95e-06)
Fixed Telephones		-0.00675***		-0.00642***		-0.00662***		-0.00706***
		(0.00124)		(0.00130)		(0.00129)		(0.00133)
t	0.142**	0.374***	0.166**	0.378***	0.163**	0.372***	0.149**	0.362***
	(0.0678)	(0.0499)	(0.0699)	(0.0507)	(0.0701)	(0.0505)	(0.0756)	(0.0547)
Constant	-3.921***	-9.251***	-3.832***	-9.044***	-3.845***	-9.054***	-3.804***	-9.250***
	(1.102)	(0.814)	(1.122)	(0.820)	(1.126)	(0.818)	(1.219)	(0.899)
Observations	1,142	1142	1,142	1142	1,142	1142	1,142	1142
R-squared	0.762	0.859	0.755	0.858	0.753	0.861	0.752	0.861

Notes:

(i) Regression of $\ln(y_{it}/(y_{it}^{*}-y_{it}))$ on geographic variables.

(ii) $y_{it}^{*}=\gamma_i \text{Population}_i$

(iii) In the first specification, γ is constant and set equal to 205. In the following three specifications γ_{it} is a predicted value based on results of regressions of the number of Internet users in 2009 on various explanatory variables for a subsample of countries that ha achieved a high level of Internet penetration.

(iv) Regional dummies included in all regressions.

(v) Robust standard errors in parentheses

(vi) *** p<0.01, ** p<0.05, * p<0.1

Table 6: Institutional variables and rates of Internet use

	γ=205		predicted γ1		predicted γ2		predicted γ3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOCATION								
Democratic	1.852**	0.460	1.915**	0.506	1.939***	0.501	2.048**	0.461
	(0.738)	(0.638)	(0.747)	(0.642)	(0.747)	(0.641)	(0.807)	(0.683)
Autocratic	-0.548	-0.589	-0.596	-0.543	-0.583	-0.552	-0.767	-0.638
	(1.179)	(1.031)	(1.182)	(1.029)	(1.182)	(1.026)	(1.233)	(1.062)
Regulatory Quality	2.497***	1.168***	2.312***	1.085***	2.322***	1.124***	2.441***	1.226***
	(0.247)	(0.241)	(0.252)	(0.244)	(0.253)	(0.242)	(0.274)	(0.263)
DSL Monopoly	-0.438	-0.186	-0.367	-0.108	-0.384	-0.118	-0.292	-0.0391
	(0.605)	(0.539)	(0.602)	(0.536)	(0.602)	(0.534)	(0.634)	(0.554)
DSL Partial Comp	-1.765***	-1.328**	-1.677***	-1.214**	-1.706***	-1.226**	-1.700***	-1.204**
	(0.560)	(0.548)	(0.565)	(0.550)	(0.564)	(0.549)	(0.575)	(0.550)
Int. Services Monopoly	-0.879	-0.777	-0.913	-0.793	-0.916	-0.793	-0.901	-0.736
	(0.711)	(0.633)	(0.706)	(0.629)	(0.706)	(0.627)	(0.739)	(0.655)
Int. Services Partial Comp	1.530***	1.234**	1.454***	1.176**	1.468***	1.199**	1.503**	1.227**
	(0.549)	(0.531)	(0.548)	(0.530)	(0.547)	(0.529)	(0.594)	(0.567)
Common Law	-0.0441	-0.000871	-0.0943	-0.0444	-0.0937	-0.0271	0.0535	0.128
	(0.458)	(0.384)	(0.460)	(0.385)	(0.461)	(0.385)	(0.496)	(0.414)
GDPpc		0.136***		0.132***		0.133***		0.149***
		(0.0187)		(0.0194)		(0.0193)		(0.0201)
Fixed Telephones		-0.0121		-0.0154		-0.0148		-0.0142
		(0.0254)		(0.0257)		(0.0256)		(0.0273)
GROWTH								
Democratic	-0.0595**	-6.21e-05**	-0.0636**	-7.27e-05**	-0.0647**	-7.70e-05***	-0.0692**	-0.000107***
	(0.0293)	(2.73e-05)	(0.0300)	(2.88e-05)	(0.0300)	(2.94e-05)	(0.0324)	(2.97e-05)
Autocratic	0.0302	0.0212	0.0322	0.0183	0.0320	0.0186	0.0427	0.0242
	(0.0475)	(0.0414)	(0.0479)	(0.0415)	(0.0479)	(0.0414)	(0.0499)	(0.0427)
Regulatory Quality	-0.0936***	-0.0455***	-0.0721***	-0.0359**	-0.0719***	-0.0402**	-0.0693***	-0.0416**
	(0.0162)	(0.0156)	(0.0169)	(0.0161)	(0.0171)	(0.0160)	(0.0186)	(0.0172)
DSL Monopoly	0.0209	0.0111	0.0115	0.00197	0.0124	0.00307	0.00647	-0.00153
	(0.0396)	(0.0351)	(0.0397)	(0.0351)	(0.0397)	(0.0350)	(0.0419)	(0.0364)

Table 6 (cont.): Institutional variables and rates of Internet use

	γ=205		predicted γ1		predicted γ2		predicted γ3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GROWTH								
DSL	0.0668*	0.0448	0.0568	0.0335	0.0591	0.0349	0.0605	0.0357
Partial Comp	(0.0359)	(0.0350)	(0.0370)	(0.0356)	(0.0369)	(0.0355)	(0.0372)	(0.0352)
Int. Services	0.0720	0.0535	0.0782	0.0572	0.0788	0.0570	0.0700	0.0440
Monopoly	(0.0499)	(0.0443)	(0.0497)	(0.0439)	(0.0498)	(0.0438)	(0.0522)	(0.0462)
Int. Services	-0.0767**	-0.0660*	-0.0669*	-0.0581*	-0.0677*	-0.0599*	-0.0759*	-0.0687*
Partial Comp	(0.0367)	(0.0351)	(0.0370)	(0.0352)	(0.0369)	(0.0351)	(0.0398)	(0.0375)
Common Law	0.0417	0.0382	0.0457	0.0411	0.0454	0.0391	0.0359	0.0288
	(0.0293)	(0.0248)	(0.0299)	(0.0253)	(0.0299)	(0.0252)	(0.0323)	(0.0272)
GDPpc		3.51e-06**		4.72e-06**		5.58e-06***		7.49e-06***
		(1.73e-06)		(1.87e-06)		(1.92e-06)		(1.95e-06)
Fixed		-0.00500***		-0.00460***		-0.00478***		-0.00536***
Telephones		(0.00117)		(0.00124)		(0.00124)		(0.00128)
t	0.380***	0.406***	0.395***	0.414***	0.395***	0.411***	0.418***	0.430***
	(0.0302)	(0.0284)	(0.0306)	(0.0286)	(0.0306)	(0.0284)	(0.0333)	(0.0308)
Constant	-10.05***	-10.89***	-9.814***	-10.58***	-9.850***	-10.60***	-10.60***	-11.35***
	(0.468)	(0.438)	(0.469)	(0.437)	(0.470)	(0.436)	(0.506)	(0.471)
Observations	1,142	1142	1,142	1142	1,142	1142	1,142	1142
R-squared	0.830	0.876	0.829	0.877	0.828	0.879	0.824	0.878

Notes:

(i) Regression of $\ln(y_{it}/(y_{it}^{*}-y_{it}))$ on institutional variables.

(ii) $y_{it}^{*}=\gamma_i Population_i$

(iii) In the first specification, γ is constant and set equal to 205. In the following three specifications γ_{it} is a predicted value based o
results of regressions of the number of Internet users in 2009 on various explanatory variables for a subsample of countries that h
achieved a high level of Internet penetration.

(iv) Regional dummies included in all regressions.

(v) Robust standard errors in parentheses

(vi) *** p<0.01, ** p<0.05, * p<0.1

Table 7: Economic variables and rates of Internet use

	γ=205		predicted γ1		predicted γ2		predicted γ3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LOCATION	GROWTH	LOCATION	GROWTH	LOCATION	GROWTH	LOCATION	GROWTH
GDPpc	-5.61e-05**	4.24e-06**	-7.04e-05**	5.82e-06***	-7.35e-05**	6.55e-06***	-8.76e-05***	7.39e-06***
	(2.80e-05)	(1.73e-06)	(2.95e-05)	(1.87e-06)	(2.95e-05)	(1.86e-06)	(2.76e-05)	(1.77e-06)
Low Literacy	-3.133*	0.241*	-3.313**	0.260*	-3.250**	0.254*	-3.335**	0.254*
	(1.632)	(0.139)	(1.609)	(0.137)	(1.609)	(0.137)	(1.611)	(0.137)
Medium Low Literacy	-1.926**	0.0795	-2.021**	0.0906*	-1.977**	0.0863	-2.076***	0.0905*
	(0.805)	(0.0552)	(0.797)	(0.0548)	(0.797)	(0.0547)	(0.793)	(0.0541)
Medium Literacy	-0.561	0.0388	-0.655	0.0491	-0.622	0.0457	-0.690	0.0476
	(0.627)	(0.0414)	(0.626)	(0.0415)	(0.625)	(0.0414)	(0.631)	(0.0417)
Medium High Literacy	-0.0657	-0.0227	-0.151	-0.0139	-0.138	-0.0155	-0.191	-0.0139
	(0.444)	(0.0299)	(0.444)	(0.0301)	(0.444)	(0.0301)	(0.440)	(0.0296)
Services	0.0305	-0.000946	0.0268	-0.000621	0.0274	-0.000666	0.0299	-0.000438
	(0.0195)	(0.00120)	(0.0196)	(0.00121)	(0.0196)	(0.00121)	(0.0195)	(0.00120)
Agriculture	-0.0739***	0.00277**	-0.0688***	0.00235*	-0.0713***	0.00262*	-0.0905***	0.00250*
	(0.0206)	(0.00135)	(0.0207)	(0.00136)	(0.0206)	(0.00136)	(0.0205)	(0.00135)
Fixed Telephones	0.133***	-0.00532***	0.131***	-0.00503***	0.132***	-0.00519***	0.132***	-0.00530***
	(0.0197)	(0.00123)	(0.0204)	(0.00131)	(0.0203)	(0.00129)	(0.0194)	(0.00123)
t		0.386***		0.372***		0.369***		0.354***
		(0.0811)		(0.0817)		(0.0818)		(0.0803)
Constant	-10.26***		-9.780***		-9.808***		-9.812***	
	(1.322)		(1.325)		(1.327)		(1.307)	
Observations		1,142		1,142		1,142		1,142
R-squared		0.880		0.878		0.881		0.899

Notes:

(i) Regression of $\ln(y_{it}/(y_{it}^{*}-y_{it}))$ on economic variables.

(ii) $y_{it}^{*}=\gamma_i \text{Population}_i$

(iii) In the first specification, γ is constant and set equal to 205. In the following three specifications γ_{it} is a predicted value based on the results of regressions of the number of Internet users in 2009 on various explanatory variables for a subsample of countries that have achieved a high level of Internet penetration.

(iv) Regional dummies included in all regressions.

(v) Robust standard errors in parentheses

(vi) *** p<0.01, ** p<0.05, * p<0.1

Table 8: Rates of Internet use and all explanatory variables

	γ=205		predicted γ1		predicted γ2		predicted γ3	
	(1) LOCATION	(2) GROWTH	(3) LOCATION	(4) GROWTH	(5) LOCATION	(6) GROWTH	(7) LOCATION	(8) GROWTH
Rugged	-0.0869	0.00447	-0.0474	0.000537	-0.0517	0.00101	-0.0749	0.00825
	(0.149)	(0.00951)	(0.150)	(0.00964)	(0.150)	(0.00962)	(0.154)	(0.0101)
Pop Density	-0.000131	2.07e-06	-0.000195	9.75e-06	-0.000188	9.09e-06	-0.000223	1.49e-05
	(0.000151)	(9.98e-06)	(0.000148)	(1.00e-05)	(0.000148)	(1.01e-05)	(0.000153)	(1.06e-05)
Rural Pop	-0.0143	0.000214	-0.0130	0.000244	-0.0134	0.000319	-0.0146	0.000495
	(0.0101)	(0.000644)	(0.0102)	(0.000659)	(0.0102)	(0.000657)	(0.0101)	(0.000651)
Democratic	0.169	-0.00531	0.0994	-0.00291	0.114	-0.00342	0.175	-0.0112
	(0.658)	(0.0264)	(0.668)	(0.0270)	(0.666)	(0.0269)	(0.659)	(0.0264)
Autocratic	-0.723	0.0194	-0.697	0.0175	-0.707	0.0180	-0.690	0.0195
	(0.997)	(0.0401)	(1.005)	(0.0406)	(1.003)	(0.0405)	(1.005)	(0.0405)
Regulatory Quality	0.840***	-0.0339**	0.808***	-0.0285	0.837***	-0.0317*	0.837***	-0.0340**
	(0.258)	(0.0169)	(0.261)	(0.0174)	(0.260)	(0.0173)	(0.261)	(0.0173)
DSL Monopoly	0.173	-0.0184	0.268	-0.0280	0.241	-0.0252	0.200	-0.0216
	(0.514)	(0.0342)	(0.516)	(0.0345)	(0.515)	(0.0344)	(0.516)	(0.0344)
DSL Partial Comp	-0.625	0.00469	-0.497	-0.00841	-0.527	-0.00543	-0.502	-0.00469
	(0.564)	(0.0366)	(0.565)	(0.0371)	(0.566)	(0.0371)	(0.568)	(0.0372)
Int. Services Monopoly	-0.978	0.0886**	-1.005	0.0919**	-0.975	0.0884**	-0.923	0.0832*
	(0.618)	(0.0438)	(0.620)	(0.0441)	(0.619)	(0.0440)	(0.622)	(0.0441)
Int. Services Partial Comp	0.888	-0.0289	0.826	-0.0224	0.870	-0.0266	0.887	-0.0284
	(0.564)	(0.0372)	(0.564)	(0.0375)	(0.565)	(0.0376)	(0.564)	(0.0375)
Common Law	-0.505	0.0699***	-0.551	0.0726***	-0.526	0.0696***	-0.436	0.0620**
	(0.381)	(0.0245)	(0.385)	(0.0251)	(0.385)	(0.0251)	(0.385)	(0.0250)
GDPpc	-2.27e-05	1.09e-06	-3.57e-05	2.48e-06	-4.11e-05	3.43e-06*	-5.94e-05**	4.40e-06**
	(2.71e-05)	(1.75e-06)	(2.88e-05)	(1.90e-06)	(2.96e-05)	(1.98e-06)	(2.75e-05)	(1.84e-06)
Low Literacy	-4.078***	0.308**	-4.168***	0.315**	-4.125***	0.310**	-4.122***	0.318**
	(1.528)	(0.127)	(1.528)	(0.127)	(1.528)	(0.127)	(1.571)	(0.131)
Medium Low Literacy	-1.970**	0.0965*	-2.078***	0.107**	-2.038***	0.103*	-2.160***	0.116**
	(0.776)	(0.0539)	(0.776)	(0.0541)	(0.777)	(0.0541)	(0.774)	(0.0538)

Table 8 (cont.): Rates of Internet use and all explanatory variables

	γ=205		predicted γ1		predicted γ2		predicted γ3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	LOCATION	GROWTH	LOCATION	GROWTH	LOCATION	GROWTH	LOCATION	GROWTH
Medium Literacy	-0.929	0.0666	-0.994	0.0727*	-0.968	0.0702*	-1.004	0.0769*
	(0.626)	(0.0414)	(0.626)	(0.0418)	(0.626)	(0.0418)	(0.630)	(0.0418)
Medium High Literacy	-0.194	-0.0129	-0.209	-0.0114	-0.199	-0.0126	-0.290	-0.00377
	(0.403)	(0.0271)	(0.405)	(0.0275)	(0.406)	(0.0274)	(0.403)	(0.0271)
Services	0.0170	-0.000661	0.0141	-0.000446	0.0139	-0.000411	0.0150	-2.32e-06
	(0.0190)	(0.00118)	(0.0191)	(0.00119)	(0.0191)	(0.00120)	(0.0190)	(0.00119)
Agriculture	-0.0479**	0.00189	-0.0468**	0.00182	-0.0481**	0.00194	-0.0646***	0.00119
	(0.0232)	(0.00153)	(0.0232)	(0.00155)	(0.0232)	(0.00155)	(0.0233)	(0.00154)
Fixed Telephones	0.0890***	-0.00285**	0.0889***	-0.00265**	0.0898***	-0.00283**	0.0938***	-0.00304**
	(0.0183)	(0.00115)	(0.0192)	(0.00124)	(0.0193)	(0.00124)	(0.0186)	(0.00119)
t		0.300***		0.296***		0.286***		0.259***
		(0.0837)		(0.0855)		(0.0855)		(0.0847)
Constant	-8.175***		-7.829***		-7.808***		-7.759***	
	(1.361)		(1.376)		(1.378)		(1.368)	
Observations		1,142		1,142		1,142		1,142
R-squared		0.899		0.896		0.897		0.911

Notes:

(i) Regression of $\ln(y_{it}/(y_{it}^{*}-y_{it}))$ on all explanatory variables.

(ii) $y_{it}^{*}=\gamma_i Population_i$

(iii) In the first specification, γ is constant and set equal to 205. In the following three specifications γ_{it} is a predicted value based on the results of regressions of the number of Internet users in 2009 on various explanatory variables for a subsample of countries that have achieved a high level of Internet penetration.

(iv) Regional dummies included in all regressions.

(v) Robust standard errors in parentheses

(vi) *** p<0.01, ** p<0.05, * p<0.1

Table 9: Rates of Internet use and GDP p.c.

	γ=205		predicted γ1		predicted γ2		predicted γ3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOCATION								
GDPpc	0.000252***	-9.39e-05***	0.000232***	-0.000110***	0.000230***	-0.000112***	0.000237***	-0.000142***
	(2.54e-05)	(2.97e-05)	(2.59e-05)	(3.13e-05)	(2.56e-05)	(3.12e-05)	(2.65e-05)	(3.08e-05)
Fixed Telephones		0.206***		0.202***		0.203***		0.225***
		(0.0198)		(0.0204)		(0.0202)		(0.0209)
GROWTH								
GDPpc	-9.19e-06***	6.69e-06***	-6.93e-06***	8.41e-06***	-6.51e-06***	9.04e-06***	-6.03e-06***	1.11e-05***
	(1.62e-06)	(1.86e-06)	(1.69e-06)	(2.01e-06)	(1.66e-06)	(2.00e-06)	(1.72e-06)	(1.99e-06)
Fixed Telephones		-0.00857***		-0.00810***		-0.00832***		-0.00915***
		(0.00128)		(0.00134)		(0.00132)		(0.00137)
t	0.474***	0.478***	0.472***	0.476***	0.471***	0.475***	0.482***	0.487***
	(0.0236)	(0.0213)	(0.0235)	(0.0211)	(0.0235)	(0.0211)	(0.0260)	(0.0233)
Constant	-11.94***	-12.11***	-11.55***	-11.72***	-11.59***	-11.76***	-12.30***	-12.48***
	(0.374)	(0.334)	(0.371)	(0.331)	(0.371)	(0.331)	(0.412)	(0.367)
Observations	1,142	1,142	1,142	1,142	1,142	1,142	1,142	1,142
R-squared	0.789	0.846	0.793	0.848	0.798	0.851	0.792	0.849

Notes:

(i) Regression of $\ln(y_{it}/(y_{it}^{*}-y_{it}))$ on GDP p.c. and Fixed Telephone Lines per 100 people.

(ii) $y_{it}^{*}=\gamma_i \text{Population}_i$

(iii) In the first specification, γ is constant and set equal to 205. In the following three specifications γ_{it} is a predicted value based on the results of regressions of the number of Internet users in 2009 on various explanatory variables for a subsample of countries that have achieved a high level of Internet penetration.

(iv) Regional dummies included in all regressions.

(v) Robust standard errors in parentheses

(vi) *** p<0.01, ** p<0.05, * p<0.1

3.6 Chapter 3 References

1. Aker, Jenny, (2010), "Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger", *American Economic Journal: Applied Economics* 2, pp. 46–59

2. Bohlin, Anders, Harald Gruber and Pantelis Koutroumpis, (2010), "Diffusion of new technology generations in mobile communications," *Information Economics and Policy,* 22, pp. 51–60.

3. Chu, Wen-Lin, Feng-Shang Wu, Kai-Sheng Kao and David C. Yen, (2009), "Diffusion of mobile telephony: An empirical study in Taiwan," *Telecommunications Policy,* 33, pp. 506–520.

4. Ding, Lei, Kingsley E. Haynes and Huaqun Li, (2010), "Modeling the Spatial Diffusion of Mobile Telecommunications in China," *The Professional Geographer,* 62:2, pp. 248-263.

5. Frank, Lauri Dieter, (2004), "An analysis of the effect of the economic situation on modeling and forecasting the diffusion of wireless communications in Finland," *Technological Forecasting & Social Change*, 71, pp. 391–403.

6. Gamboa, Luis Fernando and Jesus Otero, (2009), "An estimation of the pattern of diffusion of mobile phones: The case of Colombia," *Telecommunications Policy,* 33, pp. 611–620.

7. Goyal, Aparijita, (2001), "Information, Direct Access to Farmers and Rural Market Performance in Central India," *American Economic Journal: Applied Economics*, 2 (3), pp. 22-45.

8. Gruber, Harald and Frank Verboven, (2001), "The diffusion of mobile telecommunications services in the European Union," *European Economic Review*, 45, pp. 577-588.

9. Gruber, Harald and Frank Verboven, (2001), "The evolution of markets under entry and standards regulation - the case of global mobile telecommunications," *International Journal of Industrial Organization*, 19, pp. 1189–1212.

10. Hyytinen, Ari and Otto Toivanen, (2011), "Income Inequality and Technol-

ogy Diffusion: Evidence from Developing Countries," *Scandinavian Journal of Economics,* 113(2), pp. 364–387.

11. Jang, Show-Ling, Shau-Chi Dai and Simona Sung, (2005), "The pattern and externality effect of diffusion of mobile telecommunications: the case of the OECD and Taiwan," *Information Economics and Policy*, 17, pp. 133–148.

12. Jensen, Robert, (2007), "The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector", *The Quarterly Journal of Economics,* 122 (3), pp. 879-924.

13. Kaufmann, Daniel, Aart Kraay and Massimo Mastruzzi, (2008), *Governance Matters VII: Aggregate and Individual Governance Indicators 1996-2007,* Policy Research Working Paper 4654.

14. Koski, Heli and Tobias Kretschmer, (2005), "Entry, Standards and Competition: Firm Strategies and the Diffusion of Mobile Telephony," *Review of Industrial Organization*, 26, pp. 89–113.

15. La Porta, Rafael, Florencio Lopez-de-Silanes and Andrei Shleifer, (2007), "The Economic Consequences of Legal Origins," NBER Working Paper 13608.

16. Lee, Minkyu and Youngsang Cho, (2007), "The diffusion of mobile telecommunications services in Korea," *Applied Economics Letters*, 14:7, pp. 477-481.

17. Lee, Sangwon, Mircea Marcu and Seonmi Lee, (2011), "An empirical analysis of fixed and mobile broadband diffusion," *Information Economics and Policy,* 23, pp. 227–233.

18. Nunn, Nathan and Diego Puga, (2012), "Ruggedness: The blessing of bad geography in Africa," *Review of Economics and Statistics,* 94(1), pp. 20-36.

19. Rouvinen, Petri, (2006), "Diffusion of digital mobile telephony: Are developing countries different?," *Telecommunications Policy,* 30, pp. 46–63.

References

[1] Acharya, S.S. (2005), "Agriculture marketing and rural credit: Status, Issues and Reform agenda, Area, Production and Yield of Principal Crops in India", Directorate of Economics and Statistics, Ministry of Agriculture.

[2] Agrifood Consulting International, (2005), "Northeast Thailand Rice Value Chain Study", Project Brief Series, Agrifood Consulting International, Maryland.

[3] Allen, Franklin, (1984), "Reputation and Product Quality", *The RAND Journal of Economics*, Vol. 15, No. 3, pp. 311-327.

[4] Aker, Jenny, (2010), "Information from Markets Near and Far: Mobile Phones and Agricultural Markets in Niger", *American Economic Journal: Applied Economics* 2, pp. 46–59

[5] Aker, Jenny and Marcel Fafchamps, (2011), "How Does Mobile Phone Coverage Affect Farm-Gate Prices? Evidence from West Africa. Unpublished mimeo.

[6] Badcock, Simon, B. Matlick, and J. Bako Baon, (2007), *A Value Chain Assessment of the Cocoa Sector in Indonesia,* USAID.

[7] Bauer, P.T. and B.S. Yamey (1968), "Markets, Market Control and Marketing Reform", Garden City Press Ltd.

[8] Bayes, Abdul, Joachim von Braun and Rasheda Akhter (1999), "Village Pay Phones and Poverty Reduction: Insights from a Grameen Bank Initiative in Bangladesh," Center for Development Research (ZEF), Universitat Bonn, Discussion Papers on Development Policy No. 8.

[9] Besley, Timothy and Michael Smart (2007), "Fiscal restraints and voter welfare," *Journal of Public Economics*, 91, 755-773.

[10] Biglaiser, Gary (1993), "Middlemen as Experts," *The RAND Journal of Economics*, 24 (2), 212-223.

[11] Biglaiser, Gary and James W. Friedman (1994), "Middlemen as guarantors of quality," *International Journal of Industrial Organization*, 12 (4), 509-31.

[12] Blouin, Max R., and Serrano, Roberto (2001), "A Decentralized Market with Common Values Uncertainty: Non-Steady States," *Review of Economic Studies*, 68, 323-346.

[13] Bohlin, Anders, Harald Gruber and Pantelis Koutroumpis, (2010), "Diffusion of new technology generations in mobile communications," *Information Economics and Policy,* 22, pp. 51–60.

[14] Boles, Terry, Rachel Croson and J. Keith Murnighan (2000), "Deception and Retribution in Repeated Ultimatum Bargaining," *Organizational Behavior and Human Decision Processes*, 83 (2), 235-259.

[15] Carpenter, Jeffrey (2003), "Is fairness used instrumentally? Evidence from sequential bargaining," *Journal of Economic Psychology*, 24, 467-489.

[16] Chu, Wen-Lin, Feng-Shang Wu, Kai-Sheng Kao and David C. Yen, (2009), "Diffusion of mobile telephony: An empirical study in Taiwan," *Telecommunications Policy,* 33, pp. 506–520.

[17] Cramton, Peter (1984), "Bargaining with Incomplete Information: An Infinite-Horizon Model with Two-Sided Uncertainty," *Review of Economic Studies*, 51, 579-593.

[18] Croson, Rachel, Terry Boles and J. Keith Murnighan (2003) "Cheap talk in bargaining experiments: lying and threats in ultimatum games," *Journal of Economic Behavior and Organization*, 51, 143-159.

[19] DairyCo (2011), *Dairy Supply Chain Margins 2010/11,* Agriculture and Horticulture Development Board, Warwickshire.

[20] Dana, James, and A. Fong, (2011), "Product Quality, Reputation, and Mar-

ket Structure", *International Economic Review*, Vol. 52, No. 4, pp. 1059-1076.

[21] Ding, Lei, Kingsley E. Haynes and Huaqun Li, (2010), "Modeling the Spatial Diffusion of Mobile Telecommunications in China," *The Professional Geographer,* 62:2, pp. 248-263.

[22] van Djik, Eric, David de Cremer and Michel J.J. Handgraaf, (2002), "Social value orientations and the strategic use of fairness in ultimatum bargaining," *Journal of Experimental Social Psychology*, 40 (6), 697-707.

[23] Eggleston, Karen, Robert Jensen and Richard Zeckhauser, (2002) "Information and Communication Technologies, Markets and Economic Development," *Global Information Technology Report*, 62-76.

[24] Esfahani, Hadi Salehi, (1989), "Reputation and Uncertainty: Toward an Explanation of Quality Problems in Competitive LDC Markets", *Journal of Development Economics,* 35, pp. 1-32.

[25] Faye, B. and Loiseau, G. (2002), "Sources of Contamination in Dairy Supply Chains and Approaches to Quality Control" in Hanak, E., E. Boutrif, P. Fabre and M. Pineiro, (ed.), *Food Safety Management in Developing Countries. Proceedings of the International Workshop*, CIRAD-FAO, Montpellier, France.

[26] Fafchamps, Marcel and E. Gabre-Madhin, (2006), "Agricultural Markets in Benin and Malawi", African Journal of Agricultural and Resource Economics, 1(1): 67-85.

[27] Fafchamps, Marcel, R. Vargas-Hill and B. Minten, (2007), "Quality Control in Non-Staple Food Markets: Evidence from India" in *Global Supply Chains, Standards, and the Poor*, Johan Swinnen (ed.), Cabi Publications.

[28] Fafchamps, Marcel, Ruth Vargas Hill (2008), "Price Transmission and Trader Entry in Domestic Commodity Markets," *Economic Development and Cultural Change*, 56 (4), 729-66.

[29] Fafchamps, Marcel and Bart Minten, (2011), "Impact of SMS-Based Agricultural Information on Indian Farmers," *World Bank Economic Review* (forthcoming).

[30] Ferris, Shaun (2004), "FOODNET: Information is Changing Things in the Marketplace", *ICT Update*, Issue 18, CTA, The Netherlands.

[31] Fingleton, John (1997), "Competition Among Middlemen When Buyers and Sellers Can Trade Directly," *The Journal of Industrial Economics*, 45 (4), 405-427.

[32] Frank, Lauri Dieter, (2004), "An analysis of the effect of the economic situation on modeling and forecasting the diffusion of wireless communications in Finland," *Technological Forecasting & Social Change*, 71, pp. 391–403.

[33] Fudenberg, Drew, David K. Levine and Jean Tirole (1985), "Infinite-Horizon Models of Bargaining with One- Sided Incomplete Information," in Alvin Roth (ed), Game Theoretic Models of Bargaining, Cambridge, England: Cambridge University Press.

[34] Futch, Michael and Craig McIntosh (2009), "Tracking the Introduction of the Village Phone Product in Rwanda," *Information Technologies and International Development*.

[35] Gale, Douglas and R. Rosenthal, (1994), "Price and Quality Cycles for Experience Goods", *The RAND Journal of Economics*, Vol. 25, No. 4, pp. 590-607.

[36] Gamboa, Luis Fernando and Jesus Otero, (2009), "An estimation of the pattern of diffusion of mobile phones: The case of Colombia," *Telecommunications Policy,* 33, pp. 611–620.

[37] Goyal, Aparijita, (2001), "Information, Direct Access to Farmers and Rural Market Performance in Central India," *American Economic Journal: Applied Economics*, 2 (3), pp. 22-45.

[38] Grossman, Sanford J. and Motty Perry (1986b), "Sequential Bargaining Under Asymmetric Information," *Journal of Economic Theory*, 39(1), 120-154.

[39] Gruber, Harald and Frank Verboven, (2001), "The diffusion of mobile telecommunications services in the European Union," *European Economic Review*, 45, pp. 577-588.

[40] Gruber, Harald and Frank Verboven, (2001), "The evolution of markets un-

der entry and standards regulation - the case of global mobile telecommunications," *International Journal of Industrial Organization*, 19, pp. 1189–1212.

[41] Hai, Luu Thanh Duc, (2002), "The Organization of the Liberalized Rice Market in Vietnam", PhD thesis, University of Groningen, Groningen.

[42] Harrison, G. and John A. List (2004), "Field Experiments," *Journal of Economic Literature*, 42 (4), 1009-1055.

[43] Hayami, Y., M. Kikuchi and E. B. Marciano (1999), "Middlemen and peasants in rice marketing in the Philippines," *Agricultural Economics*, 20 (2), 79-93.

[44] Hyytinen, Ari and Otto Toivanen, (2011), "Income Inequality and Technology Diffusion: Evidence from Developing Countries," *Scandinavian Journal of Economics,* 113(2), pp. 364–387.

[45] Jang, Show-Ling, Shau-Chi Dai and Simona Sung, (2005), "The pattern and externality effect of diffusion of mobile telecommunications: the case of the OECD and Taiwan," *Information Economics and Policy*, 17, pp. 133–148.

[46] Jensen, Robert (2007), "The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector," *Quarterly Journal of Economics*, 122 (3), 879-924.

[47] Jensen, Robert (2010), "Information, Efficiency and Welfare in Agricultural Markets," *Agricultural Economics.*

[48] Johri, Alok and John Leach (2002) Middlemen and the Allocation of Heterogeneous Goods," *International Economic Review*, 43 (2), 347-61.

[49] Kaufmann, Daniel, Aart Kraay and Massimo Mastruzzi, (2008), *Governance Matters VII: Aggregate and Individual Governance Indicators 1996-2007,* Policy Research Working Paper 4654.

[50] Kibiego, Michael (2010), *Training Manual for the Development of the Milk Marketing Chain,* Ministry of Livestock Development Smallholder Dairy Commercialization Programme.

[51] Koski, Heli and Tobias Kretschmer, (2005), "Entry, Standards and Compe-

tition: Firm Strategies and the Diffusion of Mobile Telephony," *Review of Industrial Organization*, 26, pp. 89–113.

[52] Kranton, Rachel, (2003), "Competition and the Incentive to Produce High Quality", Economica, New Series, Vol. 70, No. 279, pp. 385-404.

[53] Kremer, Michael, (1993), "The O-Ring Theory of Economic Development", *The Quarterly Journal of Economics,* Vol. 108, No. 3, pp. 551-575.

[54] Kumar, Praduman, P. Shinoj, S.S. Raju, Anjani Kumar, Karl M. Rich and Siwa Msangi (2010), "Factor Demand, Output Supply Elasticities and Supply Projections for Major Crops of India," *Agricultural Economics Research Review*, 23, 1-14.

[55] La Porta, Rafael, Florencio Lopez-de-Silanes and Andrei Shleifer, (2007), "The Economic Consequences of Legal Origins," NBER Working Paper 13608.

[56] Lee, Minkyu and Youngsang Cho, (2007), "The diffusion of mobile telecommunications services in Korea," *Applied Economics Letters*, 14:7, pp. 477-481.

[57] Lee, Sangwon, Mircea Marcu and Seonmi Lee, (2011), "An empirical analysis of fixed and mobile broadband diffusion," *Information Economics and Policy,* 23, pp. 227–233.

[58] Li, Yiting (1998), "Middlemen and private information," *Journal of Monetary Economics*, 42 (1), 131-59.

[59] Marshall, Monty G., Keith Jaggers and Ted Robert Gurr, (2010), *Polity IV Project: Political Regime Characteristics and Transitions, 1800-2010,* Center for Systemic Peace.

[60] Masters, Adrian (2007) "Middlemen in Search Equilibrium," *International Economic Review*, 48 (1), 343-62.

[61] Masters, Adrian (2008), "Unpleasant Middlemen," *Journal of Economic Behavior and Organization*, October 2008, 68 (1), 73-86.

[62] Merel, Pierre R., Richard J. Sexton and Aya Suzuki (2009) "Optimal Investment in Transportation Infrastructure When Middlemen Have Market

Power: A Developing-Country Analysis," *American Journal of Agricultural Economics*, 91 (2), 462-76.

[63] Mikkelsen, Laerke, (2010), "Quality Assurance along the Primary Processing Chain of Cocoa Beans from Harvesting to Export in Ghana", Dissertation, University of Copenhagen, Faculty of Life Sciences, Copenhagen.

[64] Minten, Bart and Steven Kyle (1999), "The effect of distance and road quality on food collection, marketing margins, and traders' wages: evidence from the former Zaire", *Journal of Development Economics*, 60 (2), 467-95.

[65] Mitra, Sandip and Abhirup Sarkar (2003), "Relative Profitability from Production and Trade. A Study of Selected Potato Markets in West Bengal," *Economic and Political Weekly*, November, 4694-4699.

[66] Mohammed, Dawuni, D. Asamoah, and F. Asiedu-Appiah, (2012), "Cocoa Value Chain - Implication for the Smallholder Farmer in Ghana" in *2012 SWDSI Proceedings,* Southwest Decision Sciences Institute, Texas.

[67] Molony, Thomas (2008), "Running Out of Credit: The Limitations of Mobile Phone Telephony in a Tanzanian Agricultural Marketing System," *Journal of Modern African Studies*, 46(4), p. 637-58.

[68] Muto, Megumi and Takashi Yamano (2009), "The Impact of Mobile Phone Coverage Expansion on Market Participation: Panel Data Evidence from Uganda," *World Development*.

[69] Mythili, G. (2006), "Supply Response of Indian Farmers: Pre and Post Reforms," Indira Gandhi Institute of Development Research, Mumbai.

[70] Nestle website: http://www.nestle.com/Brands/Dairy/Pages/DairyCSV.aspx

[71] Nunn, Nathan and Diego Puga, (2012), "Ruggedness: The blessing of bad geography in Africa," *Review of Economics and Statistics,* 94(1), pp. 20-36.

[72] Overa, Ragnhild (2006), "Networks, distance and trust: telecommunications development and changing trading practices in Ghana," *World Development*, 34 (7), 1301-15.

[73] Panlibuton, Henry and F. Lusby, (2006), *Indonesia Cocoa Value Chain Case Study,* MicroReport No. 65, USAID.

[74] Pillutla, M. M., & Murnighan, J. K. (1995). Being fair or appearing fair: Strategic behavior in ultimatum bargaining. *Academy of Management Journal*, 38, 1408–1426.

[75] Riordan, Michael, (1986), "Monopolistic Competition with Experience Goods", *The Quarterly Journal of Economics*, Vol. 101, No. 2, pp. 265-280.

[76] Robinson, Elizabeth and S. Kolavalli, (2010), *The Case of Tomato in Ghana: Marketing*, GSSP Working Paper No. 20, IFPRI, Washington, D.C.

[77] Rosenberg, David, M. Eckstein, and C. Brett, (2009), *Traders as agents of sustainability in coffee and cocoa supply chains,* Best Practices Series, The Dutch Sustainable Trade Initiative (IDH), Utrecht.

[78] Rota, Antonio and S. Sperandini (2010), *Value chains, linking producers to the markets,* Livestock Thematic Papers: Tools for Project Design, IFAD, Rome.

[79] Rouvinen, Petri, (2006), "Diffusion of digital mobile telephony: Are developing countries different?," *Telecommunications Policy,* 30, pp. 46–63.

[80] Rubinstein, Ariel (1985), "A Bargaining Model with Incomplete Information about Time Preferences," *Econometrica*, 53, 1151-1172.

[81] Rubinstein, Ariel and Asher Wollinsky (1985), "Equilibrium in a Market with Sequential Bargaining," *Econometrica,* 53, 1133-1150.

[82] Rust, John and George Hall (2003), "Middlemen versus Market Makers," *Journal of Political Economy*, April 2003, 111 (2), 353-403.

[83] Sen, Arijit (2000), "Multidimensional Bargaining under Asymmetric Information," *International Economic Review*, 41, (2), 425-50.

[84] Shapiro, Carl, (1983), "Premiums for High Quality Products as Returns to Reputations", *The Quarterly Journal of Economics*, Vol. 98, No. 4, pp. 659-680.

[85] Smith, Howard and J. Thanassoulis (2008), *The Milk Supply Chain Project,* University of Oxford.

[86] SNV Netherlands Development Organisation (2008), *Study on Dairy Investment Opportunities in Ethiopia*, TAM Consult, Addis Ababa.

[87] Sobel, Joel, and Ichiro Takahashi (1983), "A Multi State Model of Bargaining," *Review of Economic Studies*, 50, 411-426.

[88] Spulber, Daniel F. (2002), "Market Microstructure and Incentives to Invest," *Journal of Political Economy*, 110 (2), 352-81.

[89] Srivastava, Joydeep, Dipankar Chakravarti and Amnon Rapoport (2000), "Price and Margin Negotiations in Marketing Channels: An Experimental Study of Sequential Bargaining Under One-sided Uncertainty and Opportunity Cost of Delay," *Marketing Science*, 19 (2), 163-84.

[90] Svensson, Jakob and David Yanagizawa, (2009), "Getting Prices Right: the impact of the market information service in Uganda ," *Journal of the European Economic Association*, 7 (2-3), 435-45.

[91] TechnoServe Rwanda (2008), *The Dairy Value Chain in Rwanda,* East Africa Dairy Development Program, Rwanda.

[92] Van Raalte, Chris and Harry Webers (1998), "Spatial Competition with Intermediated Matching", *Journal of Economic Behavior & Organization*, 34, 477-488.

[93] VECO, (2011), *Increased incomes for Indonesian cocoa farmers in sustainable markets: NGO-private sector cooperation on Sulawesi island,* VECO, Leuven.

[94] Vesala, Timo (2008), "Middlemen and the adverse selection problem," *Bulletin of Economic Research*, 60 (1), 1-11.

[95] White, Benjamin, P. Morey, R. Natawidjaja, and W. Morgan (2007) *Vegetable value chains in Eastern Indonesia–a focus on chilli,* SADI-ACIAR research report, Australian Centre for International Agricultural Research, Canberra

[96] Williams, Tracy, (2009), *An African Success Story: Ghana's Cocoa Marketing System,* IDS Working Paper 318, Institute of Development Studies at the University of Sussex, Brighton.

[97] World Bank, (2008), *World Development Report: Agriculture for Development*, World Bank, Washington D.C.

[98] World Bank, (2011), *World Development Indicators,* (Edition: September 2011), ESDS International, University of Manchester.

[99] Zia, Umm e, T. Mahmood and M.R. Ali (2011), *Dairy Development in Pakistan*, FAO, Rome.