Asymmetric Information and Middleman Margins: An Experiment with Indian Potato Farmers*

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Abstract

In an experiment where potato farmers in randomly chosen villages in two Indian districts were provided information about prices at which middlemen resold their output, we find no significant average treatment effects on traded quantities or revenues, but both became more responsive to market price variations. The results confirm predictions of a model of *ex post* bargaining and sequential price competition between village middlemen and external middlemen, where farmers lack direct access to wholesale markets. Alternative explanations such as collusion, simultaneous price competition and insurance via relational contracts between middlemen and farmers can be ruled out. (JEL Codes: O120, L140)

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1 Introduction

Research has long suggested that middlemen margins are a large component of agricultural value chains in many developing countries. For example, Morisset (1998) argues that the large and increasing gaps between world commodity prices and consumer prices cannot be explained by trade or tax policies, or by transport, processing and marketing costs. Middlemen are also thought to be the reason why rises in export prices do not translate into commensurate increases in producer prices.[1]

However, there is little evidence on the magnitude of middlemen margins, and their determinants. Our understanding of the market structure of middlemen and trading mechanisms is also limited.[2] Do farmers and traders bargain *ex post*, or do they enter into *ex ante* contracts? Do farmers have less information than traders about price movements in downstream markets? Would providing farmers with this price information reduce middleman margins and increase the pass-through of retail prices to farmers?

In this paper we study these questions in the context of the supply chain for potatoes, a high-value cash crop grown in the Indian state of West Bengal. We collect data that allow us to describe the relevant trading institutions, and conduct a randomized intervention providing price information to farmers, which allows us to identify the trading mechanisms at work in this context. This also allows us to estimate the empirical effect of a policy intervention aimed at improving farmers' price information.

In 2008, farmers in randomly chosen villages from two potato-growing districts in West Bengal were given daily information about the prevailing potato prices in neighboring wholesale and retail markets. Different models of competition among middlemen and contracting mechanisms between middlemen and farmers predict significantly different impacts of this intervention on the quantity of potatoes that farmers sell and the revenue they receive. The empirical effects of the information provision enable us to identify the trading arrangements at this stage of the agricultural value chain. This helps to understand the rationale for the middleman margins we observe, and also

[1]Fafchamps and Hill (2008) find that when the export price of Ugandan coffee increased in 2002-03, wholesale prices also rose, and the gap between wholesale and farmgate prices widened. McMillan, Rodrik, and Welch (2002) claim that no more than 40-50 percent of the increased cashew export prices in the 1990s accrued eventually to farmers in Mozambique.

[2]Recent theoretical contributions include Antras and Costinot (2010), Antras and Costinot (2011), Bardhan, Mookherjee, and Tsumagari (2013) and Chau, Goto, and Kanbur (2009).

explains how these margins change when farmers become better informed about market prices.

In our study, providing market price information to farmers did not change the average earnings of farmers, but increased their volatility, thus reducing farmer welfare. Our analysis provides an explanation for this finding, by identifying the underlying trading institutions. As we show theoretically, the effects of price information provision to farmers depends crucially on the market structure of potato buyers, farmers' outside options and the resulting contracting arrangements between farmers and intermediaries. Our surveys provide rich institutional detail that helps understand why direct sales to wholesalers are very infrequent, despite the absence of any legal restrictions against them. West Bengal potato farmers are excluded from selling directly at wholesale markets, and direct purchases by retailers are barred by law, leaving farmers with little option but to sell to middlemen. In turn, these middlemen re-sell the crop to wholesalers in privately negotiated trades. Farmers do not know the prices at which these trades between intermediaries and wholesalers occur.

Middlemen operating within the same village appear to collude. Collusion among the village trader and the trader in the small local market is more difficult, possibly because the market trader does not visit the village. However this also means that to sell to this trader the farmer must incur a cost to transport his potatoes to the small local market, and then incur this cost again to transport them back to the village if the trade does not take place, which leads to a hold-up problem. These features limit competition severely. As a result, delivering market price information to farmers does not provide them with additional arbitrage opportunities of the sort that Jensen (2007) analyses among Kerala fishermen or Goyal (2010) finds among soybean farmers in Madhya Pradesh.

We propose a model of *ex post* bargaining with sequential competition, where a village middleman observes the (wholesale) price at which he can resell the potatoes, and then makes a take-it-or-leave-it price offer to the farmer. The offer is designed to leave the farmer indifferent between accepting and refusing. If he refuses, the farmer has only one alternative: to take his potatoes to the neighboring market where an alternative middleman is located. In the absence of any other alternatives, being informed about the wholesale prices does not change the price offer the farmer receives from this alternative middleman. Whether it affects the price offer the original middleman makes to him, depends on whether the village middleman's price offer was fully revealing or not. If it was, then the farmer already infers the true market price from the offer, and so the information intervention has no effect. If the offer was not fully revealing, the intervention can have an impact: it enables the farmer to learn when the wholesale price, and correspondingly the price he expects to receive from the alternative middleman, is relatively high or low. This induces the village middleman to lower the price offer when the market price is low, and raise it when it is high, with no effect on the price offered on average. We show theoretically that both kinds of equilibria can exist. We therefore obtain the theoretical prediction that the intervention will either have no effect at all, or it will have a zero average effect, while raising volatility of traded quantities and revenues earned by the farmer.

Our empirical results are consistent with the model described above. The experimental provision of wholesale market price information to farmers improved the precision of the farmers' price information, consistent with an initial equilibrium with pooling price offers. The treatment did not change average quantities traded or revenues earned. However it had a non-significant impact on the farmgate price and quantity traded that was heterogenous with respect to the realization of wholesale prices: the quantity sold and revenue received by farmers fell (resp. rose) significantly in areas where the wholesale price was low (resp. high). Importantly, these effects are estimated after controlling for both the potato variety and the (self-reported) quality of potatoes that the farmer sells. Hence, they are not driven by endogenous changes in quality or variety of potato sales in response to the wholesale market price. Additional testable predictions of the model are also verified empirically. Controlling for the wholesale price, the farmgate price is lower on average than the price the farmer would receive at the market. We verify the predictions that the farmer is more likely to sell at the market both when the wholesale market price is higher and when transport costs are higher.

These results are inconsistent with alternative trading arrangements. If local traders collude perfectly, the information intervention would not change the responsiveness of the farmer price or quantity to the wholesale market price. This would also be true in a model of simultaneous price competition among traders. Models of *ex ante* risk-sharing arrangements involving commitment by both trading partners predict either no effect at all, or an increase in the quantity traded at low wholesale prices, because the intervention would remove a screening distortion caused by asymmetric information. We do not see either of these effects in the data. More generally, we do not find evidence for the hypothesis that local traders insure farmers against price risk, and that their margins are competitive risk premia. Since we find no average treatment effects of the information intervention, any price insurance would have to be actuarially fair, suggesting that traders make losses when wholesale prices are low. However there is no evidence that traders' net margins are ever negative, no matter how low the wholesale prices are. We therefore conclude that the middleman margins we observe are caused by minimal competition among middlemen and limited outside options for farmers.

In this respect our results are different from previous work finding that increased access to market price information increases farmer prices (Goyal 2010) and reduces price dispersion across markets (Jensen 2007, Aker 2010). In all of those contexts, the information was provided to agents who could sell directly in the markets, without relying on middlemen. Instead, our results are similar to those of Fafchamps and Minten (2012), who find that providing farmers with free access to information had no significant effects on the average prices they earned. They also suggest that their results are driven by limited arbitrage opportunities for these farmers, caused either by high transport costs or the lack of trustworthy buyers in alternative markets.

Section 2 of the paper describes the institutional setting, based on farmer and trade surveys, as well as data on market price movements. Section 3 describes the nature of the experiment and the data collected from farmer surveys, and Section 4 presents the theoretical model. The main empirical results are presented in Section 5. Arguments against alternative explanations are provided in Section 6. Finally, Section 7 concludes the paper. Proofs of theoretical results and supplementary tables are provided in the Appendix.

2 The Context: Potato Production and Sales

The state of West Bengal accounts for about 40 percent of the total volume of potatoes produced in India and is a leading exporter of potatoes to several other states. Potatoes are the primary cash crop in West Bengal in terms of value added per acre, and have the highest acreage planted among all winter crops in the two districts in our study, Hugli and West Medinipur (Bardhan and Mookherjee 2011). They are planted between October and December, and harvested between January and March. Farmers have a long time horizon over which they can sell their harvest: they can be sold immediately at the time of harvest, or, if placed in home stores they can be sold up to two or three months later. Alternatively they could be placed in cold stores, and then the farmer has the option to sell them any time until November, when the new planting season begins.

Clearly, farmers must decide when to sell their potatoes during the year based on their expectations of future prices and their time discount rate. The information intervention is likely to have affected their expectations and therefore could have affected the timing of their sales, and through that, the revenue that they receive. This makes an observation of a sale in any given week endogenous to the intervention. However, since potatoes cannot be stored for longer than 11 months, all potatoes harvested in a year must be sold within the year.[3] Therefore, we simplify the analysis by aggregating the data to the annual level. All our analysis will focus on the aggregate quantity the farmer sells and the aggregate revenue he receives during the year.

2.1 Farmer-Trader Transactions and Market Structure

The principal focus of this paper is on trades occurring between farmers and traders. We now provide further detail about this layer of the supply chain. These facts motivate the model of farmer-trader contracts that we present in Section 4 and then test in Section 5.

The local supply chain is organized as shown in Figure 1. Our baseline survey shows that in 2006 (that is, before our intervention began), sample farmers sold 98 percent of their produce to local intermediaries or village traders. These village traders aggregate purchases from local farmers, transport them to wholesale markets called *mandis* and then sell to traders in city markets or in neighboring states.[4] They are usually residents of the same village or neighbouring villages. Besides buying potatoes, they trade in other seasonal produce and often sell agricultural inputs and provide credit as well. They interact with farmers with high frequency, so that it does not appear that either farmers or village traders incur large search costs for a trade to take place.

Potatoes from Hugli district are usually sold ultimately in Kolkata retail markets, and in states in Eastern and Northeastern India such as Assam, Bihar and Jharkhand. Potatoes from West Medinipur are sold in the Bhubaneswar market in neighboring Orissa, or in the southern state of

[3] This is because of the technical difficulty of storing potatoes from different vintages together, as well as government regulations governing cold storage facilities.

[4] The category of village traders is made up of *phorias* and *aratdaars*. *Phorias* are primarily responsible for sourcing potatoes from farmers; *aratdaars* own sheds where potatoes can be aggregated, dried, sorted and packaged. *Phorias* may be entrepreneurs selling to *aratdaars* who then sell to buyers in distant markets, they may be commission agents of *aratdaars*, or they may bypass *aratdaars* altogether and sell to distant buyers directly. Thus the distinction between the two is somewhat nebulous. For the purposes of this paper, we club them together and refer to them as village traders.

Andhra Pradesh. Figure 2 shows a district map of West Bengal which shows the location of these two districts, and the neighboring states where potatoes are sold. As we show in Section 2.4, price movements in these city retail markets explain much of the movement in local wholesale (*mandi*) prices that we observe.

In 2006, sample farmers sold only 1 percent of potatoes in small local markets (*haats*) located on average 5 kilometres outside the village. To make these sales, farmers transported their potatoes to the *haat* and sold them to an intermediary operating in that market. In informal interviews, large buyers from distant markets confirmed they do not transact directly with farmers because it "is not worth their while" to negotiate small trade volumes with so many different farmers whom they do not know personally, and therefore cannot trust to provide reliable quality.

Village traders usually buy from a network of farmers who have a track record of selling potatoes of uniform quality and not cheating them by mixing potatoes of different grades into their sacks, or putting less potatoes into the sack than they claim. In 2007, nearly 72 percent of the potato sales by our sample farmers were to buyers whom they had been selling to for longer than a year, and 32 percent were to buyers whom they had sold to for longer than two years. This high incidence of repeat transactions among the same partners raises the possibility of implicit contracts. It is not uncommon for potato purchases by village traders to be bundled with credit market transactions, or transactions of other inputs. However, only 21 percent of the potato sales in 2007 were to buyers whom the farmer had an outstanding loan from. Moreover, farmers also told us that they were not bound to sell to the trader who had provided these inputs or credit, but instead were free to sell to someone else and to use the proceeds to repay the loan. In informal interviews village traders told us that they do not have any explicit *ex ante* contractual agreements with particular farmers about quantity or price. They also do not have any exclusive dealing clauses. Instead, they reported that trades occurring on any given day were negotiated on that day: the village traders made a price offer, and the farmer responded with a decision of whether and how much to sell at that price.

There are on average 10 traders operating in any given village, and farmers report being free to sell to any of these. However, village traders do admit to discussing price offers with other village traders, and checking with farmers the prices at which they recently sold to others. It is thus quite possible that village traders within a village tacitly collude on prices. Distance also appears to matter: traders within the village meet and discuss the state of the market on a daily basis, but meet with traders from outside the village less frequently. Hence it is less likely that they can collude with traders operating in other villages or at *haats*. When responding to a price offer from a village trader on any given day, farmers perceive their main outside option as taking their potatoes to the *haat* and try and sell to another trader located in that market, or waiting to sell later in the year. These facts motivate our model of *ex post* bargaining with sequential competition between a village trader and a trader at a local market (*haat*).

2.2 Price Information of Farmers

Since transactions between the traders and buyers from distant markets are often bilateral, information about what price the trader receives when he sells potatoes at the *mandi* is not in the public domain. Farmers therefore do not have the opportunity to learn directly about prices at which the traders are able to resell their potatoes. Their main source of information is the village trader whom they deal with most frequently: in 2007 before our intervention began, nearly half of our sample farmers reported they learnt about wholesale prices only from the village trader. Another 15 percent reported they found out prevailing prices from friends or neighbours. The media tends to report wholesale prices in distant city markets, and only about 6 percent of farmers reported that as their source of information. Note that telecommunication facilities are available: 51% of the villages in our sample had telephone booths, 24% of the households reported they had landline phones and 33% had mobile phones in 2007. When asked in informal interviews why they could not find out the price at which traders were selling in the wholesale market, they reported having no contacts in the wholesale market who would be willing to give them this information.

Our surveys also provide evidence consistent with this information asymmetry. In our fortnightly surveys, we asked farmers what the price in the neighboring market had been recently.[5] The prices reported did not match prices at which traders were selling at the *mandi* in the relevant week, but instead was much closer to the price received by farmers who made a sale to a trader in a *haat* in that week. The average price they reported (Rupees 2.57 per kg) was close to the gross price at which farmers sold in *haats* (Rupees 2.55 per kg), and substantially different from the average gross price at which traders sold at the wholesale market (Rupees 4.82 per kg).[6]

[5] They also told us how many days ago they had tracked this price. Combined with the date of the survey, this allows us to estimate the week that they reported their tracked price for, and match their report to the actual price in that week.

[6] The gross price at which a farmer sold at *haats* is computed by dividing the total revenue he received from selling at a market across all weeks in the year, by the quantity sold. Rupees 2.55 is the average of this number

The gross price at which traders sold to distant buyers is the annual average of the *mandi* price. These price reports were submitted to us by "insiders" in the wholesale markets, who were either employees of the distant buyers, or small entrepreneurs (e.g. tea shop owners) located at the markets, and observed trades at the wholesale level. They were persuaded by our investigators to give us this information on a daily basis, in return for a monthly fee.

2.3 Margins Earned by Traders

Estimating the margins earned by middlemen is not straightforward because they often hold potatoes after buying them, and sell them later in the year when the price is high. Also, they incur costs of transport, handling and loading, and storage in case they hold potatoes beyond the harvest period; these have to be subtracted from their gross margin. In the absence of data about actual costs incurred by traders, we can calculate a lower bound to their expected margins as follows. First, traders have the option of re-selling at the same time as they buy, so the difference between their selling and buying prices at the same point of time provides a lower bound to their expected gross margin. Second, farmers in our survey who sold in local markets (*haats*) incurred transport and handling costs, and those who stored potatoes beyond the harvest season incurred storage costs. It is plausible that unit costs of transport and storage incurred by traders are lower than those incurred by farmers, because they can avail of economies of scale and connections with store-owners. Hence the transport and storage costs incurred by farmers provide an upper bound to the corresponding costs that traders incurred; subtracting them from gross margins then yields a lower bound to trader net margins.

Using this method, lower bounds to trader net margins need to be calculated separately for harvest and post-harvest periods. This is because storage costs would not be incurred, while transport costs would be incurred for potatoes bought and sold during the harvest period. For such transactions, the trader would buy potatoes from the field right after the harvest, have them cleaned, sorted and transported to the *mandi* and then loaded directly onto trucks sent by buyers. In transactions occurring after June, the trader would buy potato bonds from farmers, pay storage charges to release the potatoes from the cold store, then have them dried, sorted, colored and loaded into the buyers' trucks.[7] They would incur storage costs, but no transport

across all farmers who sold at markets.

[7]Most cold storage facilities are located near *mandis*.

costs because these would have been incurred by farmers who had earlier placed them in the store.

Using average prices for the harvest and post-harvest season (using the distribution of quantities sold in the sample in different weeks as weights), lower bounds to trader gross margins were Rs. 2.59 per kg during the harvest period (the average selling price was Rs 4.81 and buying price was Rs 2.22), and Rs 2.72 during the post-harvest period (the average selling price was Rs 4.83 and buying price was Rs 2.11). The mean unit costs (per kg) incurred by sample farmers who sold potatoes at a *haat* were as follows: transport costs Rs. 0.23 in the harvest period, handling and other costs Rs. 0.35/0.45 in the harvest/post-harvest period, and storage costs Rs. 0.91 incurred for post-harvest sales. Note that cold stores charge a flat rate irrespective of the duration for which the potatoes are stored. Since farmers tend to transport and sell potatoes only in *haats* which are on average 5 kilometres away from the village whereas traders tend to transport them to *mandis* which are on average 8 kilometres away, we make a proportional adjustment and revise traders' unit cost of transport to Rs. 0.39 for harvest transactions.

We thus obtain the following lower bounds on average trader margins in 2008:

$$\text{Middleman margin} = \begin{cases} \text{Rs.}4.81 - 2.22 - 0.39 - 0.35 = \text{Rs.}1.85 & \text{per kg for harvest transactions,} \\ \text{Rs.}4.83 - 2.11 - 0.45 - 0.91 = \text{Rs.}1.36 & \text{per kg for post-harvest transactions.} \end{cases}$$

Middlemen therefore earned at least 28 to 38 percent of the wholesale market price, and 64 to 83 percent of the farm-gate price, depending on which part of the year they bought and sold the crop in.[8]

Figure 3 provides a non-parametric plot of the lower bound to trader gross margins against the mandi price, averaging for the year as a whole. Note that the gross margin lower bound is always positive, even at the bottom end of the *mandi* price distribution. The mean gross trader margin was Rs. 2.24, ranging from a low of Rs. 1.04 in the first quartile of the *mandi* price, to a high of Rs. 4.06 in the fourth quartile. It is not possible to compute the corresponding distribution of the net margin lower bound averaged for the entire year, due to asymmetry of costs between harvest and post-harvest seasons, but we can provide these separately for the harvest and post-harvest seasons. During the harvest, the lower bound of the trader net margin for the four quartiles of

[8]Our findings are similar to the conclusions of previous work: In his 1998-99 study of 136 potato farmers in the Arambagh block of Hugli district, Basu (2008) found that middlemen margins net of transactions costs were 25 percent of retail price in the busy season, and 20 percent in the lean season. Farmgate prices were between 49 and 36 percent.

the *mandi* price were Rs 0.71, 0.83, 2.13 and 3.48 respectively. Hence, traders earned a sizeable margin in the harvest season even when *mandi* prices were very low. Post-harvest, these were Rs -0.71, -0.08, 1.33 and 2.60 respectively for the four quartiles. Since these are lower bounds, we cannot infer the sign of the trader's net margin at the bottom two quartiles of *mandi* price during the post-harvest season. In all other cases it appears clear that traders earned a positive margin.

2.4 Price Variations

The key premise in this project is that farmers have less information about prices prevailing in the *mandi* than traders do, and that the information intervention should have decreased this asymmetry. We now discuss the evidence suggesting a significant informational asymmetry.

We have described anecdotal evidence that farmers do not have any sources of information in the *mandis*. However, one may wonder if they could infer the prevailing *mandi* price from their observations of farmgate prices in previous years or from the realization of local potato harvests. How much information about the current *mandi* price can be extracted from these observations?

To examine this, we look at spatial and temporal price patterns. When we focus on the period from May to November, we find substantial volatility in wholesale prices at the *mandi*.[9] The average price per kilogram in the post-harvest period across all *mandis* in our sample was Rs 7.60 in 2007, Rs 4.83 in 2008, Rs 5.55 in 2011 and 10.99 in 2012.[10]

The variation in *mandi* prices can occur at multiple levels. Table 1 presents an analysis of variance of weekly prices in sample *mandis* for weeks 13 and beyond in 2007, 2008, 2011 and 2012. As the F-statistics show, the highest variability occurs across-years, followed by period-year variations and spatial *mandi*-level variations. Prices also follow different patterns in different periods over time within the year.[11] Finally, different *mandis* often follow different patterns from year to year.

[9] The analysis in this section uses *mandi* price data from 2007, 2008, 2011 and 2012. Although in 2008 we collected *mandi* price data from January to November, in the other years we have these data only for the period May-November. For this reason we restrict this analysis to the post-harvest period. However in Section 5 we will analyze all sales that occur in 2008, regardless of timing.

[10] Our information interventions were only done in 2008 and so our main empirical results are only for that year. However we collected *mandi* price data for 2007, 2008, 2011 and 2012. These additional data are used in this section to examine the predictability of *mandi* prices.

[11] Weeks 13 to 26 are considered to be the post-harvest early period when farmers could be selling the last of their home-stored potatoes, and weeks 26-52 are the post-harvest late period, when any potatoes being sold are coming out of cold storage.

The first column in Table 2 presents the result of a regression on a pooled cross-section of annual *mandi* prices on various factors that could explain the annual variation: average wholesale price in the relevant city market (Kolkata for Hugli, Bhubaneswar for West Medinipur) which is the ultimate destination in the wholesale supply chain, distance between the *mandi* and the city, interactions between distance and city price (representing fluctuating transport costs) and local potato yields (from output data for sample farmers located in each *mandi* area), and a variety of local village infrastructure measures.[12] The regression coefficient on the city price is 0.84, significant at 1%, and the only other significant variables are the year dummies. Hence supply shocks in the local areas where our study was conducted do not appear to explain *mandi* prices, and so we do not expect that farmers can infer *mandi* prices by observing local yields. Column 2 presents a similar regression using weekly *mandi* prices, and controlling for *mandi* week and year fixed effects. Once again, city prices explain *mandi* prices significantly. Local yields do not. This is also true in Column 3, where the sample excludes data points in 2008, the year of our study.

Finally, Column 4 of Table 2 presents a regression of weekly farmer prices in 2008 on the city price and local yields, controlling for *mandi* dummies and week dummies. It is clear that the pass-through from city prices to farmer prices is extremely low: the pass-through coefficient is 0.02 and is statistically insignificant from zero. Thus, farmer prices do not co-move with city prices, whereas *mandi* prices do. This implies that it is very difficult for farmers to back out the prevailing *mandi* price from the current farmer price.

3 The Experiment and the Data

Our experiment was conducted in 72 randomly chosen villages in the potato growing areas of Hugli and West Medinipur districts. The sample villages under each market catchment area were randomly assigned to three groups, resulting in 24 villages in each treatment group. In two groups we conducted two different information treatments and one group served as control where no information was provided. To reduce information spillovers, villages were selected such that they were at a minimum distance of 8 kilometres from each other.[13] In the two treatment groups,

[12] These annual averages are computed only for the post-harvest weeks, i.e. weeks 13 and beyond.

[13] In informal interviews conducted in the area in 2006 before our sample was drawn, we found that in the regular course of events the typical farmer tended to travel no more than 8 kilometres out of the village. We therefore chose an 8 kilometre distance to ensure that information would not spread from information villages to control villages.

we delivered daily information about the prices in one or two nearby *mandis* and the nearest city market. The information we conveyed to farmers was the average price at which traders sold physical potatoes to buyers located in markets further away. This information was delivered to us by market "insiders" described above in Section 2.2. In our analysis below we refer to this as the *mandi* price.

In the 24 private information villages, the price information was given individually to 4 households selected randomly from our survey households. To deliver this price information, we gave each of these households a mobile telephone. Each morning, the "tele-callers" based in our Kolkata information center made phone calls to each of these farmers and relayed the *mandi* prices from the previous evening. The mobile phones were intended merely as a device for relaying price information to the farmer, not for improving the farmer's connectivity more generally. For this reason, the service provider blocked outgoing calls from all the phones, and changed the phone settings so farmers could not view their own phone number. We did not inform the farmers of their mobile phone numbers, and all phone bills were delivered to us. In this way we aimed to prevent the farmer from receiving any incoming calls except from us. Since we had access to the log of calls for each phone, we were able to check that our restrictions were effective.[14]

In the 24 public information villages, we delivered the *mandi* price information to a single individual (called the "vendor") in the village. This person was usually a local shopkeeper or phone-booth owner. For a nominal fee, he wrote the price information on charts and posted them in three public places in each village. These were places that we expected farmers to pass by as they went about their daily business. Each chart had room to write down 7 days' worth of information. At the end of 7 days the chart was changed.[15]

Our information interventions were piloted in the sample villages during June-November 2007. The actual experiment began in January 2008 and continued until November 2008. All villages and households were in the same treatment or control group in 2008 as they were in 2007. All empirical results on the effect of the interventions on farmer quantities and revenues will be presented for the 2008 data.

[14]When the phones were first given out a few farmers tried to download ringtones (a feature that was subsequently blocked as well). Other than that, our plan succeeded.

[15]Our tele-callers and village information vendors were given clear instructions not to reveal our research question to the information recipients. If farmers asked them why they were being given this information, they were instructed to say that they were part of a research study where price information was being relayed to farmers, but that they did not know why this was being done or how farmers could use this information.

One may wonder whether our experiment changed the prevailing *mandi* prices in the areas where the information treatments were delivered. Since we delivered price information in only 48 villages, this is unlikely to have happened. Note also that the total volume of potatoes sold by our sample farmers in 2008 was less than 1 percent of the total volume traded in the large *mandis* in this area.[16]

3.1 Data

Our datasets come from household surveys conducted with a stratified random sample of 24 potato-growing households in each of the 72 villages in our study.[17] Our analysis in this paper is restricted to farmers who planted either one of the two main varieties (*jyoti* and *chandramukhi*) of potatoes in 2008.[18] This leaves us with a sample of 1545 farmers.

In 2008, we conducted two types of household surveys. A production survey was done in February to collect data about the planting and cultivation of potatoes, including area planted, inputs used, output harvested, and allocation of harvest across sales from the field, home storage, cold storage, and other uses. The questionnaire also included questions about household demographics, assets, land ownership and credit. Second, a trade survey was administered to all sample households each fortnight between February and November. This collected information on each individual potato sale that the farmer had made in the previous fortnight: whether the potatoes were sold from the field, from home stores or cold stores, the variety and (self-reported) quality of potatoes, the quantity sold, place where the exchange took place, costs incurred by the farmer to undertake the sale, and the payment received, both immediately and deferred. When payment was deferred, we followed up with the farmer in subsequent rounds to ensure that we recorded the date and the amount of each installment received.

3.2 Descriptive Statistics

Table 3 shows a number of village and households characteristics by treatment groups, from data collected before the pilot information interventions began in June 2007. Villages were on

[16]Data on trade volume in large *mandis* were taken from the Government of India's Agmark dataset that reports daily price information in the large *mandis* in all states of India, for major agricultural crops.

[17]In 2006 we conducted a village census where we recorded for each household whether they had planted potatoes that year, and their landholdings. We then stratified all potato-growing households by landholding category and drew a random sample from each stratum.

[18]These two varieties accounted for 70 and 20 percent, respectively, of the potatoes grown in 2008.

average 8.5 kilometres away from the *mandis* whose price information we provided. About half the villages had a public telephone booth.

The sample of households was a stratified random sample of farmers who had grown potatoes in the year 2007, where agricultural landholding categories formed the strata. As Panel B shows, the average landholding size of sample households was 1.1 acres. Thus these households own very limited wealth in the form of agricultural land. The average cultivator in the household was about 49 years old, and had attended 7 years of school.

As stated, we drew the sample from potato farmers in 2007; therefore in Panel C nearly all farmers reported planting potatoes. In particular we restrict the sample to those who had planted either the *jyoti* or the *chandramukhi* variety in 2008. Among these farmers, *jyoti* is the more widely-grown variety, with nearly 94% of the sample farmers having planted it in 2007. The total area planted with potatoes in 2007 was 0.9 acres, and on average farmers harvested 7056 kilograms. They sold about 80 percent of this through the year, at an average price of Rupees 2.9. Nearly all of this quantity was sold to traders in the village, and less than 1 percent was to traders located outside the village.

Nearly a quarter of sample households told us they had a landline phone, and 33 percent said they had a mobile phone (Table 4 Panel D). Despite this, 71 percent of farmers reported that the trader informed them about prevailing potato prices, and 46 percent said the trader was their only source of information. About 18 percent said they received information from a market and 13 percent said they spoke to friends.[19] Six percent said they learned about prices from the media such as newspapers or television, and less than 1 percent said they did not search for price information. Taken together, this suggests that farmers do make an effort to collect potato price information, but tend to rely mainly on word-of-mouth from traders to find out what it is.

For most village characteristics, the pre-intervention differences across treatment groups were small and insignificant. A notable exception is that control villages had a much higher probability of having a public telephone box. However this is the result of a random draw. We include *mandi* fixed effects in all our regressions, which control for such fixed differences at the village level.[20]

[19] As discussed in Section 2.2, even farmers who say they gather price information from a "market" are probably not learning about the *mandi* price, i.e. the price at which village traders resell potatoes to buyers in the wholesale market. Instead they appear to collect information about the price at which they can sell to alternative traders at small local markets (*haats*).

[20] Sample villages are mapped to the markets whose catchment area they lie in. In the information interventions, we provided farmers/village vendors with the price information for the corresponding market. We define a

To evaluate if the household-level variables in Panels B, C, D and E are jointly different across the treatment and control groups, we run a test that all household-level variables are significantly different from each other. The p-values are provided at the bottom of Table 4. All three tests are rejected at conventional levels of significance.

3.2.1 Effect of Information Treatments on Farmers' Price Information

In our fortnightly surveys conducted between February and November 2008, we asked farmers if they tracked prices in wholesale and retail potato markets. If they did, they were asked for more detail about the markets they tracked, when last they had tracked the price, what the price was when tracked, and who their source of information was. To avoid the concern that through asking these questions we might make our information intervention more salient to the farmers, we asked these questions only to a randomly selected one-half of the sample. As a result we have these data at the fortnightly level for 853 farmers.[21]

Table 5 presents evidence that the intervention changed the probability that farmers tracked prices, caused them to track prices more frequently and report that they received information through the interventions. We use the specification

$$y_{ivt} = \beta_0 + \beta_1 \text{Private Information}_v + \beta_2 \text{Phone Recipient}_{iv} + \beta_3 \text{Public Information}_v + \beta_4 X_{ivt} + \epsilon_{ivt} \tag{1}$$

where y_{ivt} measures the dependent variable for farmer i in village v in fortnight t. The dependent variables are whether the farmer reports tracking wholesale prices (Column 1), the number of days since he last tracked prices (Column 2), and who his source of information is (Column 3). In accordance with the dependent variables, we use a logit specification in Column 1, and a Poisson regression in Column 2. For Column 3, we re-code the farmer's response to identify whether the source of information included the information intervention, or not, and then run a logit regression.[22] Control variables include a dummy for the potato variety (*jyoti* or *chandramukhi*),

mandi as a market-potato variety combination. For example, both *jyoti* and *chandramukhi* potatoes are traded at Bhandarhati market, which generates two *mandis* for the purposes of our analysis: Bhandarhati-*jyoti* and Bhandarhati-*chandramukhi*.

[21] As we show in Table B7 in the Appendix, the results reported in Tables 9 and 10 continue to hold even if we analyze only the subset of households that were *not* asked questions about their price-tracking behaviour.

[22] To avoid making our intervention salient to the farmers, we did not offer a category indicating our intervention. The list of categories provided was, in order: friends, relatives, neighbours, caste members, traders, local government officials, NGO employees, cooperative members and other. Since the farmers chose the category "other" instead of a long list of categories available we interpret their report as indicating the price information intervention.

district, and the survey month. For convenience we report exponentiated coefficients in all three columns.

Column 1 indicates that the public information treatment increased tracking: in villages where price information was posted in public locations, farmers were more likely to report that they tracked prices. In the private information treatment the positive significant effect is seen on farmers who received phonecalls from us. The magnitude of the effect is much larger in the public information treatment: relative to the control group, respondents in the public information treatment group were 8 times more likely to report that they tracked wholesale potato prices. Column 2 shows that among those tracking prices, the treatments increased the frequency with which they tracked prices: they were likely to report that they had last tracked prices much more recently. The magnitude of this effect was similar across the three groups of recipients. Finally, Column 3 shows that farmers in the information intervention groups were more likely to report that they received price information from a source in the "other" category. As explained above, this category includes the tele-callers who provided information to farmers, and the public notice boards. The results suggest that this effect was larger in the public information treatment than in the private information treatment, and within the private information treatment, was larger for phone recipients.

Hence the intervention did work as planned: farmers who received the interventions directly (through phones or public notice boards) reported a greater likelihood of tracking market prices, and farmers in intervention villages were likely to have tracked prices more recently. Table 6 shows that the intervention improved the precision with which farmers tracked prices. We match the prices that farmers reported with the actual prices in the markets that they reported tracking. As stated in Section 2.2, the average price that farmers reported was similar to the price they would have received if they had sold to a trader in a local market (*haat*), rather than the trader's resale price. Nevertheless, the information did reduce the error in this price. In Table 6 we compute the sum of squares of the normalized error in reported price, where the error is the difference between the reported and the actual price. The average sum of squares is significantly lower for intervention households than for control households. It is not significantly different between phone non-recipients and phone recipients, or between the private and public information treatments.[23]

[23]The reader may wonder why, if the interventions did not cause farmers to report the actual *mandi* prices, they reduced the error in their reports. It is likely that the information provided helped farmers infer the price they could get if they sold in the *haat*.

4 The Trading Mechanism: Theoretical Analysis

As mentioned above, the farmers we surveyed and traders we interacted with asserted that they did not enter into *ex ante* contracts, either explicit or implicit. Instead they described a process of *ex post* bargaining, where on any given day, village traders observe the *mandi* price and then make a price offer to farmers. Farmers respond to the offer by choosing whether and how much to sell to the trader. This process is repeated on successive days of the year. On any given day, the farmer has a stock of potatoes. If he refuses the trader's price offer, he can either sell nothing that day, or incur the cost of transporting some potatoes to a nearby market (known locally as a *haat*) outside the village, where he encounters other traders. These traders make a price offer to buy his potatoes and resell them in the wholesale market. If the farmer refuses this offer as well, he must either transport the potatoes back to the village at a cost, or else discard them. The trader in the market is aware of this "hold-up" situation and so takes advantage of it by offering a low price. As a result the option of selling to a trader in the *haat* is not very attractive. If village traders collude with one another, it enables them to force the farmer down to a low price.

The other option of not selling on this day becomes less valuable towards the end of the year, because technical difficulties with storing potatoes for too long and regulations governing cold storage facilities prevent potatoes from staying in the cold stores from one year to the next. For the sake of simplicity, we abstract from the dynamics of sale on different dates, and the storage option available to the farmer earlier in the year. So we consider a single date where the farmer has a given stock, and must either sell or consume all potatoes by the end of the date. We view this as a first approximation for aggregate trades in any given year. The empirical analysis in Section 5 will correspondingly focus on information impacts on aggregate trades for the year, for any given farmer.

The other key simplifying assumption is that all village traders collude with one another, and all traders in the market collude with one another, but the set of village traders and the set of market traders compete with one another.[24] In other words, there is a single representative village trader (denoted VT), who competes with a single representative market trader (denoted MT). Importantly, the competition between them is sequential. Since VT is located in the farmer's

[24] In Section 6 we consider the alternative assumptions of collusion and competition.

village, he has a spatial first-mover advantage. Suppose the farmer F has a stock of $\bar{q}$ potatoes. First, he makes a price offer p to the farmer F. If F refuses this offer, he can incur a per unit cost of t and transport the quantity q_2 to the *haat*. There he approaches market trader MT, who offers him price m. If the farmer refuses this offer as well, he transports the potatoes back to the village to consume them.[25] We assume that it is common knowledge that both MT and VT can sell potatoes subsequently at the *mandi* at the price ν (net of transport costs), and that they both know the realization of ν, but that farmer's prior information about the realization of ν is imperfect. Hence price offers by traders allow F to make inferences about the realization of ν.

The Appendix provides a detailed analysis of the resulting bargaining game with sequential competition between VT and MT. Here we provide a heuristic account of equilibrium outcomes and how they could be affected by an intervention that informs farmers about the *mandi* price realization ν.

Sequential competition between VT and MT creates the scope for an information intervention to affect trading outcomes that most other market structures do not. To see this, consider two polar opposite cases where there is either no competition between the two, or where they compete through simultaneous price offers. If there is no competition from MT, VT has full monopsony power, and F's only outside option is autarky and the resulting consumption of potatoes. It will pay VT to buy more potatoes from F and pay him a higher price when ν is high, but it is irrelevant whether F knows the value of ν: F will receive the same price offer from VT irrespective of whether he is informed or not. As a result providing farmers with the information will not change the equilibrium. This is because F has no opportunity to sell at the *mandi* directly, and so knowing the value of ν has no effect on his outside option. In the opposite case of simultaneous price competition à la Bertrand, both traders offer F the price ν and therefore earn no rent. Once again, whether F knows the realization of ν or not would not change the outcome. This will also be true in the case of simultaneous monopsonistic price competition between different traders who are not perfect substitutes for one another (for example, if they are located at different distances from the farmer, or differ along some other non-price dimension that F cares about).

Return now to the case of sequential competition. Here, it is possible for the information intervention to affect the trading outcome. To see this, consider the possible equilibria in this set-up.

[25] We simplify by assuming that the value of self-consumption is large enough relative to the transport cost that it will always be in the farmer's interest to bring all the potatoes back.

As we show in the Appendix, one possibility is a perfectly separating equilibrium such that price offer to the farmer varies with the realization of ν. Other possibilities include either complete pooling so that the price offer to F is constant regardless of the level of ν, or partial pooling, where the price offer is constant over particular ranges of ν levels. As these ranges get narrower, we say that there is a lower degree of pooling and the equilibrium begins to approach a separating equilibrium. The separating equilibrium is illustrated in Figure 5, and pooling equilibria in Figure 6.

In either case, we can use backward induction to solve for MT's price offer to F. MT has an *ex post* monopsony, and also can "hold up" F because of the additional cost that F must incur to transport potatoes back to the village in the event that he refuses MT's offer. Call the *ex post* optimal price offer by MT $m(\nu)$, where $m(\cdot)$ is strictly increasing in ν under standard distributional assumptions. Since F only has an autarky option at this last stage, this price offer is not directly dependent on F's information about ν.

MT's offer function $m(\nu)$ serves as the effective outside option for F at the first stage of bargaining with VT. This function is commonly known to all three parties. The optimal price offer that VT makes is designed to make F indifferent between accepting it, and his outside option of approaching MT subsequently. However, whether F chooses to accept or reject this offer depends on his inference about ν after observing VT's price offer. This in turn depends on whether the equilibrium is separating or pooling.

In a separating equilibrium, VT's offer $p(\nu)$ is strictly increasing in ν, thereby revealing ν perfectly. It is the monopsony price for VT, given the *ex post* outside option for F represented by the price $m(\nu)$, and the transport costs of taking the potatoes to the market. The price $p(\nu)$ makes F indifferent between accepting and rejecting VT's offer. It therefore contains information for F: a high $p(\nu)$ suggests that ν is high, which suggests that $m(\nu)$ will be high as well. It therefore increases the probability that F *rejects* VT's offer and instead tries to sell in the market. To avoid this possibility, VT has an incentive to offer a lower $p(\nu)$, in order to make F indifferent between selling to him and not. As a result, $p(\nu)$ is increasing in ν, but is lower than VT's *ex post* monopsony price would have been if there had been no information asymmetry.

The separating equilibrium is not directly relevant in our context, as farmers would be effectively fully informed about the wholesale price, so there would be no asymmetry of information. However, we have provided evidence above that provision of information in the experiment did improve their ability to forecast the price. We therefore need to focus on the class of pooling equilibria which leave open the possibility that external information provision improves farmers' ability to forecast the market price. In a pooling equilibrium, village traders make price offers that locally do not vary with ν, thereby concealing information about small variations in ν from the farmer. However, the price offer can shift up by a discrete amount at particular thresholds of ν (call these thresholds ν_i), thereby revealing that ν lies in a specific range. The values of the thresholds ν_i and corresponding offers r_i are such that the farmer is indifferent between accepting and rejecting VT's offer (on the equilibrium path), conditional on the information communicated by the offer. Therefore these values depend on the farmer's prior beliefs. Roughly speaking, the width of the pooling intervals (ν_{i-1}, ν_i) depend on the farmer's information: the better informed he is, the narrower these intervals tend to be.

The price offers that VT makes in the pooling equilibrium are a local average of the price offers in the separating equilibrium, since they are tied down by a similar indifference property between acceptance and rejection for the farmer. The average is rough, since the price offer made by VT conceals information about ν from the farmer, which in turn affects what the farmer expects from carrying the potatoes to the *haat*. The price offer affects the quantity of potatoes he transports to the *haat*; he may find that he has taken less than what MT is willing to buy, or that he has taken more and has to cart the excess back to the village. The outside option payoff of F from rejecting VT's offer is therefore not the same as in the separating equilibrium, and is itself influenced by the offer.

There are many such pooling equilibria, and they vary in how much information in conveyed to the farmer by VT's price offer at Stage 1. For any given extent of asymmetric information and a given pooling equilibrium of this kind, there also exist other pooling equilibria which convey more information to F through the price offers. Here the intervals of the induced information partition of F are narrower, and the price offers are closer to those in the separating equilibrium.

The set of such pooling equilibria depends both on how much asymmetric information there is to start with, and on the degree of risk-aversion of the farmer. For the farmer to be indifferent between a pooled price offer and the price he expects to receive by rejecting it and going to the market instead, there must be an asymmetry of information. In other words, the farmer must be uncertain about what he will get at the *haat*, because otherwise he would be able to compare the two options directly and would not be indifferent. In some states of the world he will end up doing better *ex post* by rejecting the offer; in others he will be worse off. The set of pooling equilibria converges to the separating equilibrium as the extent of asymmetric information decreases.

This discussion implies that reducing the extent of asymmetric information through an external intervention would eliminate equilibria with a high degree of pooling.[26] Hence the degree of pooling will decline. To illustrate the implications of this, consider the case where we move to an equilibrium close to the separating equilibrium where increases in ν give rise to increases in $p(\nu)$, whereas earlier they did not result in any change in VT's offer. This implies that $p(\nu)$ will fall when ν is at the low end of the range of pooling, and rise when it is at the high end. On average the price offer will remain unaffected, owing to the indifference property of the original pooling equilibrium. This implies that the farmer's quantity response and revenues earned will remain unaffected on average, but become more responsive to movements in ν.

Figure 7 illustrates the effect of the intervention on an equilibrium with a high degree of pooling, which is replaced by one with less pooling. If F is risk averse, this increase in volatility of revenue reduces his welfare *ex ante*. The traders' welfare is unaffected. *Thus information provision results in Pareto-inferior outcomes, if traders are risk neutral.* If, on the other hand, F is sufficiently well-informed before the experiment, either because he received a highly precise signal about the realization of ν, or was in a sufficiently informative equilibrium close to the separating equilibrium, then the information intervention has no effect.

The *ex post* bargaining model therefore generates a number of implications which can be tested empirically.

(i) If initially the market is in a pooling equilibrium that is vulnerable to an information treatment in the sense described above, the intervention providing *mandi* price information to farmers causes farmers in the village to become better informed about the *mandi* and local market (*haat*) price.

(ii) If initially the market is in a vulnerable pooling equilibrium, the intervention will have zero average effects on traded quantities and farmgate prices. It will increase the pass-through

[26] The following discussion is based on the assumption that the information interventions do not themselves change the market structure of village traders and thereby the nature of their contracts with farmers. This assumption is supported by data on trader market concentration from trader surveys conducted in 2011-12 for a different study, where also price information was provided in a random set of villages. Even after nearly 3 years of price information provision, we cannot reject the hypothesis that the Herfindahl index of trader concentration was no different in information versus non-information villages.

of *mandi* prices to farmgate prices, and correspondingly increases the volatility of traded quantities and farmer revenues.[27]

(iii) The farmgate price (p) is always lower than the price (m) the farmer receives at the market. In a separating equilibrium, this is because the farmer is indifferent between selling to VT and selling to MT, where he sells to the MT a sub-optimally low quantity, due to the hold-up problem. In a pooling equilibrium, this is aggravated by the risk-averse farmer's uncertainty about the MT's price offer.

(iv) As ν increases, and VT makes a higher price offer, the farmer is more likely to reject the offer and sell to MT in the *haat*. This is because a higher price offer by VT signals to F that ν is high, and therefore m will be high as well.

(v) If transport costs rise and everything else is unchanged, $m(\nu)$ shifts down, and the gap between $p(\nu)$ and $m(\nu)$ increases. F accepts VT's offer less often and sells to MT more often. Moreover, in pooling equilibria close to the separating equilibrium, the likelihood of rejection rises faster in response to an increase in ν, under an additional distributional condition.[28]

5 Empirical Results

Evidence in favor of the first prediction was provided in Table 6 and discussed in Section 3.2.1: farmers in the information treatment groups provided reports of the market prices that were more precise than farmers in the control group did.

[27] If the initial equilibrium is separating or had a small degree of pooling, there will be no effect on either pass-through or volatility.

[28] This condition is that $t\frac{q'^*(m(\nu)+t)}{q^*(m(\nu)+t)}$ is decreasing in t, which requires $\frac{q'^*}{q^*}$ to be falling fast enough at $m(\nu)+t$. This condition obtains by first differentiating expression (7) for $\frac{\alpha'(\nu)}{\alpha(\nu)}$ in the separating equilibrium in Appendix A with respect to a fall in $p(\nu)$ that results from a rise in t, and then: (i) noting that $[\frac{q'^*(p)}{q^*(p)} - \frac{1}{\nu - p}]$ is decreasing in p, and (ii) using the indifference condition in the equilibrium and this distributional condition to infer that $p'(\nu)$ rises as t rises.

5.1 Average and Heterogenous Treatment Effects of the Information Interventions

We now examine the second prediction by estimating the effect of the interventions on the farmers' sales and revenues. As explained previously, we aggregate the data about sales transactions collected through fortnightly surveys to yearly averages in order to abstract from dynamics of farmer decisions about whether and when to sell in any given week. For each farmer we know each variety that he produced and the amount of his harvest of each variety that was of (self-reported) high or low quality. Our data are thus at the level of farmer-variety-quality. The regressions discussed below include variety and quality dummies. This helps address the concern that farmers may react to low farmgate prices by selling potatoes of lower quality, or a different variety, or that traders react to low *mandi* prices by purchasing lower quality potatoes.

Table 8 shows the average effects of the information intervention on annual quantity sold and average revenue received by farmers (net of transactions costs paid by the farmer).[29] The unit of observation is a farmer-variety-quality combination. Besides the variety and quality dummies, we include a district dummy for West Medinipur, and control for the landholdings of the farmer. All standard errors are clustered at the *mandi* level to account for correlated error terms across different farmers under the same *mandi*. The regression specification is as follows:

$$y_{ikqv} = \beta_0 + \beta_1 \text{Private information}_v + \beta_2 \text{Phone recipient}_{iv} + \beta_3 \text{Public information}_v + \beta_4 X_{ikqv} + \epsilon_{ikqv}$$

where y_{ikqv} is the dependent variable: gross revenue, net revenue received from the sale of, or quantity sold of variety k and quality q by farmer i in village v. Private information and Public information are dummy variables indicating the treatment group that the farmer's village is assigned to. In the villages that received the private information treatment, four sample households were also phone recipients; those four households also received a value of 1 for the Phone recipient dummy. Hence the coefficient on Private information should be interpreted as the effect on farmers whose village received the private information treatment, but who did not personally receive phonecalls. Their outcomes would presumably be affected through the spread of information within the village about the calls received by phone recipients.

[29]These are our main dependent variables, since there is no problem with aggregating quantities or revenues across different transactions. In contrast, the calculation of an average farmgate price is subject to an index number problem. Since the theoretical predictions can be equivalently rephrased in terms of effects of the information interventions on quantities and revenues rather than quantities and prices, we choose to use revenues. However Columns 1 and 2 of Table B1 in the Appendix show that the effects on average prices are qualitatively similar.

Column (1) does not include *mandi* fixed effects. The sign of the coefficient is positive for all intervention dummies, but they are not significantly different from zero.[30] In column (2) we include *mandi* fixed effects. This reverses the sign of the public information coefficient, and they all remain insignificant, consistent with the theoretical predictions of the bargaining model. Columns (3)-(6) show that there is no significant impact of the intervention on the average gross or net revenue. Figure 7 provides a visual illustration of average weekly farmgate prices throughout the entire year corresponding to the two information treatments and the control areas, plotted on the same graph as the corresponding *mandi* prices. There is no apparent difference between the different farmgate price series.

Nevertheless, the theory predicts that the information treatments could have affected quantity and revenues in different directions, depending on whether the *mandi* price was high or low. Therefore, next we examine effects on pass-through, i.e., heterogeneity of treatment effects with respect to variations in the mandi price. This involves estimating the interactive effect of *mandi* prices and the information interventions on the farmers' quantity and revenues. We have explained in Section 2.4 how variations in the yearly *mandi* price are driven principally by temporal variations in retail prices rather than local infrastructure or supply shocks. Moreover, the across-*mandi* price variation in 2008 could not be predicted from past price patterns. Assigning to each *mandi* in our sample a rank based on its annual price average in different years, we find that while 2007 and post-2008 ranks were positively correlated with a correlation coefficient of 0.95, the correlation between the 2007 and 2008 ranks was negative and insignificant. Many *mandis* with below-median prices in 2007 and post-2008 were above the median in 2008. Hence, 2008 *mandi* prices do not reflect fixed *mandi* characteristics. Instead, the across-*mandi* price differences were principally the effect of shocks to retail prices and/or costs of transport to retail markets, which are exogenous to the *mandis* concerned.[31]

To estimate heterogenous treatment effects with respect to the realized *mandi* price, we use

[30] However, as the row at the bottom of the table shows, the magnitudes of the coefficients are sizeable: the coefficient on the private information dummy is 457.6 and the coefficient on the public information dummy is 230.5, which are 11.8 percent and 6 percent of the mean quantity sold by control households. Thus the estimated coefficients are larger than the minimum detectable effect size. So we do not believe the lack of significance here is driven by a lack of power.

[31] We control for time-invariant *mandi* characteristics by including *mandi* fixed effects.

the following regression specification.

$$
\begin{aligned}
y_{ikqv} \quad = \quad & \beta_0 + \beta_1 \nu_{ikm} + \beta_2 \text{Private information}_v + \beta_3 \text{Phone recipient}_{iv} + \beta_4 \text{Public information}_v \\
& + \beta_5 (\text{Private information}_v \times \nu_{ikm}) + \beta_6 (\text{Phone recipient}_{iv} \times \nu_{ikm}) \\
& + \beta_7 (\text{Public information}_v \times \nu_{ikm}) + \beta_8 X_{ikqv} + \epsilon_{ikqv}
\end{aligned}
$$

where ν_{ikm} is the realized average price (or price shock) in the *mandi* m that this farmer's village is in the catchment area of. We explain below how the *mandi* price average is computed.

The results are presented in Tables 9 and 10, corresponding to quantity sold and farmer revenue (net of transactions costs), respectively. For the sake of parsimony, we only show results from regressions that include *mandi* fixed effects.[32] This ensures that the effects are not being driven by across-*mandi* fixed characteristics. The different columns in this table use different specifications of the *mandi* price and different samples. Columns 1-3 use different yearly averages of the actual *mandi* price, each corresponding to different sets of weights. Column 1 uses the average *mandi* price for each specific farmer-variety combination in the sample, over those weeks in which this farmer sold this variety. Thus it captures the average *mandi* price prevailing at times when this farmer made a sale. This average represents the average resale price the trader can receive for potatoes he purchases from this farmer, and so is the relevant variable to use in this regression.

Column 1 shows a positive coefficient on the *mandi* price average although it is not significant. The intercept effect on both information treatments is negative, and the interaction of the treatment with the average *mandi* price is positive. In other words, the information interventions caused farmers facing a low *mandi* price to sell a smaller quantity than they would have sold otherwise. However, at higher *mandi* prices, this negative effect was attenuated. Thus the evidence points to heterogeneous effects of the information intervention, in line with the predictions of the model in Section 4.

For a farmer facing the 10th percentile of *mandi* price, the private information intervention caused sold quantity to go down by a statistically significant 1089 kg (or 28 percent of the control mean), and the public information intervention caused it to go down by 1189 kg (or 31 percent). For a farmer facing the 90th percentile of *mandi* price, we estimate the private and

[32] Results are qualitatively similar when *mandi* fixed effects are not included.

public information to have caused farmers to increase quantity sold by 1158 kg (or 30 percent) and 762 kg (or 20 percent) respectively, although these two positive effects are not significant in this specification.

The farmer-specific *mandi* price average used in Column 1 has the problem that it is endogenous to a farmer's decision to sell: if a farmer chooses to sell only when the actual *mandi* price is high, then this average is an overestimate of the true average *mandi* price the farmer was facing. This problem is addressed in Columns 2 and 3 by creating weighted averages. In Column 2, the *mandi* prices in the different weeks of the year are weighted by the volume of potatoes sold in that week by all sample farmers from villages in the catchment area of that *mandi*. In Column 3 the weighted average uses as weights the volume sold in that week by all sample farmers in that district. These averages are less prone to endogeneity bias, but may have a lower relevance to the farmgate price. In both Columns 2 and 3, we continue to see a negative intercept effect and a positive slope effect of the private information interventions which are large and statistically significant. This is also true for the public information treatment although the coefficients are not as precisely estimated.

The regressions in columns 1-3 abstract from the possibility that farmers in distinct *mandis* may have had different price expectations in 2008. Since the theory is about distortions caused by asymmetric information, what matters are *mandi* price shocks, or deviations from the expected *mandi* price. So the results discussed so far are subject to the concern that variations in realized *mandi* prices may reflect heterogenous beliefs rather than deviations of realized prices relative to expectations. In Column 4 in Table 9 we instead use as the price regressor the estimated *mandi*-year effect for 2008 as a measure of the 2008 shock to the *mandi* price for the variety in question. This is estimated from a regression of weekly *mandi* prices on *mandi* dummies, period and year dummies and interactions between them, applied to data from 2007, 2008, 2011 and 2012.[33] This filters out *mandi* specific components of the price that are fixed over time, besides correcting for seasonal fluctuations. The resulting weekly *mandi*-year effect for 2008 is then averaged over all weeks in which the concerned farmer made a sale.

In Column 5 we use as the price regressor the deviation of the actual 2008 *mandi* price for

[33] Ideally we would have used data from 2007 and prior years. However we only have baseline data for the *mandis* in our sample for the second half of 2007, and not for earlier years. The Agmark dataset mentioned previously provides data for a wider sample of West Bengal *mandis*, but there is very little overlap between those *mandis* and ours. However, these data show that price patterns for 2011 and 2012 were similar to those in the years 2005-2007. For this reason we use our 2011-12 price data for our sample *mandis* as a proxy for pre-2007 data.

any given week from an expected price for that *mandi*-week-variety combination. This is then averaged over weeks in which the farmer in question made a sale of that variety. The expected price is estimated from a regression of weekly *mandi* prices in that *mandi* in 2007, 2011 and 2012, after removing the year effect. Hence it represents the price that would "normally" be expected to prevail in the *mandi* for the specific variety, based on observations from years excluding 2008. The deviation of the actual price in 2008 from this expected price is an estimate of how much the actual 2008 *mandi* price deviated from what farmers in the catchment area of that *mandi* would have expected. Note that the price variable now is a deviation from the expected value, so the intercept term needs to be interpreted differently. It measures the effect of the information treatment for farmers selling in states where the expected *mandi* price equals the actual (rather than at a hypothetical price of zero, as in the previous specifications). The interpretation of the slope coefficient remains the same. We see in column 5 that the intercept term is now positive and significant. The slope coefficient is also significant and reassuringly of the same order of magnitude as in the other columns. The implied quantity effects at the 10th and 90th percentiles are large and statistically significant: a farmer facing the 10th percentile of the price deviation responded to the private (public) information intervention by selling 2970 or (2506) kg or less than he would have sold otherwise. A farmer facing the 90th percentile of the price deviation and the private (public) information intervention sold 2070 (1049) kg more than otherwise.[34]

Table 10 provides corresponding estimates of treatment effects on net farmer revenue.[35] The intercept and slope effects of the interventions have the same signs as those in the quantity regressions. In other words, the treatments caused farmer revenues to fall (resp. rise) for farmers facing low (resp. high) *mandi* prices. Using the specification in Column 1 we find that the private information intervention decreased the net revenue of farmers facing the 10th percentile of *mandi* prices by a statistically significant Rupees 2596 (or 33 percent of the control mean), and the public information decreased it by Rupees 3331.8 (43 percent of the control mean). The public intervention decreased the net revenue of farmers facing the 10th percentile of *mandi* prices by a statistically significant Rupees 2863 (37 percent of the control mean).[36] Once again, when in Column 5 we use the deviation from the expected *mandi* price as the price regressor, we find

[34]Since Columns 4 and 5 use explanatory variables that are themselves derived from estimates from other regressions, we report cluster-bootstrap standard errors, where the *mandis* are defined as the clusters.

[35]Results are similar for farmer revenue gross of transactions costs, as can be seen in Table B3 in the Appendix. In the Appendix we also show results for alternative specifications of the dependent variables, viz. the logarithms of quantity sold (Table B4), gross farmer revenue (Table B5) and net farmer revenue (Table B6).

[36]The estimated effect of the public intervention at the 90th percentile is not significant.

sharp effects. The estimated effects at the 10th percentile for the private and public information interventions are a reduction of respectively Rs 9507 and Rs 14142, both significant at 1% level. The effects at the 90th percentile are an expansion of Rs 6062 (significant at 5%) and Rs 9523 (significant at 1%).

5.2 Difference between Price Offers by Village Trader and Market Trader

The third prediction of the model is that, irrespective of the initial equilibrium, at any realization of *mandi* price ν, the price paid by a village trader is lower than the price the farmer receives at the market. This is verified in Column 1 of Table 11: controlling for the prevailing *mandi* price, district and land ownership, farmers who sold in the market received a higher gross price than those who sold to the village trader or other traders/moneylenders.

5.3 Relationship between the *Mandi* price and Likelihood that Farmer Sells in the *Haat*

A surprising prediction of the model was that when the village trader offers the farmer a higher price at higher levels of ν, the farmer is more likely to reject his offer. This is verified in Column 2 of Table 11, which shows a higher likelihood of the farmer selling in the market when the *mandi* price is higher, after controlling for land ownership and a district dummy.

5.4 Relationship between Transport Costs and Gap between Price Offers by Village and Market Traders

Finally, the model predicted that with higher transport costs, $m(\nu; t)$ is smaller, the gap between $p(\nu; t)$ and $m(\nu; t)$ is larger, the farmer is more likely to sell at the *haat*, and the likelihood of selling in the *haat* rises faster as the *mandi* price ν rises. Since transport costs within Medinipur are substantially higher than in Hugli, we test these predictions by comparing the likelihood of sales between these two districts, controlling for the mandi price in Column 3. Column 4 additionally includes an interaction between the mandi price and the Medinipur dummy. We see that the predictions are verified: in West Medinipur, which is less densely populated and where distances to the market are higher, farmers were more likely to sell in the market than in Hugli, and this responded faster to the *mandi* price.

6 Alternative Explanations

We now discuss alternative hypotheses about the nature of the trading mechanism. Consider first the hypothesis of perfect collusion among traders. As we discussed in Section 4, if traders colluded with each other perfectly, they would force the farmer down to his reservation price for potatoes, and whether the farmer knew the realization of ν would not matter for the outcome. The information interventions would then have no effect on the equilibrium. So this hypothesis cannot explain the heterogenous treatment effects we observe. Similarly, if all traders engaged in simultaneous price competition, and the farmer did not have an option to sell directly in the wholesale market, the farmer's response to price offers of various traders would be independent of his prior information about the wholesale market price. The equilibrium would then be unaffected by the information interventions.

Next, consider the possibility of *ex ante* or relational contracts that specify the quantity that the farmer will sell and the price the trader will pay, at each realization of the *mandi* price ν (as reported by the trader to the farmer). Such contracts would allow traders to insure farmers against price risk. The middleman margins could then conceivably represent risk premia on such insurance. As mentioned previously, farmers and traders we interviewed categorically rejected the presence of any such contractual commitments. Only one in three farmers sold repeatedly to the same trader over the past two years. Nevertheless there may be implicit contracts in vogue that serve this function. The context here is essentially the same as for implicit wage-employment contracts where workers do not know the price at which employers sell the firm's product. As Hart (1983) argues, in such a setting, asymmetric information has no effect on trading outcomes at all if employers (traders) are risk neutral and workers (farmers) are risk-averse. This is because when traders insure farmers perfectly, they bear all the residual risk. This removes any incentive for them to understate the *mandi* price, and so their private information does not create any distortions. Asymmetric information generates distortions only if traders are also risk-averse, so that insurance is imperfect, and farmers also bear part of the risk associated with *mandi* price fluctuations. In such cases, traders have an incentive to understate the *mandi* price. To keep them honest, traded quantities are (sub-optimally) low if the *mandi* price is low. Information interventions that reduce the asymmetry of information would then reduce the screening distortion, and cause the quantity traded at low *mandi* prices to increase. Instead, in Table 9 we saw exactly the opposite: the information interventions caused traded quantities to fall significantly when the *mandi* price was low.

An additional check of the hypothesis of relational contracts is provided in Column 6 in Tables 9 and 10. We restrict the sample to farmers who had been selling to the same trader repeatedly over the past three years prior to 2008. If relational contracts are at all in vogue, this is the sub-sample where they are most likely to occur, and we expect to see that the information interventions cause the quantity and farmer revenue to increase if the farmer faces a low *mandi* price. Instead, the pattern of results in Column 6 matches that in Columns 1-3 for the whole sample, although it loses statistical significance (a natural consequence of the substantially smaller size of the sub-sample).

Finally, consider the possibility of relational contracts involving one-sided commitment: traders commit to insuring farmers against price risk, but farmers cannot commit to selling to the traders at the contractually agreed price.[37] In such a contract, traders provide a price floor to farmers, and incur losses when the *mandi* price falls below this floor. In exchange, farmers are required to sell to the trader at below the *mandi* price when the *mandi* price is high. If farmers are able to sell directly at the market (which we have seen they are not, in this case), they would be tempted to renege on the *ex ante* contract when the *mandi* price is high, if they have good information about market prices. Providing *mandi* price information to farmers can then aggravate their temptation to renege, and cause the insurance arrangement to unravel. In turn this would cause the farmgate price to co-move more with the *mandi* price, and farmers would be observed to be selling directly outside the village more often.

This is indeed consistent with the observed effects of the information interventions. However, we have seen that potato farmers in these districts were unable to sell directly to buyers at the wholesale markets. We also observed that there was no significant average effect on traded quantities, revenues or farmgate prices. Thus, for all the observed treatment effects to be consistent with this alternative explanation, the insurance must have been priced competitively to start with, in order for the average farmgate price to remain unaffected when the insurance breaks down. For this to be true, traders must be breaking even on the insurance occurring in the absence of the information interventions, by incurring losses when the *mandi* price is low, and financing these with profits when the *mandi* price is high. However, as we saw in Section 2.3, the evidence for trader losses during low mandi prices is quite weak: trader gross margins were always positive

[37]We thank Abhijit Banerjee for suggesting this as a possible explanation.

even at the bottom end of the *mandi* price distribution, and net margins were also positive during the harvest period. No inference could be made about the sign of net margins during the post-harvest period. Thus there is very little evidence that traders ever incurred any losses, even when *mandi* prices were very low.

7 Conclusion

We have reported results of a field experiment providing market price information to potato farmers in the state of West Bengal in eastern India. In contrast to other settings studied in the literature where producers have direct access to markets, the farmers in our context are unable to sell to wholesale buyers directly, and must rely on local trade intermediaries. The effects of information provision in our context depend on the trading mechanism between farmer and trader.

Our findings are consistent with descriptions of the *ex post* bargaining mechanism reported to us in interviews by farmers and traders, involving sequential competition between a representative village trader and a representative trader located in the local market. Competition between these two (sets of) traders is limited both by the sequential and spatial separation of the two trading options. The fundamental reason that farmers cannot benefit from interventions that reduce informational asymmetries is the fact that they are unable to bypass the traders and sell directly in the wholesale market, or to other retail buyers.

While confirming the descriptions of the trading mechanism by farmers and traders we interviewed, we argued these are not consistent with explicit or implicit *ex ante* contracts involving trade pre-commitments or risk sharing. Nor are they consistent with models of monopsony, perfect competition or monopsonistic/oligopsonistic competition where middlemen make simultaneous price offers. Contrary to the predictions of all these models, information treatments had heterogenous effects depending on market price realizations: for farmers facing low (high) prices, the treatments caused both quantities sold and farmer revenues to fall (rise).[38]

We ignored the effects of the information treatments on farmer decisions about storage and timing of sales. As is well known from the literature on durable goods monopoly, endogenous

[38] While the heterogeneity pertains to variation across different *mandis*, we showed the results were even sharper when the *mandi* price variable was measured as a deviation from the expected price for each *mandi*.

timing of transactions combined with lack of price commitment by the monopolist can limit the effective monopoly power of a monopolist. In our context, farmers can decide to delay sales if a monopsonistic trader make them a low price offer. If he is unable to pre-commit to future prices, the monopsonist effectively competes against his future selves. Delaying a sale in response to an unfavorable price offer is similar in some ways to taking one's potatoes to the local market to sell to some other trade intermediary with substantial market power. Whereas in the first case the farmer incurs storage costs, in the second case he incurs transport costs. The monopsonist accordingly sets the early price so as to leave the farmer indifferent between selling rightaway and delaying the sale. We therefore expect that if the *ex post* model is extended to accommodate endogenous timing of sales, similar results will obtain.[39] Nevertheless this remains an interesting extension to be pursued in future work.

[39] In fact, we find the public information treatment did tend to induce greater storage and delayed sales by farmers.

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Table 1: Analysis of Variance of Weekly *Mandi* Prices

Source	MSE (1)	F (2)
Year	5117.97	8106.78***
Period	36.20	57.35***
Year × Period	87.43	138.49***
Mandi	81.57	129.2***
Mandi × Year	26.55	42.06***
Observations	*2845*	
R-squared	*0.92*	

Notes: An observation is a *mandi*-week. Data for weeks 13 and beyond in years 2007, 2008, 2011 and 2012 are included. *** : $p < 0.01$,** : $p < 0.05$,* : $p < 0.1$.

Table 2: Pass-through of City Prices to *Mandi* and Farmer Prices

	Annual *mandi* price	Weekly *mandi* price		Farmgate price
	all years	all years	excl. 2008	2008
	(1)	(2)	(3)	(4)
City price	0.84***	0.81***	0.64***	0.02
	(0.108)	(0.009)	(0.018)	(0.068)
Distance to city ('00 km)	-0.34			
	(0.304)			
City price × Distance to city	0.00			
	(0.000)			
Local yield ('000 kg/acre)	-0.15	-0.03	0.02	0.05
	(0.152)	(0.020)	(0.027)	(0.582)
Percent households with landline phones	1.07			
	(2.140)			
Percent villages with metalled roads	0.58			
	(0.627)			
Percent villages with factories/mills	-0.80*			
	(0.445)			
Year 2008	0.88	0.40***		
	(0.599)	(0.067)		
Year 2011	2.02**	1.38***	0.66***	
	(0.839)	(0.083)	(0.128)	
Year 2012	2.40***	2.25***	2.50***	
	(0.600)	(0.073)	(0.095)	
Constant	0.80	-0.59***	0.18	1.02
	(1.736)	(0.185)	(0.248)	(6.165)
Observations	*78*	*2,691*	*1,901*	*596*
R-squared	*0.92*	*0.98*	*0.98*	*0.53*

Notes: In column 1 an observation is a *mandi* in a given year. In columns 2, 3 & 4 it is a *mandi* in a given week. Week dummies are included in columns 2, 3 & 4, and year and *mandi* dummies are included in columns 2 and 3. Robust standard errors are in parentheses. *** : $p < 0.01$,** : $p < 0.05$,* : $p < 0.1$.

Table 3: Baseline Characteristics of Sample Villages and Households

	Total (1)	Control (2)	Private information (3)	Public information (4)	Public v. Control (4)-(2)	Private v. Control (3)-(2)	Public v. Private (4)-(3)
Panel A: Village Characteristics							
Distance to *mandi* (km)	8.52	8.93	8.558	8.071	-0.859	-0.372	-0.487
	(0.700)	(0.882)	(1.648)	(1.014)	*0.526*	*0.843*	*0.802*
Public telephone	0.514	0.667	0.417	0.458	-0.208	-0.250*	0.042
	(0.059)	(0.098)	(0.103)	(0.104)	*0.152*	*0.085*	*0.777*
Factory/mill	0.556	0.458	0.667	0.542	0.083	0.208	-0.125
	(0.059)	(0.104)	(0.098)	(0.104)	*0.573*	*0.152*	*0.387*
Metalled road	0.361	0.250	0.458	0.375	0.125	0.208	-0.083
	(0.057)	(0.090)	(0.104)	(0.101)	*0.361*	*0.137*	*0.568*
Panel B: Household Characteristics							
Land owned (acres)	1.114	1.123	1.079	1.144	0.021	-0.045	0.065
	(0.0305)	(0.0497)	(0.0503)	(0.0584)	*0.889*	*0.675*	*0.653*
Cultivator's age (yrs)	48.84	49.5	48.92	48.05	-1.451	-0.577	-0.874
	(0.404)	(0.682)	(0.682)	(0.737)	*0.304*	*0.644*	*0.385*
Cultivator's schooling (yrs)	6.989	6.597	7.01	7.4	0.803	0.413	0.39
	(0.116)	(0.204)	(0.201)	(0.192)	*0.062*	*0.356*	*0.333*
Panel C: Potato Cultivation							
Planted potatoes	0.995	0.987	0.998	1.00	0.013**	0.011*	0.002
	(0.002)	(0.005)	(0.002)	(0.00)	*0.047*	*0.099*	*0.316*
Planted *jyoti*	0.935	0.949	0.954	0.901	-0.048	0.005	-0.053
	(0.006)	(0.010)	(0.009)	(0.013)	*0.195*	*0.844*	*0.172*
Planted *c'mukhi*	0.096	0.051	0.111	0.126	0.076	0.06	0.016
	(0.007)	(0.010)	(0.014)	(0.015)	*0.123*	*0.192*	*0.763*
Area planted (acres)	0.904	0.822	0.851	1.051	0.229	0.029	0.2
	(0.058)	(0.087)	(0.048)	(0.151)	*0.243*	*0.833*	*0.27*
Harvest (kg)	7056.3	6396.6	7186.7	7641.4	1244.843	790.14	454.703
	(224.5)	(282.7)	(376.7)	(496.8)	*0.429*	*0.432*	*0.778*
Fraction of harvest sold	0.798	0.811	0.783	0.801	-0.01	-0.028	0.018
	(0.006)	(0.009)	(0.010)	(0.010)	*0.764*	*0.4*	*0.601*
Average price	3.935	3.879	3.844	4.093	0.214	-0.035	0.249*
	(0.023)	(0.036)	(0.040)	(0.039)	*0.126*	*0.832*	*0.094*
Frac. sold to trader	0.986	0.989	0.986	0.984	-0.005	-0.002	-0.003
	(0.003)	(0.005)	(0.005)	(0.006)	*0.62*	*0.766*	*0.781*
Frac. sold at market	0.008	0.006	0.01	0.009	0.003	0.004	-0.001
	(0.002)	(0.004)	(0.005)	(0.004)	*0.725*	*0.498*	*0.846*

Notes: Standard errors in parentheses.

Table 4: Baseline Characteristics of Sample Villages and Households, Continued

	Total (1)	Control (2)	Private information (3)	Public information (4)	Public v. Control (4)-(2)	Private v. Control (3)-(2)	Public v. Private (4)-(3)
Panel D: Telecommunications							
Has landline phone	0.238	0.231	0.23	0.254	0.023	-0.001	0.023
	(0.011)	(0.019)	(0.019)	(0.020)	*0.797*	*0.992*	*0.774*
Has cellphone	0.332	0.323	0.316	0.361	0.039	-0.006	0.045
	(0.012)	(0.021)	(0.021)	(0.023)	*0.65*	*0.941*	*0.551*
Panel E: Source of Price Information							
Trader	0.712	0.795	0.68	0.659	-0.136*	-0.115	-0.021
	(0.012)	(0.018)	(0.021)	(0.022)	*0.064*	*0.172*	*0.804*
Only trader	0.455	0.487	0.443	0.434	-0.053	-0.043	-0.009
	(0.013)	(0.023)	(0.022)	(0.023)	*0.525*	*0.663*	*0.916*
Market	0.177	0.148	0.186	0.197	0.049	0.037	0.012
	(0.010)	(0.016)	(0.017)	(0.019)	*0.48*	*0.61*	*0.876*
Friends	0.131	0.15	0.141	0.101	-0.049	-0.009	-0.04
	(0.009)	(0.016)	(0.015)	(0.014)	*0.34*	*0.89*	*0.525*
Media	0.06	0.081	0.055	0.044	-0.037	-0.026	-0.011
	(0.006)	(0.012)	(0.010)	(0.010)	*0.266*	*0.482*	*0.749*
Doesn't search	0.005	0.004	0.006	0.004	0	0.002	-0.001
	(0.002)	(0.003)	(0.003)	(0.003)	*0.949*	*0.779*	*0.839*
Test of joint significance (χ^2 p-value)					*0.525*	*0.926*	*0.336*

Notes: Standard errors in parentheses.

Table 5: Effect of Information on Tracking Behavior and Source of Information

	Track wholesale price (1)	Days since tracked (2)	Source of information "other" (3)
Private information	0.805	0.692***	3.530
	(0.358)	(0.089)	(3.154)
Phone recipient	1.818**	0.796***	11.161***
	(0.429)	(0.041)	(4.746)
Public information	8.596***	0.736**	52.173***
	(4.221)	(0.092)	(41.806)
Land	1.578**	0.988*	0.932
	(0.286)	(0.006)	(0.053)
Constant	8.197***	4.945***	0.005***
	(3.583)	(0.584)	(0.005)
Observations	*11719*	*10267*	*10267*
Prob > χ^2	*0.000*	*0.000*	*0.000*
Pseudo R-squared	*0.159*		*0.302*

Notes: An observation is a farmer's report of whether he tracked prices in wholesale markets, the days since he last tracked prices, and his source of information, for a given potato variety, in the past fortnight. Dummy variables for potato variety, district and survey month are included in all columns. To identify his source of information, the farmer made one choice from a list presented in the following order: friend, relative, neighbour, caste member, trader, local government official, NGO employee, cooperative member, other. Standard errors in parentheses are clustered at the *mandi* level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table 6: Effect of Information Intervention on Error in Tracked Price

	Mean (1)	N (2)
Control	0.2214	3046
Private Information		
No phone	0.1904	2588
Phone	0.1787	688
Public Information	0.1808	4714
F-test of ratio of sum of squares (p-values)		
Control/Private Info without phone	*0.000*	
Control/Private Info with phone	*0.000*	
Control/Public Info	*0.000*	
Private Info/Public Info	*0.112*	
Private Info without phone/Private Info with phone	*0.151*	

Notes: An observation is a farmer-fortnight. The normalized "error" is the percentage difference between the wholesale price he reports for a *mandi* in a given week and the average actual price in that *mandi* in that week (as reported to us by the market information vendors). The reported means are the mean sums of squared normalized errors.

Table 7: Potato Cultivation by Sample Farmers, 2008

	Mean/(SE)
Area planted (acres)	0.663
	(0.017)
Quantity harvested (kg)	6553.3
	(177.2)
Pct sold from the field	0.428
	(0.009)
Pct stored at home	0.165
	(0.007)
Pct stored in cold store	0.285
	(0.008)
Pct spoiled	0.0262
	(0.001)
Quantity sold (kg)	5962.6
	(184.5)
Pct sold at market	0.0786
	(0.006)
Pct sold to trader	0.908
	(0.007)
Gross revenue (Rs)	12887.2
	(413.0)
Net revenue (Rs)	11974.72
	(364.6)
Gross price received (Rs/kg)	
sold to trader	2.156
	(0.016)
sold at market	2.896
	(0.050)
Net price received (Rs/kg)	
sold to trader	2.03
	(0.016)
sold at market	2.428
	(0.050)
Mandi price (reported by vendor) (Rs/kg)	4.821
	(0.160)
Tracked price (reported by farmer) (Rs/kg)	2.763
	(0.027)

Table 8: Average Treatment Effects of Information Interventions on Farmer Sales and Revenue

	Quantity sold (kg)		Gross Revenue (Rs)		Net Revenue (Rs)	
	(1)	(2)	(3)	(4)	(5)	(6)
Private Info.	457.635	-30.710	1,119.586	299.156	933.850	198.752
	(552.921)	(531.372)	(1,359.693)	(1,322.272)	(1,269.713)	(1,225.815)
Phone	639.892	567.278	858.599	631.945	772.968	584.047
	(417.830)	(433.748)	(872.682)	(938.449)	(870.669)	(915.268)
Public Info.	230.537	-289.755	52.252	-879.208	-47.544	-873.423
	(522.078)	(512.660)	(1,198.935)	(1,228.030)	(1,156.776)	(1,194.482)
Land	2,251.884***	2,215.653***	4,530.135***	4,460.359***	4,038.450***	3,961.191***
	(174.773)	(178.392)	(384.474)	(404.269)	(327.777)	(340.442)
Constant	2,817.063***	3,034.078***	6,455.267***	7,070.703***	6,198.811***	6,831.959***
	(551.663)	(452.416)	(1,388.710)	(1,087.765)	(1,321.973)	(1,008.147)
Observations	*2,318*	*2,318*	*2,318*	*2,318*	*2,318*	*2,318*
R-squared	*0.353*	*0.387*	*0.309*	*0.341*	*0.325*	*0.361*
Mandi fixed effects	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
Mean DV	3855		8323		7822	
SE DV	213.3		429.0		403.4	

Notes: An observation records the quantity of potatoes a farmer sold in a week of a particular variety and quality, and the gross and net (of costs incurred by the farmer) revenue he earned. In columns 1, 3 and 5 we include dummy variables for variety, quality and district of farmer's residence. In columns 2, 4 and 6 we include dummies for the quality as well as the *mandi* whose catchment area the farmer resides in. A *mandi* is defined as a (physical) market-variety combination. Standard errors in parentheses are clustered at the *mandi* level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table 9: Heterogeneous Impacts of Information Interventions on Quantity Sold

	Farmer specific average	*Mandi* weighted average	District weighted average	*Mandi* × year "shock"	Deviation from expected price	Farmers who sold to long-term buyers
	(1)	(2)	(3)	(4)	(5)	(6)
Price regressor	76.6				-567.8***	-819.3*
	(242.8)				(128.9)	(476.0)
Private information	-3,155.5**	-3,613.0**	-3,861.9**	-3,637.0*	2,116.1***	-5,838.1*
	(1,358.7)	(1,614.3)	(1,736.2)	(1,949.1)	(662.9)	(3,144.5)
Private information x Price regressor	708.2**	832.2**	905.3**	771.4*	633.7***	1,429.5*
	(320.5)	(386.4)	(420.7)	(429.9)	(143.2)	(815.1)
Phone	1,418.3	-156.7	-83.1	-85.4	1,267.4	3,344.0
	(1,419.8)	(1,547.8)	(1,561.6)	(1,036.9)	(1,006.3)	(4,040.3)
Phone x Price regressor	-200.9	163.2	149.2	137.3	127.5	-724.8
	(332.1)	(398.0)	(409.5)	(202.1)	(188.0)	(1,058.4)
Public information	-2,946.1**	-2,911.0*	-3,169.9*	-2,616.9	1,081.6	-6,570.7***
	(1,263.4)	(1,630.6)	(1,736.5)	(2,261.5)	(672.7)	(2,435.1)
Public information x Price regressor	602.4**	594.4	663.8	481.3	447.0***	1,599.8***
	(287.9)	(375.3)	(404.5)	(459.4)	(137.2)	(563.6)
Land	2,186.8***	2,198.0***	2,197.3***	2,199.4***	2,110.6***	2,463.8***
	(181.7)	(178.0)	(178.1)	(223.5)	(164.7)	(405.4)
Constant	2,794.0**	3,089.2***	3,089.2***	3,101.9***	879.8*	6,241.7***
	(1,078.8)	(422.8)	(421.8)	(430.2)	(523.5)	(2,060.1)
Observations	*2,300*	*2,317*	*2,317*	*2,318*	*2,283*	*443*
R-squared	*0.392*	*0.390*	*0.390*	*0.391*	*0.400*	*0.515*
Mean DV	3872	3859	3859	3872	3872	3780
SE DV	214.9	213.5	213.5	214.9	214.9	437.1

Notes: An observation records the quantity of potatoes a farmer sold in a week of a particular variety and quality. In all columns we include dummies for the quality of potatoes sold as well as the *mandi* whose catchment area the farmer resides in. A *mandi* is defined as a (physical) market-variety combination. Columns differ in the definition of the price regressor. In column 1 it is the price in the relevant *mandi*, averaged over the weeks when the farmer sold potatoes of that particular variety. In column 2 (resp. 3) it is the price in the relevant *mandi*, averaged over all weeks in the year, with weights assigned to each week proportional to the quantity that was sold by all sample farmers in that *mandi* (resp. district) in that week. In column 4 it is the estimated *mandi* x year effect from a regression of weekly *mandi* prices on *mandi* dummies, period dummies, year dummies and their interactions from weeks 13 to 52 in years 2007, 2008, 2011 and 2012. In column 5 it is the average deviation of the 2008 *mandi* price from the expected *mandi* price in that week, averaged for each farmer over the weeks when he sold potatoes of that variety. The expected price is the estimated weekly price in that *mandi* based on the 2007, 2008, 2011 and 2012 data for weeks 13-52, after removing the year effect. Column 6 restricts observations to farmers who told us in 2010 that they sold potatoes to a buyer whom they had been selling to for longer than 5 years. Standard errors in parentheses are clustered at the *mandi* level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table 10: Heterogeneous Impacts of Information Interventions on Net Farmer Revenue

	Farmer specific average	*Mandi* weighted average	District weighted average	*Mandi* × year "shock"	Deviation from expected price	Farmers who sold to long-term buyers
	(1)	(2)	(3)	(4)	(5)	(6)
Price regressor	608.1				-621.0**	-261.7
	(508.5)				(282.5)	(1,046.2)
Private information	-8,041.6**	-8,454.9**	-9,109.0**	-8,698.7**	5,249.6***	-8,542.9
	(3,326.0)	(4,039.2)	(4,345.4)	(4,328.2)	(1,626.6)	(6,237.7)
Private information x Price regressor	1,867.1**	2,012.9**	2,202.1**	1,906.3**	1,459.8***	2,023.3
	(705.6)	(892.7)	(977.0)	(948.8)	(352.4)	(1,557.2)
Phone	4,237.4	1,261.5	1,370.1	803.0	1,984.2	8,450.7
	(3,261.7)	(3,451.6)	(3,440.2)	(2,711.2)	(1,916.8)	(6,191.7)
Phone x Price regressor	-888.1	-177.2	-205.4	-62.8	260.9	-1,842.9
	(740.7)	(826.4)	(840.9)	(587.6)	(310.6)	(1,525.9)
Public information	-6,928.1**	-7,024.4*	-7,604.7*	-6,366.5	2,881.8*	-9,271.0
	(3,216.7)	(4,177.4)	(4,449.6)	(4,855.0)	(1,641.3)	(5,676.4)
Public information x Price regressor	1,393.6**	1,395.4	1,552.1	1,136.4	1,090.3***	2,354.7*
	(689.2)	(910.2)	(981.9)	(951.6)	(327.7)	(1,407.3)
Land	3,892.7***	3,924.2***	3,922.2***	3,926.3***	3,845.3***	4,494.3***
	(348.0)	(338.1)	(338.2)	(422.5)	(326.4)	(722.4)
Constant	4,347.7*	6,950.4***	6,950.6***	6,987.4***	4,683.7***	7,820.6*
	(2,540.2)	(954.7)	(952.8)	(825.4)	(1,337.4)	(4,549.9)
Observations	*2,300*	*2,317*	*2,317*	*2,318*	*2,283*	*443*
R-squared	*0.370*	*0.364*	*0.365*	*0.365*	*0.377*	*0.487*
Mean DV	7845	7825	7825	7845	7845	8349
SE DV	406.5	404.0	404.0	406.5	406.5	987.5

Notes: Notes below Table 9 apply. Dependent variable is the net revenue earned by the farmer. *Mandi* dummies are included in all columns. Standard errors in parentheses are clustered at the *mandi* level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table 11: Farmer Sales at the Market (*Haat*)

	Gross price received	Sold at *haat*		
	(1)	(2)	(3)	(4)
Sold at *haat*	0.361*			
	(0.178)			
Mandi price	0.233***	0.809***	0.470***	-0.796***
	(0.054)	(0.143)	(0.096)	(0.291)
W. Medinipur	-0.296*		1.562*	-3.706**
	(0.167)		(0.890)	(1.502)
W. Medinipur × *Mandi* price				1.361***
				(0.310)
Land	-0.058***	-0.028	-0.070	-0.059
	(0.013)	(0.063)	(0.066)	(0.067)
Constant	1.458***	-6.253***	-5.716***	-1.077
	(0.185)	(0.831)	(0.947)	(1.108)
Observations	*3,914*	3,914	3,914	3,914
R-squared/Pseudo R-squared	*0.368*	0.181	0.202	0.227
Mean DV	2.247	0.0242	0.0242	0.0242
SE DV	0.016	0.00113	0.00113	0.00113

Notes: Each observation corresponds to a farmer-variety-quality-week combination. Variety and quality dummies are included. In column 1 the dependent variable is the gross price per kg received for potatoes sold. In columns 2-4 it is a binary variable indicating whether the farmer sold potatoes at the *haat*. Standard errors in parentheses are clustered at the *mandi* level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

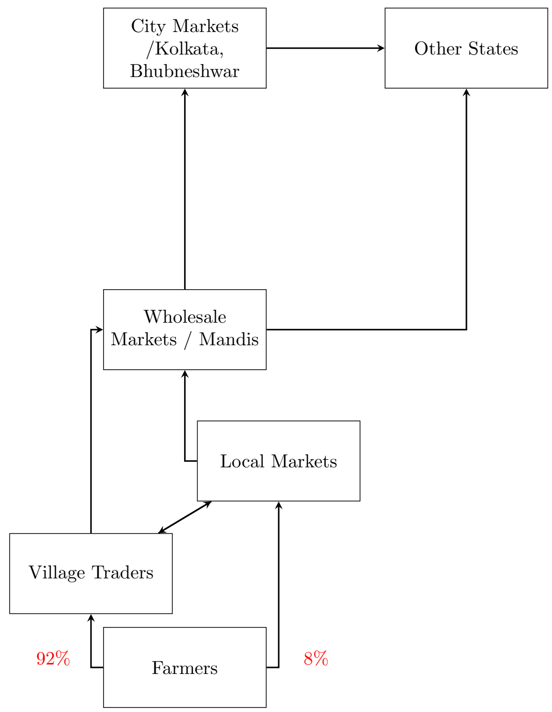

Figure 1: Potato Supply Chain

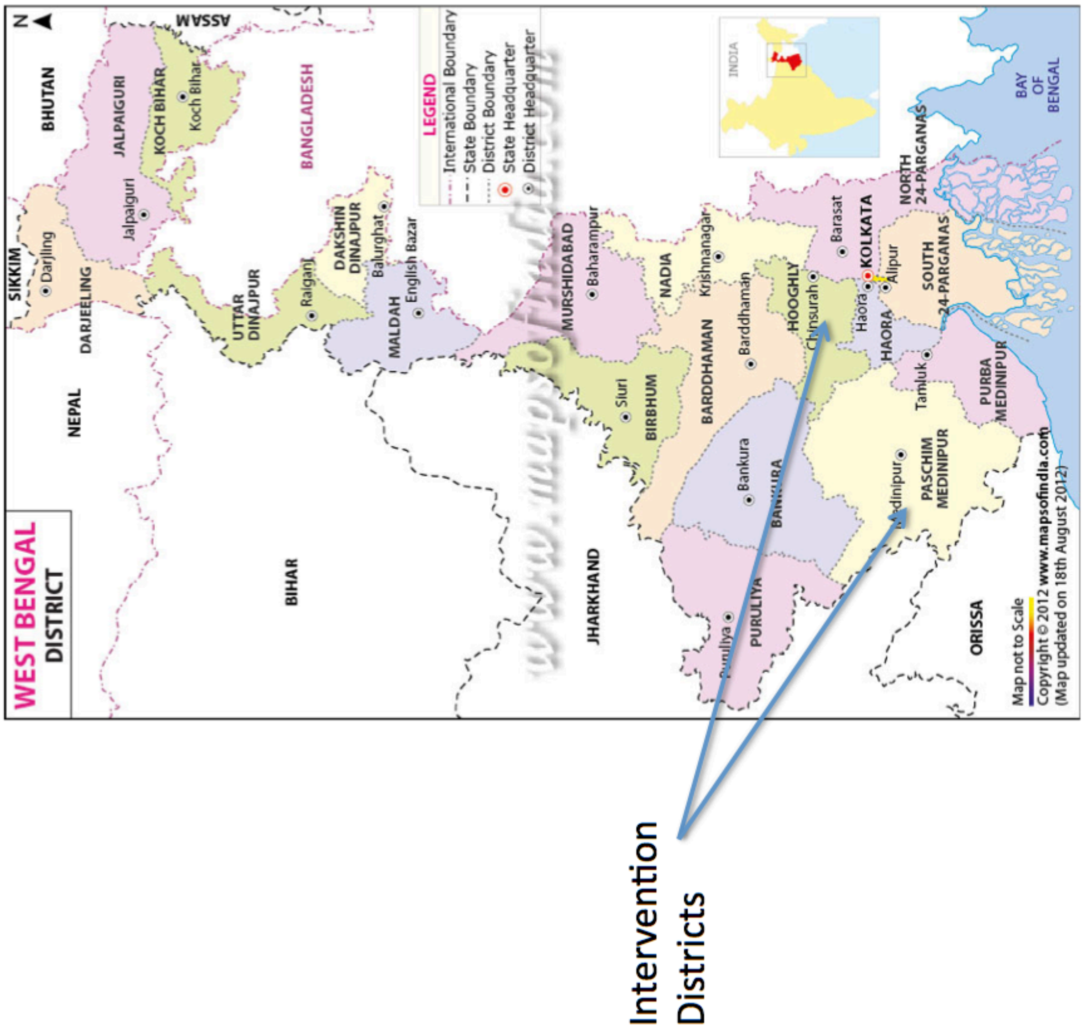

Figure 2: Map of Districts and Neighboring States

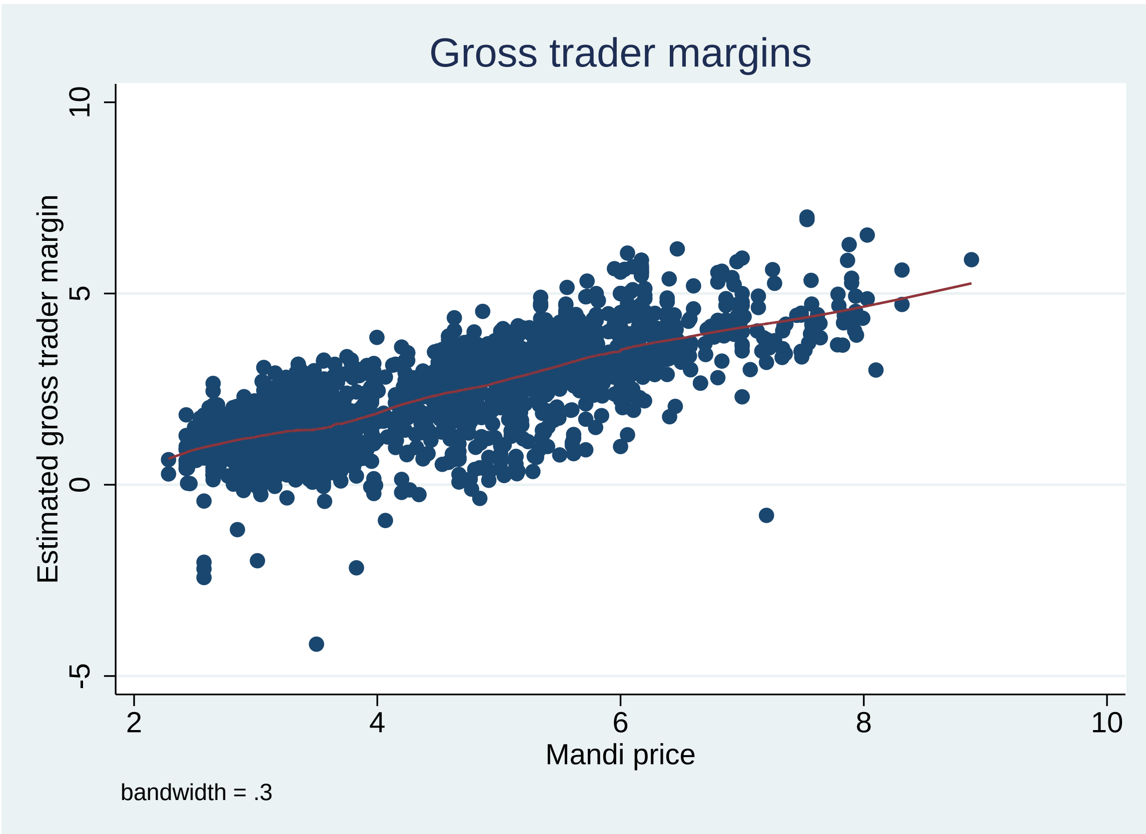

Figure 3: Gross Trader Margins

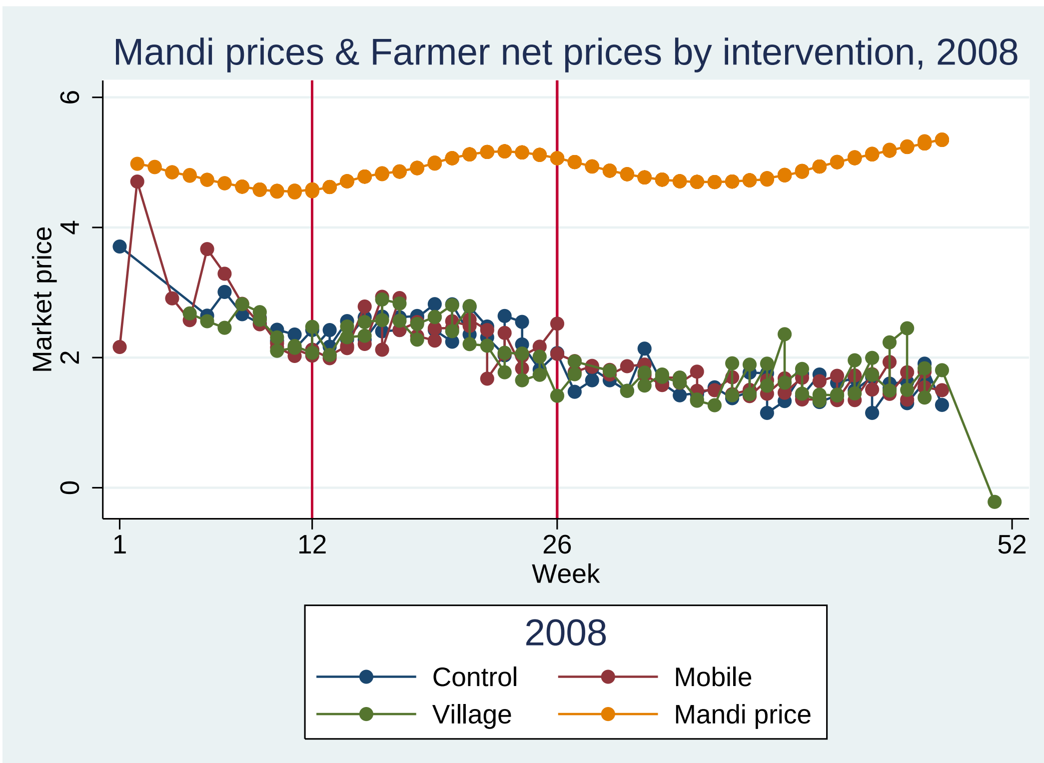

Figure 4: Intervention Impacts

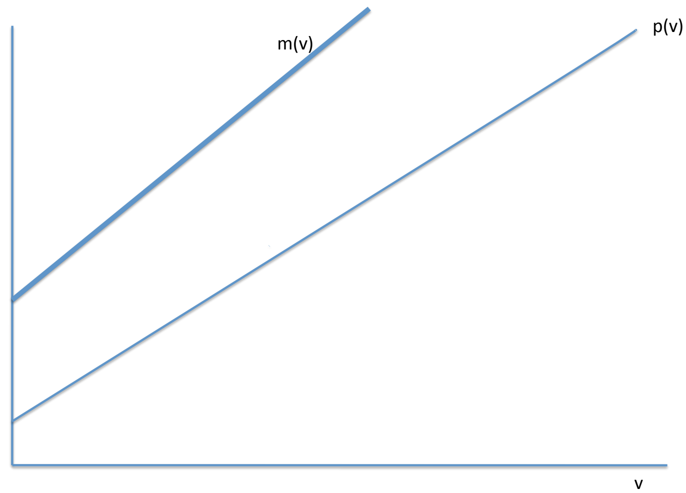

Figure 5: Separating Equilibrium

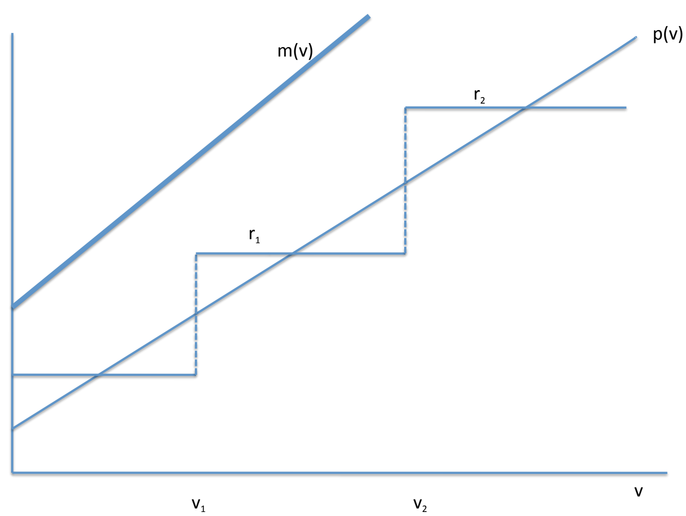

Figure 6: Partially Pooling Equilibrium

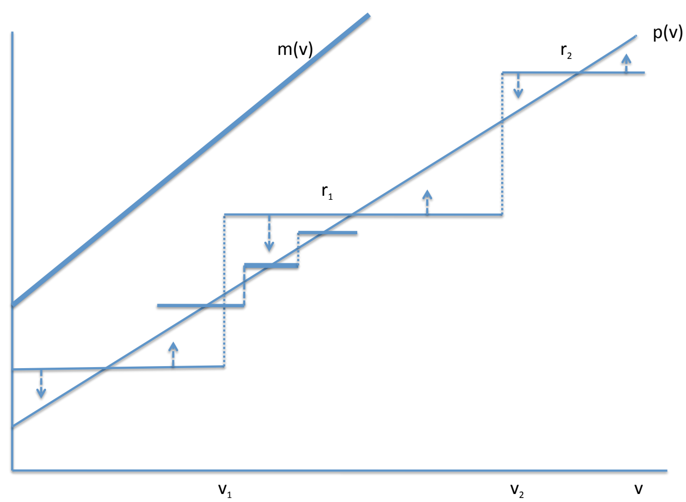

Figure 7: Effect of Information Treatment

Asymmetric Information and Middleman Margins: An Experiment with Indian Potato Farmers

A Theory Appendix

Notation and Technical Assumptions: (i) u is strictly concave, satisfying Inada conditions, and the property that $\frac{q'^*(p)}{q^*(p)}$ is non-increasing in p, where $q^*(p)$ denotes the farmer's supply function, i.e., the solution to q in maximizing $pq - u(\bar{q} - q)$. This insures that the monopsonist's marginal cost $p(q) + qp'(q)$ of procuring quantity q is increasing in q, where $p(q)$ is the inverse of $q^*(p)$. (ii) F's information about ν is represented by a c.d.f. G(ν) with full support over $[\underline{v}, \infty)$.

The Separating Equilibrium: Working backwards from Stage 5, suppose F had taken q_2 to the mandi and received a price offer of m from MT. How much would he want to sell at this price? This corresponds to selecting $q \leq q_2$ to maximize $mq - t(q_2 - q) + u(\bar{q} - q)$. The 'effective' price received by F is now $m + t$, since anything not sold here will have to be transported back at an additional cost of t. The solution to this is $q(q_2, m) = q^*(m + t)$ if $q_2 \geq q^*(m + t)$, and q_2 otherwise. Note that the farmer's beliefs regarding ν do not matter at Stage 5, since the only option he has at this stage is to either sell to MT at the offered price m or consume the rest.

Now move to Stage 4, where MT is approached by F with stock q_2. Let $n(q_2)$ be defined by the solution to m in $q^*(m + t) = q_2$. Any price m bigger than $n(q_2)$ is dominated by the price $n(q_2)$ since it would result in the same traded volume q_2 but at a higher price. Any price m lower than $n(q_2)$ will result in traded volume of $q^*(m + t)$ at price m. Hence MT selects a price $m(\nu; q_2, t) \leq n(q_2)$ to maximize $(\nu - m)q^*(m + t)$. Given the assumption that $\frac{q^*}{q^{*\prime}}$ is nondecreasing, this is a concave maximization problem. Hence MT will offer a price $m(\nu; q_2, t) \equiv \min\{n(q_2), m(\nu)\}$.

Next move back to Stage 3, and suppose that F has decided to reject VT's offer. What decision should he make regarding q_2? Here his beliefs regarding ν matter, since they affect what he expects MT to offer at Stage 4. Suppose that F believes that the realization of ν is $\tilde{\nu}$ with probability one. A choice of $q_2 \leq q^*(m(\tilde{\nu}) + t)$ will result in a sale of q_2 to MT at a price of $n(q_2)$, and a payoff of

$$\mathcal{P}(q_2, \tilde{\nu}) \equiv n(q_2)q_2 + u(\bar{q} - q_2) - tq_2. \tag{2}$$

Given the definition of the function $n(\cdot)$, it follows that $\mathcal{P}(q_2, \tilde{\nu})$ is (locally) strictly increasing in q_2. Hence any $q_2 < q^*(m(\tilde{\nu}) + t)$ is strictly dominated by $q_2 = q^*(m(\tilde{\nu}) + t)$.

Now consider any $q_2 > q^*(m(\tilde{\nu}) + t)$. This will lead to a sale of $q^*(m(\tilde{\nu}) + t)$ to MT at a price of $m(\tilde{\nu})$, with the excess transported back to the village. Hence it is optimal for F to select $q_2 = q^*(m(\tilde{\nu}) + t)$ if he rejects VT's offer. In this event his payoff from the resulting continuation game will be

$$[m(\tilde{\nu}) - t]q^*(m(\tilde{\nu}) + t) + u(\bar{q} - q^*(m(\tilde{\nu}) + t)) \tag{3}$$

At Stage 2, then, if VT offers a price $p(\tilde{\nu})$ where $\tilde{\nu} \geq \underline{v}$, the farmer believes the realization of ν is $\tilde{\nu}$ with probability one and expects a payoff equal to (3) if he rejects the offer. The farmer is indifferent between accepting and rejecting the offer, by construction of the function $p(\tilde{\nu})$. Hence it is optimal for the farmer to randomize between accepting and rejecting the offer; in the event of accepting F will sell $q^*(p(\tilde{\nu}))$ to TV. And offering any price less than $p(\underline{v})$ leads the farmer to believe that $\tilde{\nu} = \underline{v}$ with probability one, so such an offer will surely be rejected.

Finally consider VT's problem of deciding what price to offer at Stage 1. Any offer below $p(\underline{v})$ will surely be rejected, while any offer $p(\tilde{\nu}), \tilde{\nu} \geq \underline{v}$ will be accepted with probability $1 - \alpha(\tilde{\nu})$ and will result in a trade of $q^*(p(\tilde{\nu}))$ at price $p(\tilde{\nu})$. Hence VT's problem is similar to making a price report of $\tilde{\nu} \geq \underline{v}$ in a revelation mechanism which results in a trade of $q^*(p(\tilde{\nu}))$ at price $p(\tilde{\nu})$, resulting in a payoff of

$$\mathcal{W}(\tilde{\nu}|\nu) = [1 - \alpha(\tilde{\nu})][\nu - p(\tilde{\nu})]q^*(p(\tilde{\nu})) \tag{4}$$

It remains to check that it is optimal for VT to report truthfully in this revelation mechanism. Now $\mathcal{W}_\nu(\tilde{\nu}|\nu) = [1 - \alpha(\tilde{\nu})]q^*(\tilde{\nu})$, so if we define $X(\nu) = \mathcal{W}(\nu|\nu)$ we see that incentive compatibility requires that locally $X'(\nu) =$

$[1-\alpha(\nu)]q^*(p(\nu))$, i.e.,

$$X(\nu) = X(\underline{v}) + \int_{\underline{v}}^{\nu} [1-\alpha(\tilde{\nu})]q^*(p(\tilde{\nu}))d\tilde{\nu} \tag{5}$$

which implies that

$$[1-\alpha(\nu)][\nu - p(\nu)]q^*(p(\nu)) = [1-\alpha(\underline{v})][\nu - p(\underline{v})]q^*(p(\underline{v})) + \int_{\underline{v}}^{\nu} [1-\alpha(\tilde{\nu})]q^*(p(\tilde{\nu}))d\tilde{\nu} \tag{6}$$

Differentiating with respect to ν, this local incentive compatibility condition reduces to the differential equation

$$\frac{\alpha'(\nu)}{\alpha(\nu)} = [\frac{q^{*\prime}(p(\nu))}{q^*(p(\nu))} - \frac{1}{\nu - p(\nu)}]p'(\nu) \tag{7}$$

with endpoint condition $\alpha(\underline{v}) = \bar{\alpha}$ for arbitrary $\bar{\alpha} \in (0,1)$.

A sufficient condition for global incentive compatibility (see Mirrlees (1986)) is that $\mathcal{W}_\nu(\tilde{\nu}|\nu) = [1-\alpha(\tilde{\nu})]q^*(p(\tilde{\nu}))$ is non-decreasing in $\tilde{\nu}$. This is equivalent to $-\alpha'(\nu)q^*(p(\nu)) + [1-\alpha(\nu)]{q^*}'(p(\nu))p'(\nu) \geq 0$ for all ν. Condition (7) implies $-\alpha'(\tilde{\nu})q^*(p(\tilde{\nu})) + [1-\alpha(\nu)]{q^*}'(p(\nu))p'(\nu) = \frac{[1-\alpha(\nu)]p'(\nu)q^*(p(\nu))}{\nu - p(\nu)} > 0$.

That $p(\nu) < m(\nu)$ is obvious from the definition of $p(\nu)$. The unconstrained monopsony price p for VT (which maximizes $(\nu - p)q^*(p)$) exceeds $m(\nu)$, since the former solves $p + \frac{q^*(p)}{{q^*}'(p)} = \nu$ while the latter solves $m + \frac{q^*(m+t)}{{q^*}'(m+t)} = \nu$, and $\frac{q^*}{{q^*}'}$ is non-decreasing. Hence the monopsony price exceeds $p(\nu)$, implying that $\frac{{q^*}'(p(\nu))}{q^*(p(\nu))} > \frac{1}{\nu - p(\nu)}$, so $\alpha(\nu)$ is strictly increasing.

Pooling Equilibria: Note first that nothing changes from the separating equilibrium above at Stages 4 and 5, since the farmer's beliefs do not matter at these stages.

At Stage 3, the farmer's beliefs do affect his decision on the stock q_2 to take to the mandi upon rejecting VT's offer. Suppose that the farmer's updated beliefs at Stage 3 are obtained by conditioning on the event that $\nu \in [\nu^*, \nu^* + x]$ where $\nu^* \geq \underline{v}$ and $x > 0$. F will then not be able to exactly forecast the price that MT will offer him at Stage 4. He knows that if he takes q_2, and the state happens to be ν, MT will offer him a price $M(\nu; q_2, t) = \min\{n(q_2), m(\nu)\}$, that he will then sell MT a quantity $Q_2(\nu; q_2, t) = \min\{q_2, q^*(M(\nu; q_2, t) + t)\}$, and carry the rest back to the village. Since $m(\nu)$ is increasing in ν, his ex post payoff will be increasing in ν for any given q_2. Moreover, given any ν^*, an increase in x will induce him to select a higher optimal q_2 and earn a strictly higher continuation payoff from rejecting VT's offer. Denote this payoff by $Y(\nu^*, x)$, which is thereby strictly increasing in x. It is evident that $Y(\nu^*, 0)$ is the expected payoff when he is certain the state is ν^*, as in the separating equilibrium in state ν^*. Hence $Y(\nu^*, 0) = \Pi(p(\nu^*))$, the payoff attained by F in the separating equilibrium in state ν^*.

Construct the endpoints $\{\nu_i\}$ of the partition and the prices $\{r_i\}$ iteratively as follows. Define the function $\tilde{p}(\nu^*, x)$ by the property that $\Pi(\tilde{p}(\nu^*, x)) = Y(\nu^*, x)$, the price which if offered by VT would make F indifferent between accepting and rejecting, conditional on knowing that $\nu \in [\nu^*, \nu^* + x]$. By definition, then, $\tilde{p}(\nu^*, 0) = p(\nu^*)$. Select $\nu_0 = \underline{v}$. Given ν_{i-1}, select $r_i \in (p(\nu_{i-1}), \tilde{p}(\nu_{i-1}, \infty))$. Select $\nu_i = \nu_{i-1} + x_i$ where x_i is defined by the property that $\tilde{p}(\nu_i, x_i) = r_i$. By construction, F is indifferent between accepting and rejecting a price offer of r_i from TV, conditional on the information that $\nu \in [\nu_{i-1}, \nu_i]$.

The rest of the argument is straightforward. VT in state ν_{i-1} is indifferent between offering prices r_{i-1} and r_i. This implies that in any state $\nu \in [\nu_{i-2}, \nu_{i-1})$, he prefers to offer r_{i-1} rather than r_i. Moreover, the single-crossing property of VT's payoffs with respect to the state ν implies that each type is selecting offers optimally in the set $\{r_i\}_{i=1,2,...}$. Also offering a price between r_{i-1} and r_i is dominated by the price r_i, since it corresponds to the same probability of acceptance by F, and a lower profit for VT conditional on acceptance.

B Additional Tables

Table B1: Average Treatment Effects of Information Interventions on Alternative Variables

	Net price received		Ln(Quantity sold)		Ln(Gross Revenue)		Ln(Net Revenue)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Private Information	-0.073	0.023	0.075	0.031	0.056	0.043	0.040	0.033
	(0.130)	(0.115)	(0.147)	(0.119)	(0.159)	(0.138)	(0.162)	(0.140)
Phone	0.100	0.087	-0.012	-0.031	0.047	0.021	0.028	0.003
	(0.094)	(0.088)	(0.089)	(0.091)	(0.099)	(0.102)	(0.107)	(0.111)
Public Information	-0.091	-0.038	-0.031	-0.083	-0.034	-0.066	-0.080	-0.097
	(0.122)	(0.110)	(0.147)	(0.095)	(0.141)	(0.109)	(0.149)	(0.109)
Land	-0.095***	-0.075***	0.438***	0.404***	0.400***	0.378***	0.382***	0.361***
	(0.018)	(0.015)	(0.028)	(0.023)	(0.028)	(0.024)	(0.028)	(0.025)
Constant	2.223***	2.376***	7.670***	7.562***	8.420***	8.406***	8.386***	8.372***
	(0.120)	(0.090)	(0.133)	(0.084)	(0.142)	(0.101)	(0.146)	(0.101)
Observations	*2,318*	*2,318*	*2,318*	*2,318*	*2,314*	*2,314*	*2,303*	*2,303*
R-squared	*0.359*	*0.427*	*0.592*	*0.664*	*0.662*	*0.708*	*0.648*	*0.696*
Mandi *fixed effects*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
Mean DV	2.060	2.060	7.322	7.322	7.994	7.994	7.957	7.957
SE DV	0.0329	0.0329	0.0561	0.0561	0.0635	0.0635	0.0632	0.0632

Notes: The sample used is the same as in Table 4. In columns 1, 3, 5 and 8 we include dummy variables for variety, quality and district of farmer's residence. In columns 2, 4, 6 and 8 we include dummies for the quality as well as the *mandi* whose catchment area the farmer resides in. A *mandi* is defined as a market location - variety combination. Standard errors in parentheses are clustered at the *mandi* level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table B2: Heterogeneous Treatment Effects of Information Interventions on Net Price Received

	Farmer specific average	*Mandi* weighted average	District weighted average	*Mandi* × year "shock"	Deviation from expected price	Farmers who sold to long-term buyers
	(1)	(2)	(3)	(4)	(5)	(6)
Price regressor	0.181**			0.088**		0.268***
	(0.069)			(0.034)		(0.068)
Private information	-0.554*	-0.663*	-0.659*	0.120	-0.483	-0.406
	(0.301)	(0.353)	(0.373)	(0.158)	(0.325)	(0.289)
Private information × Price regressor	0.131*	0.161*	0.163*	0.024	0.111	0.060
	(0.070)	(0.085)	(0.092)	(0.031)	(0.072)	(0.071)
Phone	0.023	0.104	0.101	0.091	0.019	0.122
	(0.309)	(0.237)	(0.250)	(0.113)	(0.209)	(0.405)
Phone × Price regressor	0.011	-0.005	-0.005	-0.001	0.014	-0.014
	(0.075)	(0.063)	(0.067)	(0.027)	(0.056)	(0.086)
Public information	0.106	-0.170	-0.138	0.073	0.044	-0.027
	(0.269)	(0.323)	(0.346)	(0.161)	(0.354)	(0.290)
Public information × Price regressor	-0.027	0.031	0.024	0.017	-0.017	-0.006
	(0.066)	(0.078)	(0.085)	(0.030)	(0.079)	(0.073)
Land	-0.076***	-0.076***	-0.076***	-0.057***	-0.075***	0.001
	(0.014)	(0.015)	(0.015)	(0.015)	(0.013)	(0.014)
Constant	1.573***	2.377***	2.376***	2.737***	2.376***	1.314***
	(0.298)	(0.086)	(0.086)	(0.178)	(0.121)	(0.276)
Observations	*2,300*	*2,317*	*2,317*	*2,283*	*2,318*	*1,370*
R-squared	*0.453*	*0.433*	*0.432*	*0.462*	*0.433*	*0.498*
Mean DV	2.054	2.058	2.058	2.054	2.054	2.121
SE DV	0.0329	0.0329	0.0329	0.0329	0.0329	0.0338

Notes: Notes below Table 9 apply. Dependent variable is the average net price received, calculated as the net revenue earned divided by the quantity sold. *Mandi* dummies are included in all columns. Standard errors in parentheses are clustered at the *mandi* level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table B3: Heterogeneous Impacts of Information Interventions on Gross Farmer Revenue

	Farmer specific average	*Mandi* weighted average	District weighted average	*Mandi* × year "shock"	Deviation from expected price	Farmers who sold to long-term buyers
	(1)	(2)	(3)	(4)	(5)	(6)
Price regressor	694.9				-800.9**	-407.9
	(530.3)				(308.3)	(1,089.3)
Private information	-8,716.1**	-9,263.9**	-9,897.2**	-9,324.2**	5,141.4***	-10,641.0
	(3,546.0)	(4,228.6)	(4,542.2)	(4,430.1)	(1,722.4)	(6,706.7)
Private information x Price regressor	2,043.4**	2,225.1**	2,413.0**	2,062.9**	1,418.1***	2,523.7
	(796.4)	(968.5)	(1,054.7)	(981.3)	(390.9)	(1,679.9)
Phone	4,505.0	1,413.0	1,489.4	922.6	2,401.4	8,929.4
	(3,698.1)	(3,549.1)	(3,547.7)	(2,657.7)	(1,932.0)	(7,128.6)
Phone x Price regressor	-938.6	-203.5	-224.2	-79.8	346.3	-1,978.9
	(863.3)	(855.8)	(873.8)	(571.9)	(340.6)	(1,786.7)
Public information	-7,317.9**	-7,519.1*	-8,087.0*	-6,629.3	2,693.4	-10,085.2*
	(3,306.7)	(4,285.5)	(4,577.5)	(4,990.5)	(1,694.7)	(5,949.7)
Public information x Price regressor	1,482.3**	1,506.6	1,662.4	1,189.5	1,068.2***	2,516.5*
	(706.1)	(935.4)	(1,013.4)	(985.4)	(352.4)	(1,445.5)
Land	4,387.5***	4,420.2***	4,418.3***	4,423.7***	4,303.0***	5,035.4***
	(411.4)	(402.1)	(402.1)	(502.0)	(386.7)	(858.2)
Constant	4,220.1	7,198.8***	7,198.1***	7,234.2***	4,189.4***	8,723.1*
	(2,653.1)	(1,024.7)	(1,023.1)	(892.0)	(1,423.4)	(4,704.8)
Observations	*2,300*	*2,317*	*2,317*	*2,318*	*2,283*	*443*
R-squared	*0.350*	*0.345*	*0.345*	*0.345*	*0.351*	*0.460*
Mean DV	8350	8327	8327	8350	8350	8762
SE DV	432.3	429.6	429.6	432.3	432.3	1026

Notes: Notes below Table 9 apply. Dependent variable is the gross revenue earned by the farmer. *Mandi* dummies are included in all columns. Standard errors in parentheses are clustered at the *mandi* level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table B4: Heterogeneous Treatment Effects of Information Interventions on Logarithmic Quantity Sold

	Farmer specific average	*Mandi* weighted average	District weighted average	*Mandi* × year "shock"	Deviation from expected price	Farmers who sold to long-term buyers
	(1)	(2)	(3)	(4)	(5)	(6)
Price regressor	-0.084			-0.112***		-0.083
	(0.057)			(0.024)		(0.054)
Private information	-0.607*	-0.545	-0.589	0.498***	-0.566	-0.454
	(0.307)	(0.423)	(0.433)	(0.141)	(0.400)	(0.332)
Private information × Price regressor	0.145**	0.134	0.147	0.136***	0.128	0.115
	(0.069)	(0.102)	(0.105)	(0.028)	(0.078)	(0.075)
Phone	0.234	-0.022	-0.022	-0.074	0.013	0.081
	(0.367)	(0.371)	(0.375)	(0.151)	(0.343)	(0.570)
Phone × Price regressor	-0.064	-0.003	-0.003	-0.013	-0.011	-0.002
	(0.075)	(0.078)	(0.080)	(0.025)	(0.068)	(0.126)
Public information	-0.690**	-0.476	-0.551	0.276**	-0.524	-0.471
	(0.293)	(0.382)	(0.394)	(0.110)	(0.571)	(0.422)
Public information × Price regressor	0.135**	0.089	0.108	0.109***	0.091	0.095
	(0.062)	(0.084)	(0.088)	(0.024)	(0.102)	(0.094)
Land	0.396***	0.401***	0.401***	0.384***	0.401***	0.329***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.025)	(0.028)
Constant	7.960***	7.570***	7.571***	7.140***	7.574***	7.882***
	(0.269)	(0.081)	(0.081)	(0.108)	(0.154)	(0.269)
Observations	*2,300*	*2,317*	*2,317*	*2,283*	*2,318*	*1,370*
R-squared	*0.668*	*0.665*	*0.665*	*0.676*	*0.666*	*0.630*
Mean DV	7.960***	7.570***	7.571***	7.140***	7.574***	8.028***
SE DV	(0.269)	(0.081)	(0.081)	(0.108)	(0.154)	(0.338)

Notes: Notes below Table 9 apply. Dependent variable is the natural logarithm of the quantity sold. *Mandi* dummies are included in all columns. Standard errors in parentheses are clustered at the *mandi* level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table B5: Heterogeneous Treatment Effects of Information Interventions on Logarithmic Gross Farmer Revenue

	Farmer specific average	*Mandi* weighted average	District weighted average	*Mandi* x year "shock"	Deviation from expected price	Farmers who sold to long-term buyers
	(1)	(2)	(3)	(4)	(5)	(6)
Price regressor	-0.084			-0.112***		-0.083
	(0.057)			(0.024)		(0.054)
Private information	-0.607*	-0.545	-0.589	0.498***	-0.566	-0.454
	(0.307)	(0.423)	(0.433)	(0.141)	(0.400)	(0.332)
Private information × Price regressor	0.145**	0.134	0.147	0.136***	0.128	0.115
	(0.069)	(0.102)	(0.105)	(0.028)	(0.078)	(0.075)
Phone	0.234	-0.022	-0.022	-0.074	0.013	0.081
	(0.367)	(0.371)	(0.375)	(0.151)	(0.343)	(0.570)
Phone × Price regressor	-0.064	-0.003	-0.003	-0.013	-0.011	-0.002
	(0.075)	(0.078)	(0.080)	(0.025)	(0.068)	(0.126)
Public information	-0.690**	-0.476	-0.551	0.276**	-0.524	-0.471
	(0.293)	(0.382)	(0.394)	(0.110)	(0.571)	(0.422)
Public information × Price regressor	0.135**	0.089	0.108	0.109***	0.091	0.095
	(0.062)	(0.084)	(0.088)	(0.024)	(0.102)	(0.094)
Land	0.396***	0.401***	0.401***	0.384***	0.401***	0.329***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.025)	(0.028)
Constant	7.960***	7.570***	7.571***	7.140***	7.574***	7.882***
	(0.269)	(0.081)	(0.081)	(0.108)	(0.154)	(0.269)
Observations	*2,300*	*2,317*	*2,317*	*2,283*	*2,318*	*1,370*
R-squared	*0.668*	*0.665*	*0.665*	*0.676*	*0.666*	*0.630*
Mean DV	7.993	7.994	7.994	7.993	7.993	8.001
SE DV	0.0639	0.0636	0.0636	0.0639	0.0639	0.0719

Notes: Notes below Table 9 apply. Dependent variable is the natural logarithm of the gross revenue earned. *Mandi* dummies are included in all columns. Standard errors in parentheses are clustered at the *mandi* level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table B6: Heterogeneous Treatment Effects of Information Interventions on Logarithmic Net Farmer Revenue

	Farmer specific average	*Mandi* weighted average	District weighted average	*Mandi* × year "shock"	Deviation from expected price	Farmers who sold to long-term buyers
	(1)	(2)	(3)	(4)	(5)	(6)
Price regressor	-0.024			-0.072**		0.017
	(0.065)			(0.028)		(0.069)
Private information	-0.982**	-1.091**	-1.136**	0.606***	-0.971**	-0.793**
	(0.371)	(0.485)	(0.509)	(0.159)	(0.476)	(0.395)
Private information × Price regressor	0.231***	0.262**	0.277**	0.165***	0.215**	0.173**
	(0.077)	(0.111)	(0.118)	(0.031)	(0.092)	(0.084)
Phone	0.387	0.193	0.202	0.030	0.153	0.150
	(0.415)	(0.429)	(0.437)	(0.205)	(0.325)	(0.600)
Phone × Price regressor	-0.092	-0.047	-0.050	-0.001	-0.035	-0.009
	(0.090)	(0.096)	(0.100)	(0.040)	(0.069)	(0.135)
Public information	-0.763**	-0.796*	-0.851*	0.421***	-0.684	-0.554
	(0.348)	(0.441)	(0.464)	(0.145)	(0.529)	(0.486)
Public information × Price regressor	0.151**	0.159*	0.174*	0.145***	0.121	0.109
	(0.070)	(0.093)	(0.100)	(0.030)	(0.094)	(0.109)
Land	0.351***	0.357***	0.356***	0.348***	0.357***	0.329***
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.029)
Constant	8.503***	8.385***	8.384***	8.123***	8.388***	8.326***
	(0.326)	(0.095)	(0.095)	(0.149)	(0.143)	(0.353)
Observations	*2,286*	*2,302*	*2,302*	*2,269*	*2,303*	*1,369*
R-squared	*0.701*	*0.699*	*0.699*	*0.710*	*0.699*	*0.682*
Mean DV	7.956	7.956	7.956	7.956	7.956	7.990
SE DV	0.0636	0.0633	0.0633	0.0636	0.0636	0.0724

Notes: Notes below Table 9 apply. Dependent variable is the natural logarithm of the net revenue earned. *Mandi* dummies are included in all columns. Standard errors in parentheses are clustered at the *mandi* level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table B7: Heterogeneous Treatment Effects of Interventions on Households That Were Not Asked About Price Tracking Behavior

	Quantity Sold (1)	Gross Revenue (2)	Net Revenue (3)	Net price (4)	Ln(Quantity Sold) (5)	Ln(Gross Revenue) (6)	Ln(Net Revenue) (7)
Price regressor	-1.300	698.032	648.179	0.212***	-0.096	-0.447	-0.008
	(322.392)	(694.420)	(668.788)	(0.072)	(0.071)	(0.403)	(0.077)
Private information	-2,944.751*	-6,775.892	-6,300.493	-0.428	-0.447	-0.045	-0.757
	(1,678.458)	(4,182.642)	(4,083.944)	(0.314)	(0.403)	(0.411)	(0.468)
Private information × Price regressor	544.476	1,363.492	1,304.489	0.121*	0.110	0.110	0.188*
	(381.945)	(871.382)	(847.594)	(0.071)	(0.096)	(0.096)	(0.101)
Phone	2,609.029	5,666.420	5,283.383	-0.096	-0.045	-0.908**	-0.009
	(2,029.408)	(5,800.428)	(5,684.935)	(0.446)	(0.411)	(0.363)	(0.496)
Phone × Price regressor	-479.944	-945.315	-877.630	0.027	0.012	0.012	0.012
	(445.917)	(1,243.741)	(1,242.497)	(0.102)	(0.089)	(0.089)	(0.107)
Public information	-3,972.866**	-9,139.327**	-8,170.157*	0.358	-0.908**	-0.096	-0.898**
	(1,676.522)	(4,381.424)	(4,225.838)	(0.328)	(0.363)	(0.071)	(0.434)
Public information × Price regressor	766.826**	1,820.385**	1,659.281*	-0.074	0.189**	0.189**	0.186**
	(376.894)	(911.722)	(875.342)	(0.077)	(0.077)	(0.077)	(0.085)
Land	2,002.404***	3,845.412***	3,375.979***	-0.076***	0.360***	0.360***	0.316***
	(201.154)	(393.910)	(352.715)	(0.018)	(0.029)	(0.029)	(0.029)
Constant	3,520.771**	4,938.699	4,750.218	1.396***	8.028***	8.028***	8.441***
	(1,408.693)	(3,357.480)	(3,254.382)	(0.319)	(0.338)	(0.338)	(0.388)
Observations	*1,139*	*1,139*	*1,139*	*1,139*	*1,139*	*1,139*	*1,135*
R-squared	*0.405*	*0.379*	*0.362*	*0.472*	*0.677*	*0.677*	*0.708*
Mean DV	4060	8543	7944	2.033	7.314	7.991	7.944
SE DV	348.5	666.3	621.1	0.0453	0.0818	0.0914	0.0902

Notes: Notes for Column 1 below Table 9 apply. Sample is restricted to households that were not asked questions about their price tracking behavior. *Mandi* dummies are included in all columns. Standard errors in parentheses are clustered at the *mandi* level. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.