How Important is Coordination for Perishable Commodity Markets? Evidence from Micro-Transactions in Agricultural Markets in Pakistan *

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Abstract: Trade of perishable cash crops in developing countries suffers from inefficiencies due to unavailability of storage and a lack of coordination between farmer and trader. Can cell phones increase the efficiency of this trade by allowing active communication between farmers and traders? I use data from 689,732 micro-transaction records for past 10 years in Pakistan to estimate impact of cell phone access on efficiency of trade. For identification, I make use of a policy which restricts cell phone access from area within 10 km of Indian border. Results show that cell phone access increases the quantity and quality of the crops traded.

Keywords: Cell Phones, Perishable Crops, Traders, Agriculture, Pakistan, Coordination, ICTs and Development
JEL Classification: Q13; O13; O12; O33

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1 Introduction

The trade of perishable agricultural produce in developing countries remains inefficient due to lack of timely coordination and communications between farmers and traders. As a result, a significant proportion of product perishes while being transmitted from farmer to trader. Asad [2015] showed that access to cell phones significantly reduces the post-harvest losses incurred by farmers due to reduction in the numbers of days between harvest and sale date. This paper will go further to examine if this timely coordination benefits the trader by increasing the quantity and quality of perishable commodity purchased and how this translates into income gains for the trader.

In developing countries, where agriculture constitutes a major share of GDP, growing perishable cash crops can be a major source of increasing income of farmers and traders. One of the constraints on perishable crop production maybe the leakages in their supply chain.[1]

In Pakistan, the farmers sell their crops to traders in the agricultural wholesale market which is commonly known in South Asia as the *mandi*. The traders in the *mandi* due to storage related constraints, have limited purchasing capacity for perishable crops. In the given circumstances, it is hypothesized that both the farmer and the trader have a strong incentive to coordinate. One possible mechanism for achieving coordination can be through pre-arranging a sale date so that the trader can balance the total number of farmers that appear at the market to sell their crops on any given day. This can be beneficial as this allows him to prevent having below capacity days, leading to higher income over season. Moreover, this can reduce post-harvest losses incurred by the farmer resulting in higher quality produce

[1] Figure 1 shows that in context of Pakistan perishable cash crops are more profitable than least perishable ones in the absence of post-harvest losses. The profitability was calculated using nationwide data from different administrative sources. For all the crops except orchards(citrus and mangoes), a difference of revenue and cost was taken. The reason being that orchards require one time fixed cost and also requires the farmer to forgo income for up to 5 years which is the time required for these to produce the first harvest. After the first harvest, these plants produce a crop every year. Therefore the forgone income is only for the initial period in which the trees get to a certain age. The results in this paper are robust to excluding orchards from list of perishable crops, as we see a similar effect for extremely and highly perishable crops.

delivered to the trader.

In this paper, I follow the expansion of cell phone coverage in the district of Narowal to look at the impact of cell phones on trader efficiency and quality of produce.[2] The cell phone is only a useful tool for achieving coordination when both the farmer and the trader have access to the technology. As the penetration of cell phones increases among the farmers, the markets linkages begin to strengthen. I hypothesize that this can increase the trader's ability to purchase supply over the entire season as well as improves the quality of commodity delivered to him. Asad [2015] shows that if farmers know the sale date in advance they are able to adjust the harvest date to bring it as close as possible to the sale date. This allows them to minimize the post-harvest losses and delivery high quality output to the trader.

Cell phone towers are not placed randomly making it difficult to estimate the causal impact of access to cell phone coverage on efficiency of trader. To deal with these issues, my preferred empirical strategy relies on making use of a unique policy. As a result of security concerns, the Government of Pakistan declared area within 10 km of International border with India as the "Dead Zone", area without cell phone coverage.[3] This restriction allows the use of a Spatial Regression Discontinuity Design to estimate the causal impact of cell phone access on crop choice [Asad, 2015].

The data utilized in the paper comes both from farmer side as well as trader side. The trader side data used in this paper is unique as I generated it by digitizing the transactions records maintained by traders of 18 commodities in district of Narowal for over the past 10 years. The dataset consists of information on each of the 689,732 transactions. These transactions are recorded in the trader transaction registers, which are regularly maintained by the traders for the purpose of transaction enforcement. For all farmers who appeared with their products at the market, the register records the volume purchased as well as their village name, the non-purchased volume, date of future appointments for sale, indicators of

[2] It is important to note that the trader does not have constraint on cell phones access.

[3] The enforcement of this zone is done by the strategic placement of cell phone towers as well as the placement of signal jamming devices.

quality of commodity delivered and other general contact information of the farmer. This is then combined with village location data as well as the village census data 2008. By combining this data with spatial information, I can accurately determine the distance of village from "Dead Zone" boundary.

I then used the outlined data to estimate the causal impact of cell phone access on trader efficiency and commodity quality using Spatial Regression Discontinuity Design by Dell [2010]. The results show that access to cell phone coverage leads to an increase in proportion of output that was purchased by trader and a decrease in total number of trips made by a farmer. I find that there is a statistically significant effect on both outcomes for extremely and highly perishable crops. No effect is observed for least perishable crops.

Next, I estimate the impact of cell phones on quality of commodity delivered to the trader. The quality of perishable crops is important as retailers only purchase from traders if it meets the standard. If the quality declines a little, it is not possible to sell the crop at all as it becomes unfit for sale and is wasted. The trader observes the quality of commodity ex-post as he is unable to observe the entire output at the time of purchase. He then records the percentage of output that was not fit for sale to the retailer in his transaction log. Based on the quality, the trader places the farmer on the red list.[4] The results show that having a cell phone leads to a decrease in probability of farmer being on the red list. In addition, there is a decrease in the percentage of output unfit for sale to retailer. These results are also unique to case of extremely and highly perishable crops. Finally, the traders are able to make greater income from trading with cell phone farmers compared to those without it.

This research makes several contributions to literature. First, this to the best of my knowledge, is the first study which examines the role of cell phones on commodity quality and efficiency of traders. In addition, this is first study to utilize such high frequency data which makes it possible to address some of the outlined research questions. Previous studies

[4]A red list is a list of farmers who have a certain proportion of output below standard. The standard is determined by trader and varies over time. For example the trader understands if there was a bad season and the average quality of output is low and lower the standard. A new red list is created every season.

on post-harvest losses and trader efficiency have focused on measuring them in context of grains.[5] The focus of research related to agricultural production decisions and risk has been limited to pre-harvest risks.[6]

The rest of the paper is structured as follows. Section 2 presents the information on Mandi in Pakistan. Section 3 describes the data and measurement. Section 4 describes the identification strategy. Section 5 explains the empirical strategy and specifications. Section 6 describes estimation and results. Section 7 provides the policy implications. Section 8 provides conclusion of the paper.

2 The Mandi in Pakistan

A Pakistani mandi is a central market place where farmers take their crops to sell to traders. The traders purchase these goods from the farmers, and then sell them to retailers or actual customers. Most people buying from traders in the mandi are retailers and not consumers. Mandis operate in different parts of the world, and are particularly very common in South Asia. The relationship between the farmers and traders in Pakitani mandi has several unique features which are relevant to this paper.

In a Pakistani mandi there are only a few traders per crop. In every mandi there exists an association of all the traders in that mandi. Entry and exit of traders from this market is approved and regulated by this association. If more than one trader exists per crop they are commonly from the same family. However it is safe to assume that the number of traders per crop is very small. Traders specialize in specific in 1-2 goods. Sometimes they purchase more than one good if the goods share comparable features. For example, potatoes and

[5] For studies related to post-harvest losses see Kaminski & Christiaensen [2014], Food and Agriculture Organization [2014], International Food Policy Research Institute [2013], Grolleaud [2002], Allen [2014] and Oehmke [1992].

[6] For more details on weather based agricultural risks in developing countries' agriculture see Carter [2012], De Janvry & Sadoulet [2006], Dercon [1996], Fafchamps [2003], Food and Agriculture Organization [2014], Gine & Yang [2009], Karlan et al. [2014], Dercon & Krishnan [1996], Macours [2013], Rosenzweig & Binswanger [1993], Singh et al. [1986], Suri [2011], Cole et al. [2013], Vargas Hill & Torero [2009], Vargas Hill & Ciceisza [2012] and Cole et al. [2014].

onions both are tuber root vegetables and have similar features. Therefore the traders can evaluate the quality of the vegetables easily.

There is only one mandi in each district, therefore all farmers from a district visit the same mandi. Structured interviews with the farmers suggest that this is due to several reasons. First, the buyer-seller relationships go back for several generations and hence traders only trust the farmers they know. Second, mandi in the neighboring district is often sufficiently far so that it discourages the farmers from taking their crops to mandi in the neighboring district.

Once the harvest is completed, the farmers hire a truck to bring their harvested crops to the mandi. The trucks in which the crops are brought to the market are not modern and hence do not have any temperature control options. Most of the trucks are open on the top, however, some trucks are covered with a basic permeable cloth. The mandi operates between the hours of 6 am to 7 pm. Most trading between farmers and traders occurs at the start of the day.

Farmers with cell phone access are able to pre-arrange a sale date with the trader. Close to the harvest period there is continuous communication between farmer and trader as the sale date may fluctuate. Due to the real time nature of this communication, it is not possible to have a pre-arranged sale date if the farmer does not have cell phone access. If the farmers do not have a pre-arranged sale date, they have to wait in the line. The trader will only purchase if he has capacity left after purchasing from those with a pre-arranged sale date. If the trader does not buy their crop, the farmers will take it back to their village and then visit mandi the next day or on the next suggested date by trader. During this time the perishable crops experience post-harvest losses.

Another notable feature in the process is that when farmers arrive at the market due to the large volume of transaction, trader is only able to inspect and observe quality of a subset of crop. For example, if the farmer sold 100 bags of potatoes, trader may only have the time to look at any one bag. The ex-post realisation of quality will be discussed later in detail with regard to cell phones.

One of the main unique features of the Pakistani agriculture markets is the level of detailed information keeping with regard to transactions. The data utilized in this paper is very unique as it is obtained from actual transaction records that the traders maintain. The traders maintain these transaction records for several reasons. First, these records are maintained for the purpose of contractual enforcement within the market. A transaction with a farmer is recorded with his signature as an oath or witness to the fact that the transaction has occurred. This record can then be brought forward in case the farmer of the retailer fails to recognize or honor the transaction. Second, the traders have the role of ensuring high quality of commodity. When the traders make the purchase from farmers they are unable to observe the quality of entire sale as the commodities are stored in numerous sacks. Therefore after purchasing the trader labels and keeps track of commodity quality which is revealed ex-post. This way the trader can identify the producers of lower quality output.

The transactions with farmers are recorded in great detail. Each transaction feature the name and location of farmer along with cell phone number, quantity brought to market, quantity purchased by trader, quantity not purchased with a future purchase date set and percentage of output that was not satisfactory. Similar information is maintained for all transactions that traders make with retailers, however the focus of this paper is only on the farmer-trader relationship. As mentioned the traders also record the percentage of output that was satisfactory. In case the percentage of output drops below a critical value pre-decided by the traders, they place the farmers on a red list. The red list is a list of all farmers who have low output in a certain period. This red list is shared among traders in the market. Based on trader assessment which is based on future quality as well as quality provided to other traders in the market, the trader may decide to remove the farmer from the list.

3 Data and Measurement

3.1 Transaction Records

The main dataset utilized in this paper comes from the micro-transaction registers from 18 traders in one agricultural market in the district of Narowal. I collected these transaction registers from traders for the past 10 years so that the penetration of cell phones can be followed carefully overtime.[7] The registers are collected from 18 traders, where each trader specializes in a different agricultural commodity.[8] The transaction registers have data on every transaction that is conducted with farmers as well as the retailers.

The dataset has the following key features:

- For all farmers who appeared with products, register records the volume purchased as well as their village name;
- For farmers who appeared with products but were unable to make a sale on that day but had to return the trader records name, quantity and also an appointment to return in future;
- For retailers who arrived to purchase a product, name, address and finally quantity sold;
- For retailers who arrived to purchase a product but were not successful it records name address and quantity of unmet demand;
- There is also a log of general appointments where traders who will be bringing crops when with phone logs;

[7] While some traders have data that dates back further than 10 years, some of that is no longer legible.
[8] In one mandi only one trader can specialize in one commodity

- For each sale the trader also keeps track of quality. Although it is not possible for trader to examine each and every sack of crop or food at the time he purchases from the farmer. He does keep track of whose sacks and farmers who brought sacks with most highest percentage of crop wasted. Each trader sets his own benchmark. If a farmers sack fails to meet the standard the trader records it as well as the number of sacks that failed to meet the requirement. This is then used to decide whether the farmer should be placed on the red list or not.

The dataset contains 689,732 transactions that were conducted with farmers. The dataset also contains transactions with the retailers, however this paper only focuses on the farmer side.

3.2 Other Data

The transaction registers provide limited information on the location or characteristics of the locations that the farmers come from. In order to get that information I manually merged the transaction record data with the Mouza Census Data as well as the village boundary shapefile. This merging of Mouza Census data and village boundary shapefile is outlined in Asad [2015]. These allowed to map the villages and generate the distance from restriction line allowing the use of regression discontinuity methods as outlined in the next section.

4 Identification with Spatial Regression Discontinuity: "Dead Zone"

Over the past decade, Pakistan has experienced substantial growth in cell phone coverage as well as penetration rate. Cell phone coverage was introduced to rural areas of Pakistan after 2000. In addition to the growth in penetration rate, there has also been a sharp drop in the tariffs related to cell phone usage. Pakistan has been ranked as the country with 4th most affordable cell phone tariffs in the world.[World Economic Forum, 2012] This proliferation in growth accompanied by the modest tariffs suggests that there could be a significant impact on decisions of farmers. Access to cell phones has been the first source of information and communication technology for people living in rural areas of Pakistan. The land line coverage has been relatively low in the rural area. In places where the access node was available the land line density has remained very low.[9]

Cell phone towers are not placed randomly; hence, there is a need for identifying an exogenous source of variation in cell phone coverage. The Government of Pakistan created a cellular dead zone of 10 km around the International Border with India. In the trader transaction record we have the cell phone number recorded for farmer. The cell phone numbers recorded in the transaction data show that the cell phone ownership follows the same pattern as cell phone coverage. By 2008, farmers lying outside the dead zone have very high penetration rate. Figure 3 shows growth of cell phone penetration in farmers inside and outside the deadzone. The results from transaction data confirm that in fact only people outside the dead zone used cell phones and recorded them with the trader. Table 1 presents summary statistics showing that villages in lying in dead zone are comparable to those outside it.

5 Empirical Strategy and Specification

For estimation using trader transaction data, I utilize Sharp Spatial Regression Discontinuity design(SRD). There are a total of 689,732 transactions that took place between farmers and traders from 2004 to 2014. I apply method by Dell [2010] with quadratic, cubic as well as quartic polynomials in Euclidean distance from restriction as well as the longitude and latitude. The results are presented for all six specifications. The estimation equation here becomes:

[9] For more details on dead zone see Asad [2015].

$$Outcome_ijt = \alpha_0 + \alpha_1 Cellphone_ijt + \alpha_2 + \varphi(distancefromrestriction_ij) + \alpha_3 X_jt + \epsilon_ijt$$

In the above equation, i represents individual transaction observation, j represents the village and t represents the time. Figure 4.1 shows that the cell phone coverage changes discontinuously at the 10 km boundary. Figure 3 shows that the change in cell phone penetration overtime in dead zone as well as area adjacent to it.[10] I run the above regression only for 2008 onwards. This is due to the fact that 2008 onwards due to the high level of penetration.[11] Test by McCrary [2008] presented in Figure 4 show that density of Euclidean distance does not jump discontinuously and is smooth at village level.[12] Each outcome is estimated for each category of crop. All regressions include upto tahsil-year-crop fixed effects and are clustered at union council level. The crop ranking used in this paper is adopted from Asad [2015].[13]

6 Estimation and Results

6.1 Impact on Trader Efficiency

To study the impact of cell phones on trader efficiency, I first look at the impact of cell phones on total proportion of output that was purchased by the trader. Once a farmer brings their

[10] The penetration is estimated using listing of cell phone numbers in the trader registers. It is important to note that while even if farmers do not register their number with the trader they may still have a cell phone. However it can be said that for the purpose of communicating with trader they are not using cell phones.

[11] While this identification helps us address bias due to cell phone coverage, it does not allow for us to address any bias due to endogeneity of adoption. For this reason the specific range of years is chosen. In addition, the Mouza Census data is also from 2008 making the two comparable.

[12] While the outcome in this case is at individual level, the running variable is still at village level. This is due to the fact that the farmer level longitude and latitude data is not available. Therefore all farmers living in a certain village have the same value for distance from restriction.

[13] Extremely Perishable: Tomatoes, Orange, Mangoes, Corn, Sugar Cane
Highly Perishable: Onion, Garlic, Potatoes, Taro, Peas, Fresh Tumeric
Least Perishable: Millet, Feed, Sorghum, Rice, Wheat, Cotton

goods to the market, the trader for perishable commodities purchases based on the aggregate capacity available to them. The rest of the commodity is returned to the farmer and then the farmer is asked to bring it back to the market on a different date. In cases of perishable commodities due to the high rates of decomposition, a significant proportion is wasted while farmer takes his crops back to the market.

The SRD results presented in Table 2 show that access to cell phones leads to an increase in proportion of output that was purchased by trader. Cell phone increases proportion of output purchased by trader for extremely perishable commodities by 31-41 % , for highly perishable commodities by 24-30% both statistically significant at 1% level of significance. No significant effect is observed on the proportion of output in case of the least perishable commodities. This is due to the fact that storage of non-perishable commodities is not a constraint for either the farmer or the trader.

As another measure of trader efficiency, I look at the total number of trips that a farmer needs to make to sell his commodities. If the trader is more efficient and can purchase entire commodity in one trip then the farmer does not need to transport the good again and again leading to lower loses and hence higher efficiency. SRD results presented in Table 3 show that cell phones lead to decrease in number of trips to market by 2-3 days for extremely perishable crops and 2 days for highly perishable crops, both statistically significant at 1% level of significance. No statistically and economically significant effect is observed on the number of trips a farmer needs to make. The results are robust to 6 different specifications.

The two measures of trader efficiency discussed show that as cell phone coverage penetrates the farmers, the efficiency of trader improves. This is due to the fact that the trader is able to coordinate with the farmers with cell phones. That way he is able to purchase more from them and they have to make less trips. This indicates that cell phones have the potential to increasing the efficiency of trade of perishable commodities.

One of the issues with the data is that while I am able to measure the amount transacted it is difficult to see what happened to the commodity that was not purchased by trader and was also not brought back to this market. While I don't have access to data that could prove it, I recently followed up with a random sample of 30 farmers (10 tumeric, 10 potato, 10 onion) who returned with at least some commodity that was not transacted. With repeated phone conversations I discovered that if the farmer didn't bring it back to market it meant that the commodity was wasted. Out of the 30 farmers, only 18 brought their commodity back to the market within the same week. The other 12 never returned. Out of the 30 farmers 25 stated that they didn't even try to sell it in a different market and if the commodity was consumable they consumed it e.g. vegetables or gifted it to family friends. The rest was usually wasted lying in storage. A total of 5 farmers said that they tried to sell it in a different market but traders in other market didn't buy from them, so they also eventually gifted it to friend and family and consumed depending on quantity.

6.2 Impact on Quality of Purchase

In context of perishable commodities another important aspect of efficiency is that of the quality of output. The unique features of the trader transaction data allow us to study the impact of cell phones on the quality of output delivered to trader. This is important because the retailers only buy from traders if the quality meets their standard. Also unlike the traders who observe the quality ex-post, the retailers thoroughly inspect the commodity that they purchase before making the transaction. In order to track quality the traders maintain a system through which they tag sacks and hence know which sack belongs to which farmer and whether is meets the quality standards. In addition if a large number of farmer output sacks do not meet the quality standard, the trader places the farmer on the red list of poor quality farmers. All traders in the market maintain this system.

To measure quality, I first look at the impact of cell phones on probability of being on trader red list. Results in Table 4 show that cell phones to a decrease in probability of being on red list by 38 to 46% for extremely perishable crops and 28 to 35% for highly perishable crops, both statistically significant at 1% level. No effect is observed on the probability of being on red list for farmers of least perishable crops.

In Pakistan farmers grow 3-6 different crops in a year. As a next measure of quality I look at the impact of cell phones on total number of red lists on which a farmer is listed. SRD results in Table 5 show that cell phones reduce the total of red lists by 2.15 to 3.75 for extremely perishable crops and 1 to 3 for highly perishable crops, both economically and statistically significant at 1% level. No effect is observed on total number of red lists for least perishable crops.

Finally, i also look at impact on percentage of output not not fit for sale. SRD results in Table 6 show that cell phones reduce the percentage of output not fit for sale by 28-35% for extremely perishable crops and 16-20% for highly perishable crops, both statistically significant at 1% level. In case of least perishable crops, cell phones have no effect on percentage of output not fit for sale.

The results on quality measures illustrate as farmers are able to access cell phone the quality of perishable commodity that traders receive improves. This is important as quality is a major factor that comes in play for the context of perishable commodities. Improvement in quality of output can also increase the income of traders.

6.3 Trader Income and Net Gains

The results presented so far show that cell phones increase the efficiency of traders by increasing the total output purchased as well as raising the quality of output purchased. Next, I also look at the impact of cell phones on the total income that trader earns. To do this I need to differentiate the income that trader earns from transacting with farmers with and without cell phones. To do this, I define income as product of quantity of output fit for sale and the price on day of transaction. Then to normalize it I also divide this product by the total amount purchased from the farmers. Finally I take ln of this income. Results show that traders earn significantly higher income from output they purchased from farmers with cell phones compared to those without it. SRD results presented in Table 7, show that cell phones increase the trader income by 25-31% for extremely perishable crops and 18-26% for highly perishable crops, both statistically significant at 1% level. No significant effect is observed in context of the least perishable crops. These results show that cell phone access have a sizeable effect on the income of traders.

6.4 Robustness and Falsification Tests

To establish the robustness of results, I conduct 3 types of robustness and falsification tests. The results for these tests are explained in this section. The tests show that the results presented earlier are fairly robust.

6.4.1 1 Km Robustness Test

The first test is the 1 km robustness test. In this test, I trim the number of observations to only include the observations lying with in 1 km of the restriction line. Using the narrower margin should allow to see if the effect is only driven by observations far from cut off. The results are presented in first section of Tables 8-13. The results show that for the extremely and highly perishable crops access to cell phones leads to an increase in percentage of output purchased, decrease in number of trips to the market, a decrease in probability of being placed on red list, decrease in the total number of red lists a farmer is placed on, decrease in percentage of output not fit for sale and increase in trader income. The magnitude of the effect of extremely perishable crops is greater than that of the highly perishable crops in all cases. No statistically significant effect is observed in case of the least perishable crops. These results suggest that using the narrower margin does not alter the original results. This means that the results are robust to using the narrower margin.

6.4.2 Fake Boundary Test

In the second test, I test the impact of a fake boundary to see if the effect was caused by just being farther from the border rather than by the restriction line. To do this, I make

15 km the fake restriction line. Then i compare all farmers in villages 10-15 km to those in 15-20 km. The results presented in second section of Tables 8-13, show that in case of all variables, fake boundary has no impact on statistically significant impact. This shows that the result is not driven by the fact that cell phone villages are closer to the border.

6.4.3 Pre-Coverage Placebo Test

The third test is the pre-cell phone coverage test. In this test, I utilize outcomes from years that were before cell phone coverage was introduced. In context of this data, looking at Figure 3, the period 2004-2006 was chosen. This will help me test if the dead zone and non-dead zone villages had different outcome levels in pre-cell phones coverage period. The results presented in third section of Table 8-13 show that for all the variables, cell phones have no impact on pre-coverage period outcomes. This means that the pre-coverage outcome levels for all variables were not significantly different, adding to the robustness of the results.

7 Policy Implications

Penetration of cell phones in rural areas can benefit the traders and farmers of perishable commodities. The results from this paper show that increase in farmers access to cell phones, leads to more efficient functioning of the market. In particular, cell phone coverage expansion helps the trader spread out the supply over time. This means that the farmers make fewer trips to market and the trader is able to purchase the full amount that the farmers brings to the market. Due to this reason there is also a significant increase in the quality of the output being brought to markets as it spends less time in transport and storage. The paper also shows that improving the efficiency of the market also leads to improvement in traders income. The results show that ICTs provide a new tool, which can be leveraged to enhance farmer-trader communication leading to better and more efficient markets.

The impact of cell phone access on quality of output is specifically important. Based this results further applications can be developed for farmers, traders and retailers to further improve the quality. This will mean that higher quality product will eventually be delivered to the consumer.

8 Conclusion

Applying spatial regression discontinuity design methods to high frequency micro-transaction data from Pakistan, this is the first paper to shed light on the impact of cell phones on trader efficiency and output quality. In contrast to the earlier studies focusing on farmers, I focus on the ways in which cell phones can benefit traders. I show that cell phones lead to an increase in the proportion of output purchased by trader and a raise in quality of output delivered to the trader. The result is unique to extremely and highly perishable crops. Finally, I also show that cell phones increase the income of perishable commodity traders. The magnitude and significance of the findings presented highlight the role of cell phones in raising efficiency of perishable commodity markets.

Several important policy implications emerge from these results. I find that strengthening the communication channels can lead to increase in purchasing capacity of trader and over all quality of perishable crops. Cell phones can only establish communication channels to a certain extent. More advanced technology such as specialized cell phone and internet based applications connecting farmers, traders and retailers to each other can further reduce these losses. Due to the nature of losses that occur while the crop goes from farmer to retailer, a substantial amount of risk is involved at each stage. There is a need to conduct further empirical and theoretical research to study the losses that occur at each stage and to see if possible insurance products can be developed mitigate the risk.

An important caveat to my findings is that although access to cell phone coverage improves the income of traders, it is still not possible to estimate the impact of this increased efficiency and quality on consumers. Future work will try to address these questions by collecting additional data. A second additional aspect to be addressed by future research is to quantify the impact of cell phones on trader-retailer relationship. I am currently cleaning trader-retailer transaction data to address this question.

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Table 1: Summary Statistics from Village Level Data

Variables	10 Km Band			1 Km Band		
	Restricted	Not Restricted	Difference of Means	Restricted	Not Restricted	Difference of Means
Infrastructure Availability						
Roads (2008) in 10s of Km	2.5	2.1	0.40	2.3	2.25	0.05
Roads (2000) in 10s of Km	3.7	3.2	0.50	3.30	3.21	0.09
Household Roof (Pucca)	0.48	0.42	0.06	0.57	0.61	-0.04
Water Course Improvement Scheme	0.33	0.35	-0.02	0.44	0.48	-0.04
Wheat Procurement Center	.027	.029	-0.002	0.026	0.021	0.005
Retail Market	0.031	0.041	-0.01	0.038	0.035	0.003
Health Center in Mouza	0.081	0.090	-0.009	0.069	0.079	-0.01
Landline phone	0.046	0.059	-0.013	0.051	0.061	-0.010
Primary School im Mouza boys	0.51	0.56	-0.05	0.54	0.57	-0.03
Primary School im Mouza girls	0.45	0.42	0.03	0.45	0.43	0.02
Sui Gas	0.03	0.04	-0.01	0.035	0.040	-0.005
Credit Facility Type						
ADBP	0.43	0.46	-0.03	0.54	0.56	-0.02
Coop Bank	0.64	0.66	-0.02	0.66	0.69	-0.03
Commercial Bank	0.26	0.29	-0.03	0.27	0.28	-0.01
Microfinance Bank	0.07	0.06	0.01	0.08	0.07	0.01
Government	0.15	0.17	-0.02	0.14	0.17	-0.03
Broker	0.28	0.31	-0.03	0.29	0.34	-0.05
Sources of Employment & Opportunities						
Male Agriculture	0.85	0.90	-0.05	0.87	0.90	-0.03
Male Personal Business	0.24	0.28	-0.04	0.28	0.31	-0.03
Male Labour	0.63	0.59	0.04	0.68	0.64	0.04
Female Agriculture	0.34	0.36	-0.02	0.31	0.36	-0.05
Female Personal Business	0.025	0.027	-0.002	0.020	0.023	-0.003
Female Labour	0.36	0.41	-0.05	0.35	0.32	0.03

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

The table shows village level summary statistics for both outcome and control variables for villages around the restriction. The first three columns present the data for villages with in 10 km of the restriction line, while the next three present data for villages with in 1 km of the restriction line. The restricted villages are the ones without cell phone access while the ones outside restriction have cell phone access. All infrastructure availability, credit facility and sources of employment and opportunities variables are balanced across the treatment and control villages.

Table 2: SRD Results for Impact of Farmer Cell Phone Access on Percentage of Crop Purchased By Trader

	Percentage of Crop Purchased by Trader		
	Degree of Perishability of Crop		
	Extremely	Highly	Least
		OLS	
Cell Phone	0.41***	0.27***	0.05
	(0.07)	(0.04)	(0.04)
		Quadratic in Distance from Restriction	
Cell Phone	0.31***	0.26***	0.04
	(0.06)	(0.08)	(0.05)
		Cubic in Distance from Restriction	
Cell Phone	0.37***	0.24***	0.02
	(0.04)	(0.05)	(0.03)
		Quartic in Distance from Restriction	
Cell Phone	0.38***	0.29***	0.02
	(0.09)	(0.11)	(0.05)
		Quadratic in Lat-Long	
Cell Phone	0.41***	0.30***	0.06
	(0.08)	(0.12)	(0.10)
		Cubic in Lat-Long	
Cell Phone	0.35***	0.23***	0.03
	(0.09)	(0.07)	(0.05)
		Quartic in Lat-Long	
Cell Phone	0.36***	0.29***	0.02
	(0.04)	(0.11)	(0.03)
Tahsil-Crop-Year Fixed Effects^{+}	Y	Y	Y
Number of Transactions	117,964	133,500	96,453

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

$^{+}$The regressions include full set of tahsil, crop, year, tahsil-crop, tahsil-year, crop-year and tahsil-crop-year fixed effects.

Table presents results for the sharp regression discontinuity applied to trader transaction data. The results are presented for quadratic, cubic and quartic polynomials in Euclidean distance from restriction as well as in longitude and latitude. The extremely perishable crops are Tomatoes, Orange, Mangoes, Corn and Sugar Cane. The highly perishable crops are Onion, Garlic, Potatoes, Taro, Peas and Fresh Tumeric. The Least perishable crops are Millet, Feed, Sorghum, Rice, Wheat and Cotton. All results are clustered at union council level.

Table 3: SRD Results for Impact on Number of Trips By Farmer to Trader

	Number of Farmer Trips to Trader		
	Degree of Perishability of Crop		
	Extremely	Highly	Least
	OLS		
Cell Phone	-3.50***	-2.85***	0.43
	(0.75)	(0.52)	(0.45)
	Quadratic in Distance from Restriction		
Cell Phone	-2.14***	-1.86***	0.32
	(0.58)	(0.90)	(0.47)
	Cubic in Distance from Restriction		
Cell Phone	-2.53***	-1.98***	-0.10
	(0.38)	(0.75)	(0.14)
	Quartic in Distance from Restriction		
Cell Phone	-2.85***	-1.50***	-0.20
	(0.85)	(0.68)	(0.30)
	Quadratic in Lat-Long		
Cell Phone	-3.25***	-2.45***	0.25
	(0.60)	(0.49)	(0.30)
	Cubic in Lat-Long		
Cell Phone	-2.75***	-1.65***	-0.30
	(0.75)	(0.53)	(0.42)
	Quartic in Lat-Long		
Cell Phone	-3.50***	-2.15***	0.09
	(0.42)	(0.35)	(0.10)
Tahsil-Crop-Year Fixed Effects+	Y	Y	Y
Number of Transactions	117,964	133,500	96,453

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

+The regressions include full set of tahsil, crop, year, tahsil-crop, tahsil-year, crop-year and tahsil-crop-year fixed effects.

Table presents results for the sharp regression discontinuity applied to trader transaction data. The results are presented for quadratic, cubic and quartic polynomials in Euclidean distance from restriction as well as in longitude and latitude. The extremely perishable crops are Tomatoes, Orange, Mangoes, Corn and Sugar Cane. The highly perishable crops are Onion, Garlic, Potatoes, Taro, Peas and Fresh Tumeric. The Least perishable crops are Millet, Feed, Sorghum, Rice, Wheat and Cotton. All results are clustered at union council level.

Table 4: SRD Results for Impact on Farmer Being Red Listed

	Farmer Lies on Trader Red List		
	Degree of Perishability of Crop		
	Extremely	Highly	Least
	OLS		
Cell Phone	-0.52***	-0.37***	-0.07
	(0.15)	(0.08)	(0.06)
	Quadratic in Distance from Restriction		
Cell Phone	-0.46***	-0.35***	0.02
	(0.21)	(0.14)	(0.05)
	Cubic in Distance from Restriction		
Cell Phone	-0.38***	-0.28***	0.01
	(0.11)	(0.09)	(0.03)
	Quartic in Distance from Restriction		
Cell Phone	-0.39***	-0.31***	0.04
	(0.16)	(0.07)	(0.09)
	Quadratic in Lat-Long		
Cell Phone	-0.43***	-0.36***	-0.01
	(0.20)	(0.05)	(0.01)
	Cubic in Lat-Long		
Cell Phone	-0.37***	-0.29***	0.03
	(0.14)	(0.11)	(0.04)
	Quartic in Lat-Long		
Cell Phone	-0.45***	-0.37***	-0.02
	(0.07)	(0.11)	(0.03)
Tahsil-Crop-Year Fixed Effects$^+$	Y	Y	Y
Number of Transactions	117,964	133,500	96,453

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

$^+$The regressions include full set of tahsil, crop, year, tahsil-crop, tahsil-year, crop-year and tahsil-crop-year fixed effects.

Table presents results for the sharp regression discontinuity applied to trader transaction data. The results are presented for quadratic, cubic and quartic polynomials in Euclidean distance from restriction as well as in longitude and latitude. The extremely perishable crops are Tomatoes, Orange, Mangoes, Corn and Sugar Cane. The highly perishable crops are Onion, Garlic, Potatoes, Taro, Peas and Fresh Tumeric. The Least perishable crops are Millet, Feed, Sorghum, Rice, Wheat and Cotton. All results are clustered at union council level.

Table 5: SRD Results for Impact on Total Number of Red Lists

	Number of Red lists Farmer is On		
	Degree of Perishability of Crop		
	Extremely	Highly	Least
	OLS		
Cell Phone	-2.30***	-1.75***	-0.08
	(0.62)	(0.55)	(0.09)
	Quadratic in Distance from Restriction		
Cell Phone	-2.50***	-1.50***	0.35
	(0.75)	(0.40)	(0.37)
	Cubic in Distance from Restriction		
Cell Phone	-2.60***	-2.25***	-0.09
	(0.85)	(0.72)	(0.10)
	Quartic in Distance from Restriction		
Cell Phone	-3.15***	-2.89***	-0.75
	(0.64)	(0.50)	(0.80)
	Quadratic in Lat-Long		
Cell Phone	-2.85***	-2.15***	1.05
	(0.72)	(0.65)	(0.99)
	Cubic in Lat-Long		
Cell Phone	-3.75***	-3.25***	0.85
	(0.95)	(0.75)	(0.84)
	Quartic in Lat-Long		
Cell Phone	-3.25***	-2.50***	-0.15
	(0.43)	(0.36)	(0.20)
Controls	Y	Y	Y
Tahsil-Crop-Year Fixed Effects+	Y	Y	Y
Number of Transactions	117,964	133,500	96,453

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

+The regressions include full set of tahsil, crop, year, tahsil-crop, tahsil-year, crop-year and tahsil-crop-year fixed effects.

Table presents results for the sharp regression discontinuity applied to trader transaction data. The results are presented for quadratic, cubic and quartic polynomials in Euclidean distance from restriction as well as in longitude and latitude. The extremely perishable crops are Tomatoes, Orange, Mangoes, Corn and Sugar Cane. The highly perishable crops are Onion, Garlic, Potatoes, Taro, Peas and Fresh Tumeric. The Least perishable crops are Millet, Feed, Sorghum, Rice, Wheat and Cotton. All results are clustered at union council level.

Table 6: SRD Results for Impact on Ratio of Output Below Standard

	Proportion of Output Below Standard		
	Degree of Perishability of Crop		
	Extremely	Highly	Least
	OLS		
Cell Phone	-0.38***	-0.25***	0.06
	(0.09)	(0.05)	(0.08)
	Quadratic in Distance from Restriction		
Cell Phone	-0.23***	-0.18***	-0.03
	(0.03)	(0.07)	(0.04)
	Cubic in Distance from Restriction		
Cell Phone	-0.30***	-0.25***	0.02
	(0.07)	(0.04)	(0.02)
	Quartic in Distance from Restriction		
Cell Phone	-0.28***	-0.19***	-0.05
	(0.06)	(0.05)	(0.07)
	Quadratic in Lat-Long		
Cell Phone	-0.34***	-0.21***	0.02
	(0.08)	(0.05)	(0.03)
	Cubic in Lat-Long		
Cell Phone	-0.28***	-0.16***	-0.03
	(0.11)	(0.07)	(0.07)
	Quartic in Lat-Long		
Cell Phone	-0.26***	-0.15***	-0.06
	(0.12)	(0.06)	(0.07)
Controls	Y	Y	Y
Tahsil-Crop-Year Fixed Effects+	Y	Y	Y
Number of Transactions	117,964	133,500	96,453

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

+The regressions include full set of tahsil, crop, year, tahsil-crop, tahsil-year, crop-year and tahsil-crop-year fixed effects.

Table presents results for the sharp regression discontinuity applied to trader transaction data. The results are presented for quadratic, cubic and quartic polynomials in Euclidean distance from restriction as well as in longitude and latitude. The extremely perishable crops are Tomatoes, Orange, Mangoes, Corn and Sugar Cane. The highly perishable crops are Onion, Garlic, Potatoes, Taro, Peas and Fresh Tumeric. The Least perishable crops are Millet, Feed, Sorghum, Rice, Wheat and Cotton. All results are clustered at union council level.

Table 7: SRD Results for Impact on Ln Trader Income

	Ln Trader Income		
	Degree of Perishability of Crop		
	Extremely	Highly	Least
	OLS		
Cell Phone	0.37***	0.24***	0.01
	(0.17)	(0.08)	(0.02)
	Quadratic in Distance from Restriction		
Cell Phone	0.27***	0.21***	0.03
	(0.11)	(0.08)	(0.06)
	Cubic in Distance from Restriction		
Cell Phone	0.31***	0.26***	0.02
	(0.15)	(0.10)	(0.03)
	Quartic in Distance from Restriction		
Cell Phone	0.25***	0.19***	-0.04
	(0.12)	(0.07)	(0.05)
	Quadratic in Lat-Long		
Cell Phone	0.27***	0.16***	0.03
	(0.13)	(0.06)	(0.04)
	Cubic in Lat-Long		
Cell Phone	0.33***	0.19***	-0.01
	(0.11)	(0.06)	(0.02)
	Quartic in Lat-Long		
Cell Phone	0.28***	0.21***	0.09
	(0.08)	(0.05)	(0.10)
Controls	Y	Y	Y
Tahsil-Crop-Year Fixed Effects[+]	Y	Y	Y
Number of Transactions	117,964	133,500	96,453

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

[+]The regressions include full set of tahsil, crop, year, tahsil-crop, tahsil-year, crop-year and tahsil-crop-year fixed effects.

Table presents results for the sharp regression discontinuity applied to trader transaction data. The results are presented for quadratic, cubic and quartic polynomials in Euclidean distance from restriction as well as in longitude and latitude. The extremely perishable crops are Tomatoes, Orange, Mangoes, Corn and Sugar Cane. The highly perishable crops are Onion, Garlic, Potatoes, Taro, Peas and Fresh Tumeric. The Least perishable crops are Millet, Feed, Sorghum, Rice, Wheat and Cotton. All results are clustered at union council level.

Table 8: Robustness Checks for Impact of Farmer Cell Phone Access on Percentage of Crop Purchased

	Degree of Perishability of Crop		
	Extremely	Highly	Least
	1 km Robustness		
	Quadratic in Distance from Restriction		
Cell Phone	0.28***	0.19***	0.03
	(0.13)	(0.07)	(0.04)
	Quadratic in Lat-Long		
Cell Phone	0.31***	0.29***	0.05
	(0.14)	(0.11)	(0.7)
Number of Transactions	12,567	13,450	9,765
	Fake Boundary at 15 km		
	Quadratic in Distance from Restriction		
Cell Phone	0.04	0.03	0.01
	(0.05)	(0.07)	(0.04)
	Quadratic in Lat-Long		
Cell Phone	-0.03	0.05	0.02
	(0.04)	(0.08)	(0.03)
Number of Transactions	97,964	123,500	106,453
	Pre-Coverage Period Placebo		
	Quadratic in Distance from Restriction		
Cell Phone	0.05	0.02	0.01
	(0.06)	(0.08)	(0.05)
	Quadratic in Lat-Long		
Cell Phone	0.06	-0.01	0.03
	(0.08)	(0.12)	(0.10)
Number of Transactions	117,964	133,500	96,453
Tahsil-Crop-Year Fixed Effects+	Y	Y	Y

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

+The regressions include full set of tahsil, crop, year, tahsil-crop, tahsil-year, crop-year and tahsil-crop-year fixed effects.

The first section presents results for 1 km robustness check, where the sample is trimmed to only include farmers from villages with in 1 km of the restriction. The second section presents results for fake boundary, where villages in 10-15 km are compared to villages in 15-20 km. The third sections presents the pre-coverage period test, where only data from years 2004-2006 is used. The results are presented for quadratic polynomial in Euclidean distance from restriction as well as in longitude and latitude. The extremely perishable crops are Tomatoes, Orange, Mangoes, Corn and Sugar Cane. The highly perishable crops are Onion, Garlic, Potatoes, Taro, Peas and Fresh Tumeric. The Least perishable crops are Millet, Feed, Sorghum, Rice, Wheat and Cotton. All results are clustered at union council level.

Table 9: Robustness Checks for Impact of Farmer Cell Phone Access on Number of Trips to Market

	Degree of Perishability of Crop		
	Extremely	Highly	Least
	1 km Robustness		
	Quadratic in Distance from Restriction		
Cell Phone	-1.96***	-1.75***	0.23
	(0.60)	(0.51)	(0.32)
	Quadratic in Lat-Long		
Cell Phone	-2.50***	-1.85***	-0.35
	(0.75)	(0.50)	(0.34)
Number of Transactions	12,567	13,450	9,765
	Fake Boundary at 15 km		
	Quadratic in Distance from Restriction		
Cell Phone	-0.07	0.03	-0.01
	(0.08)	(0.05)	(0.03)
	Quadratic in Lat-Long		
Cell Phone	-0.01	0.03	0.07
	(0.04)	(0.04)	(0.09)
Number of Transactions	97,964	123,500	106,453
	Pre-Coverage Period Placebo		
	Quadratic in Distance from Restriction		
Cell Phone	0.75	-0.54	0.65
	(0.90)	(0.73)	(0.80)
	Quadratic in Lat-Long		
Cell Phone	-0.80	0.50	0.90
	(0.75)	(0.60)	(0.95)
Tahsil-Crop-Year Fixed Effects^{+}	Y	Y	Y
Number of Transactions	117,964	133,500	96,453

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

$^{+}$The regressions include full set of tahsil, crop, year, tahsil-crop, tahsil-year, crop-year and tahsil-crop-year fixed effects.

The first section presents results for 1 km robustness check, where the sample is trimmed to only include farmers from villages with in 1 km of the restriction. The second section presents results for fake boundary, where villages in 10-15 km are compared to villages in 15-20 km. The third sections presents the pre-coverage period test, where only data from years 2004-2006 is used. The results are presented for quadratic polynomial in Euclidean distance from restriction as well as in longitude and latitude. The extremely perishable crops are Tomatoes, Orange, Mangoes, Corn and Sugar Cane. The highly perishable crops are Onion, Garlic, Potatoes, Taro, Peas and Fresh Tumeric. The Least perishable crops are Millet, Feed, Sorghum, Rice, Wheat and Cotton. All results are clustered at union council level.

Table 10: Robustness Checks for Impact of Farmer Cell Phone Access on Prob of Being on Red List

	Farmer Placed on Red List		
	Degree of Perishability of Crop		
	Extremely	Highly	Least
	1 km Robustness		
	Quadratic in Distance from Restriction		
Cell Phone	-0.35***	-0.21***	0.03
	(0.07)	(0.04)	(0.04)
	Quadratic in Lat-Long		
Cell Phone	-0.38***	-0.28***	0.04
	(0.16)	(0.13)	(0.07)
Number of Transactions	12,567	13,450	9,765
	Fake Boundary at 15 km		
	Quadratic in Distance from Restriction		
Cell Phone	0.08	0.03	-0.05
	(0.10)	(0.16)	(0.06)
	Quadratic in Lat-Long		
Cell Phone	0.02	-0.09	0.06
	(0.05)	(0.11)	(0.07)
Number of Transactions	97,964	123,500	106,453
	Pre-Coverage Period Placebo		
	Quadratic in Distance from Restriction		
Cell Phone	0.01	-0.04	0.02
	(0.03)	(0.09)	(0.04)
	Quadratic in Lat-Long		
Cell Phone	0.06	-0.07	0.01
	(0.09)	(0.10)	(0.03)
Tahsil-Crop-Year Fixed Effects^{+}	Y	Y	Y
Number of Transactions	117,964	133,500	96,453

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

$^{+}$The regressions include full set of tahsil, crop, year, tahsil-crop, tahsil-year, crop-year and tahsil-crop-year fixed effects.

The first section presents results for 1 km robustness check, where the sample is trimmed to only include farmers from villages with in 1 km of the restriction. The second section presents results for fake boundary, where villages in 10-15 km are compared to villages in 15-20 km. The third sections presents the pre-coverage period test, where only data from years 2004-2006 is used. The results are presented for quadratic polynomial in Euclidean distance from restriction as well as in longitude and latitude. The extremely perishable crops are Tomatoes, Orange, Mangoes, Corn and Sugar Cane. The highly perishable crops are Onion, Garlic, Potatoes, Taro, Peas and Fresh Tumeric. The Least perishable crops are Millet, Feed, Sorghum, Rice, Wheat and Cotton. All results are clustered at union council level.

Table 11: Robustness Checks for Impact of Farmer Cell Phone Access on Number of Red Lists

	Number of Red Lists on Which Farmer is Placed		
	Degree of Perishability of Crop		
	Extremely	Highly	Least
	1 km Robustness		
	Quadratic in Distance from Restriction		
Cell Phone	-2.86***	-1.96***	0.23
	(0.82)	(0.78)	(0.35)
	Quadratic in Lat-Long		
Cell Phone	-3.15***	-2.25***	0.45
	(0.78)	(0.62)	(0.50)
Number of Transactions	12,567	13,450	9,765
	Fake Boundary at 15 km		
	Quadratic in Distance from Restriction		
Cell Phone	0.56	-0.42	0.34
	(0.60)	(0.39)	(0.32)
	Quadratic in Lat-Long		
Cell Phone	-0.29	0.35	-0.13
	(0.31)	(0.33)	(0.24)
Number of Transactions	97,964	123,500	106,453
	Pre-Coverage Period Placebo		
	Quadratic in Distance from Restriction		
Cell Phone	-0.25	0.31	0.26
	(0.22)	(0.38)	(0.30)
	Quadratic in Lat-Long		
Cell Phone	0.36	0.18	-0.29
	(0.41)	(0.30)	(0.27)
Tahsil-Crop-Year Fixed Effects^{+}	Y	Y	Y
Number of Transactions	117,964	133,500	96,453

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

$^{+}$The regressions include full set of tahsil, crop, year, tahsil-crop, tahsil-year, crop-year and tahsil-crop-year fixed effects.

The first section presents results for 1 km robustness check, where the sample is trimmed to only include farmers from villages with in 1 km of the restriction. The second section presents results for fake boundary, where villages in 10-15 km are compared to villages in 15-20 km. The third sections presents the pre-coverage period test, where only data from years 2004-2006 is used. The results are presented for quadratic polynomial in Euclidean distance from restriction as well as in longitude and latitude. The extremely perishable crops are Tomatoes, Orange, Mangoes, Corn and Sugar Cane. The highly perishable crops are Onion, Garlic, Potatoes, Taro, Peas and Fresh Tumeric. The Least perishable crops are Millet, Feed, Sorghum, Rice, Wheat and Cotton. All results are clustered at union council level.

Table 12: Robustness Checks for Impact of Farmer Cell Phone Access on Percentage of Output Below Standard

	Percentage of Output Below Standard		
	Degree of Perishability of Crop		
	Extremely	Highly	Least
	1 km Robustness		
	Quadratic in Distance from Restriction		
Cell Phone	-0.21***	-0.16***	0.02
	(0.07)	(0.04)	(0.05)
	Quadratic in Lat-Long		
Cell Phone	-0.24***	-0.15***	-0.01
	(0.06)	(0.05)	(0.04)
Number of Transactions	12,567	13,450	9,765
	Fake Boundary at 15 km		
	Quadratic in Distance from Restriction		
Cell Phone	0.04	-0.03	0.05
	(0.05)	(0.04)	(0.05)
	Quadratic in Lat-Long		
Cell Phone	-0.02	0.01	0.04
	(0.04)	(0.03)	(0.09)
Number of Transactions	97,964	123,500	106,453
	Pre-Coverage Period Placebo		
	Quadratic in Distance from Restriction		
Cell Phone	-0.07	0.05	0.03
	(0.08)	(0.11)	(0.08)
	Quadratic in Lat-Long		
Cell Phone	0.02	0.01	0.01
	(0.07)	(0.04)	(0.02)
Tahsil-Crop-Year Fixed Effects$^+$	Y	Y	Y
Number of Transactions	117,964	133,500	96,453

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

$^+$The regressions include full set of tahsil, crop, year, tahsil-crop, tahsil-year, crop-year and tahsil-crop-year fixed effects.

The first section presents results for 1 km robustness check, where the sample is trimmed to only include farmers from villages with in 1 km of the restriction. The second section presents results for fake boundary, where villages in 10-15 km are compared to villages in 15-20 km. The third sections presents the pre-coverage period test, where only data from years 2004-2006 is used. The results are presented for quadratic polynomial in Euclidean distance from restriction as well as in longitude and latitude. The extremely perishable crops are Tomatoes, Orange, Mangoes, Corn and Sugar Cane. The highly perishable crops are Onion, Garlic, Potatoes, Taro, Peas and Fresh Tumeric. The Least perishable crops are Millet, Feed, Sorghum, Rice, Wheat and Cotton. All results are clustered at union council level.

Table 13: Robustness Checks for Impact of Farmer Cell Phone Access on Ln Trader Income

	Ln Trader Income		
	Degree of Perishability of Crop		
	Extremely	Highly	Least
	1 km Robustness		
	Quadratic in Distance from Restriction		
Cell Phone	0.26***	0.14***	0.01
	(0.07)	(0.04)	(0.02)
	Quadratic in Lat-Long		
Cell Phone	0.33***	0.25***	0.04
	(0.04)	(0.05)	(0.08)
Number of Transactions	12,567	13,450	9,765
	Fake Boundary at 15 km		
	Quadratic in Distance from Restriction		
Cell Phone	0.04	0.03	-0.01
	(0.06)	(0.07)	(0.04)
	Quadratic in Lat-Long		
Cell Phone	0.02	-0.04	0.05
	(0.04)	(0.07)	(0.07)
Number of Transactions	97,964	123,500	106,453
	Pre-Coverage Period Placebo		
	Quadratic in Distance from Restriction		
Cell Phone	0.05	0.03	0.07
	(0.07)	(0.04)	(0.08)
	Quadratic in Lat-Long		
Cell Phone	0.04	0.08	0.02
	(0.11)	(0.09)	(0.08)
Tahsil-Crop-Year Fixed Effects$^+$	Y	Y	Y
Number of Transactions	117,964	133,500	96,453

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

$^+$The regressions include full set of tahsil, crop, year, tahsil-crop, tahsil-year, crop-year and tahsil-crop-year fixed effects.

The first section presents results for 1 km robustness check, where the sample is trimmed to only include farmers from villages with in 1 km of the restriction. The second section presents results for fake boundary, where villages in 10-15 km are compared to villages in 15-20 km. The third sections presents the pre-coverage period test, where only data from years 2004-2006 is used. The results are presented for quadratic polynomial in Euclidean distance from restriction as well as in longitude and latitude. The extremely perishable crops are Tomatoes, Orange, Mangoes, Corn and Sugar Cane. The highly perishable crops are Onion, Garlic, Potatoes, Taro, Peas and Fresh Tumeric. The Least perishable crops are Millet, Feed, Sorghum, Rice, Wheat and Cotton. All results are clustered at union council level.

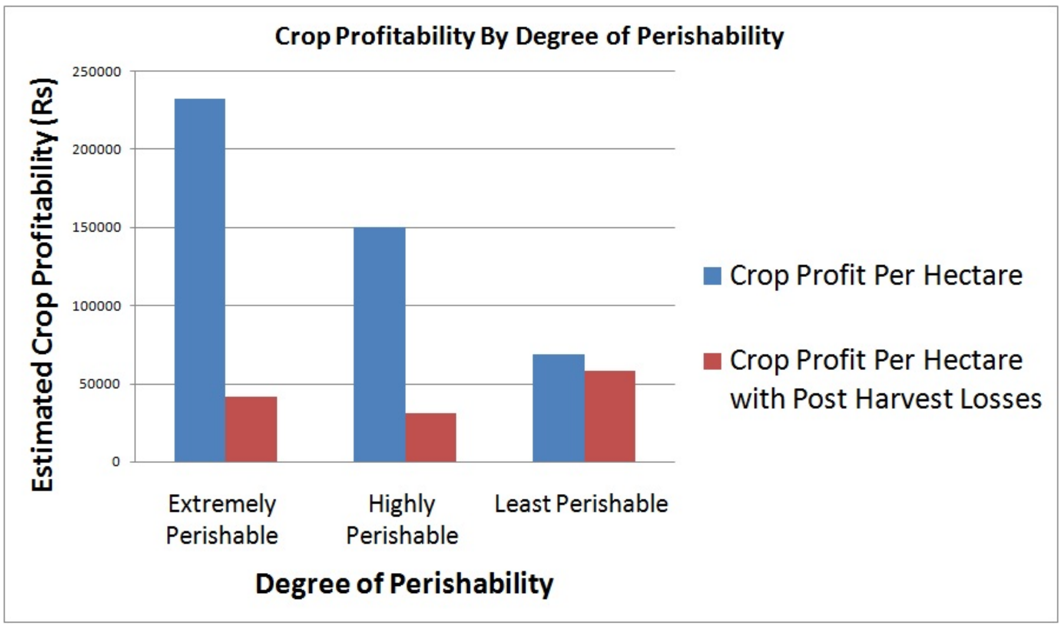

Figure 1: Profitability of Crops by Degree of Perishability

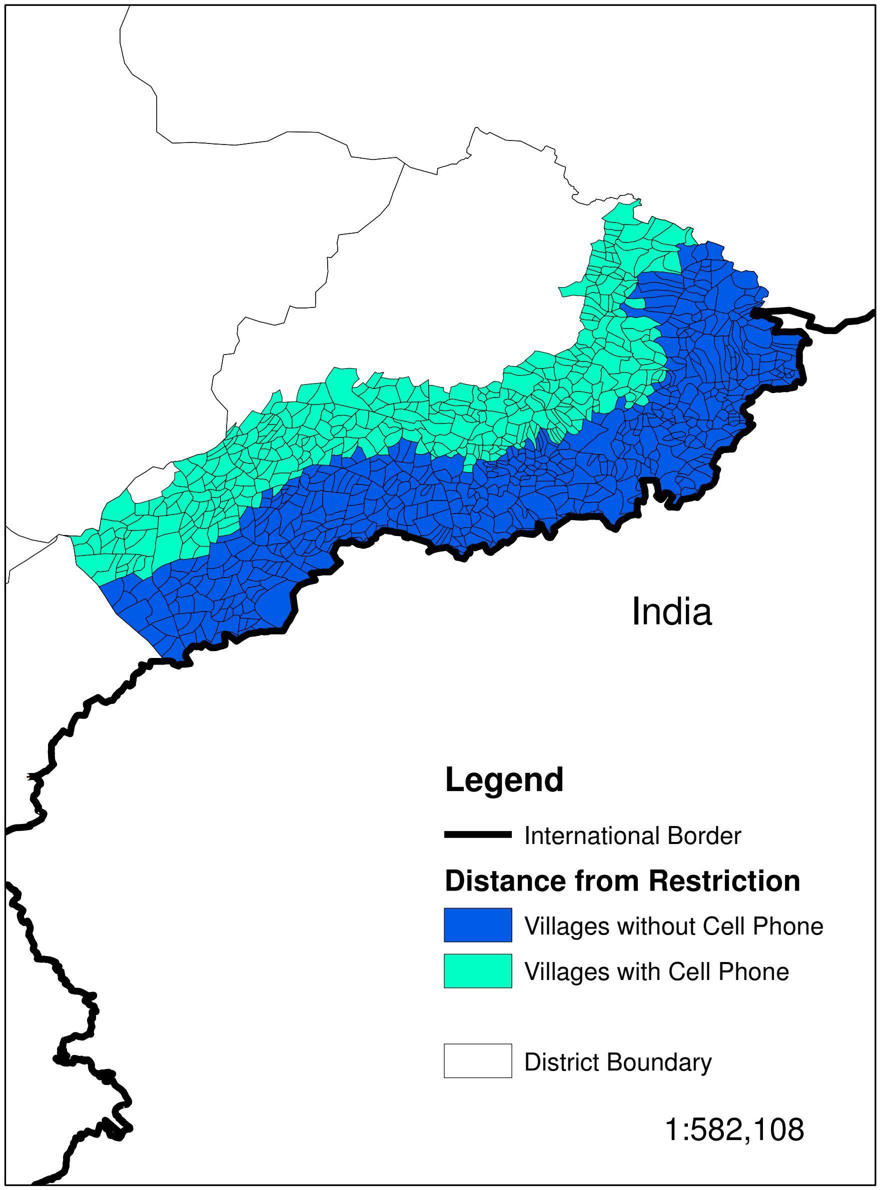

Figure 2: Map of the Restriction Coverage (Change in Color Shows Change in Coverage Status around the restriction)

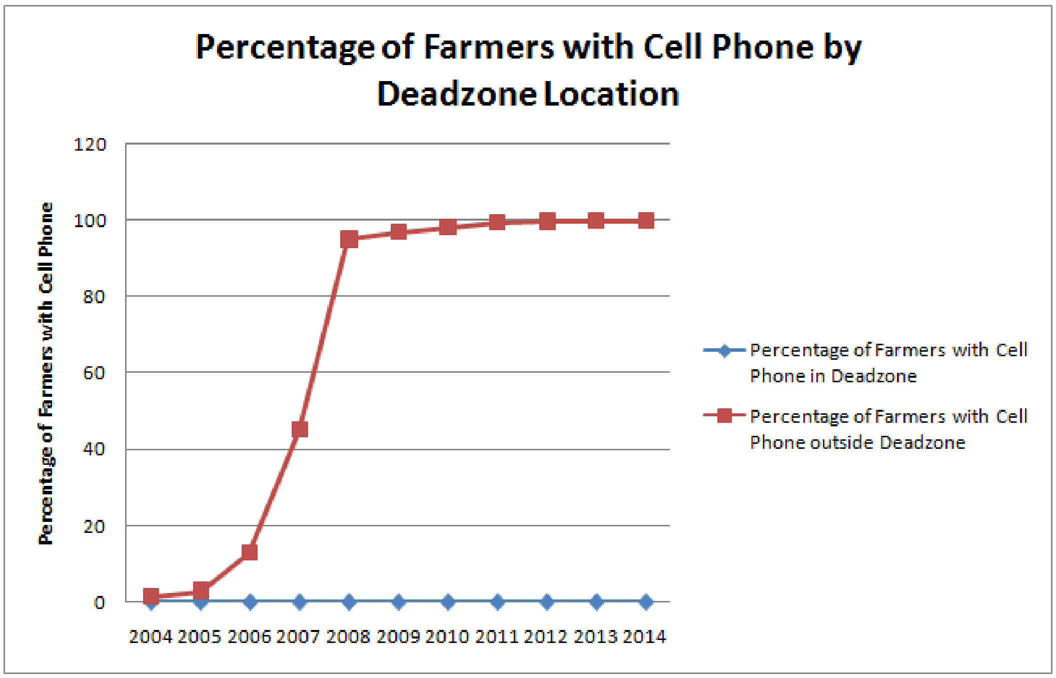

Figure 3: Graph Showing Change in Cell Phone Penetration

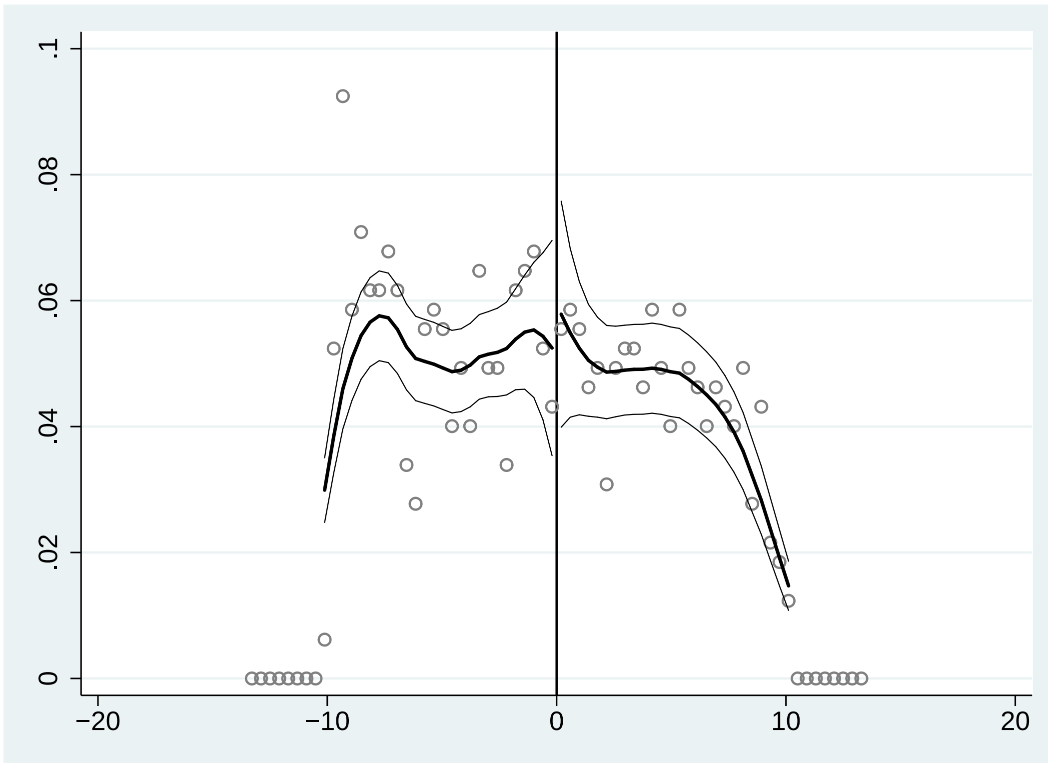

Figure 4: McCrary Density Test on Village Level Running Variable(Graph Generated using Stata Code McCrary (2008)). The graph indicates that density of villages is continuous at the cutoff.