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

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Abstract

In the Indian state of West Bengal, potato farmers sell to local middlemen because they lack direct access to wholesale markets. Using high-frequency marketing surveys we find large average middleman margins and negligible pass-through from wholesale to farmgate prices. We also find that farmers are uninformed about wholesale and retail prices. To test alternative models of farmer-middlemen trades, we conduct a field experiment, where farmers in randomly chosen villages are provided with wholesale price information. Information had negligible average effects on farmgate sales and revenues, but increased pass-through from wholesale to farmgate prices. These results are consistent with a model of *ex post* bargaining between farmers and village middlemen where farmers also have the option of selling to middlemen outside the village. They are inconsistent with models of risk-sharing contracts between

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middlemen and farmers, search frictions or standard IO models of pass-through.
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1 Introduction

It is commonly believed that middlemen margins are a large component of agricultural value chains in developing countries.[1] However, for most developing countries there is little evidence on the magnitude of middlemen margins and their determinants. Our understanding of the trading mechanisms between farmers and traders is also limited.[2] Do farmers and traders engage in *ex ante* risk-sharing contracts, or do they bargain only at the time of sale? What are farmers' outside options or bargaining power? Do they have less information than traders do about price movements in downstream markets, and does this asymmetry of information worsen their bargaining position? A better understanding of these issues can explain the observed low farmgate prices that arguably perpetuate poverty and limit agricultural growth. It can also explain why the gains from export growth do not "trickle down" to the ultimate producers, and whether and how increasing farmers' access to price information would affect their outcomes.

In this paper we examine these questions in the context of the supply chain for potatoes, a high-value cash crop in the Indian state of West Bengal. More than 90% of the potatoes produced by the farmers in our study area are sold to village middlemen, who aggregate purchases and then re-sell them at wholesale markets to buyers from distant cities or neighbouring states. The remaining tend to be sold to other middlemen in neighboring *local* markets. Not only do farmers lack direct access to distant wholesale markets, they are also uninformed about the wholesale market prices at which the middlemen resell their produce there. Our data reveal that there are large gaps between these resale prices and the prices that farmers receive. In the year of our study, farmgate prices (received from middlemen) were on average 55-61 percent of the wholesale prices at which middlemen resold the potatoes. In contrast, our back-of-the-envelope calcula-

[1] For example, Morisset (1998) conjectures that trading companies may have caused large and increasing gaps between world commodity prices and consumer prices observed from the mid-1970s to the mid-1990s. Other research in the context of African countries argues that increases in export prices do not translate into commensurate increases in producer prices for cash crops because of high middlemen margins (Fafchamps and Hill 2008, McMillan, Rodrik, and Welch 2002).

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

tion suggests that middlemen earned 28-38% of the wholesale price, and 64-83% of the farmgate price per kilogram of potatoes traded.[3] The pass-through from retail prices to wholesale prices is quite high (64-81 percent in 2008), but from retail prices to farmgate prices is negligible (a statistically insignificant 2 percent).[4]

To understand why potato middlemen earn large margins, we need to understand the trading mechanism with farmers. This is difficult to gauge directly from farmer surveys: our data show that traders and farmers often engage in repeat transactions, and yet only a minority of farmers report being bound by an advance contractual arrangement. Instead, the majority described a process of *ex post* bargaining where village middlemen make daily price offers, to which farmers respond by either selling rightaway, or holding out for a future sale, or transporting to a neighbouring small market (called a *haat*) to sell to a different middleman.

These trading arrangements contrast sharply with the arrangements in many other contexts. In some, middlemen play no role at all; for example in Madhya Pradesh, Maharashtra and Kerala, farmers sell directly to wholesale or retail markets, sometimes via auctions conducted by government regulators (Goyal 2010, Fafchamps and Minten 2012, Jensen 2007).[5] Increased access to market price information facilitates spatial arbitrage across markets, and reduces price dispersion across markets and increases average price (Jensen 2007, Goyal 2010).[6] In some other developing country contexts, farmers enter into advance contracts with middlemen but also have the option to sell directly in a spot market; the resulting moral hazard problem limits the extent of risk-sharing achieved (Blouin and Machiavello 2013, Machiavello and Morjaria 2015 and Saenger, Torero, and Qaim 2014). In yet other contexts similar to West Bengal potato markets, farmers have

[3]Here we calculate middlemen's resale prices net of transport, handling and storage costs.

[4]Unlike the "pass-through literature" that mainly examines how price fluctuations transmit from upstream producers to downstream consumers, we refer here to price transmission from wholesalers (downstream) to farmers (upstream). The same issue of market structure limiting price transmission applies in both cases.

[5]Aker (2010) also examined the effect of mobile phones on price dispersion, but studied grain traders in Niger instead of farmers.

[6]The marketing arrangements differ across Indian states partly as a result of differences in government marketing regulations. Cohen (2013) provides a detailed description of agricultural marketing regulations and practice in West Bengal.

extremely limited access to wholesale markets and almost entirely sell to local middlemen (Fafchamps and Hill 2008 study coffee in Uganda, McMillan, Rodrik, and Welch 2002 study cashews in Mozambique). At the moment we know little about the organization of such vertical supply chains. This paper aims to fill this gap.

Theoretical models of vertical relationships in supply chains are models of risk-sharing contracts (Hart 1983, Ligon, Thomas, and Worrall 2002, Machiavello 2010) or spot market models of oligopolistic competition among middlemen either with or without search frictions.[7] We are not aware of any attempts to discriminate between these different models, and bargaining without any contracts. The main goal of this paper is to use empirical evidence from West Bengal potato supply chains to fill this gap. The paper also aims to shed light on the impact of policy measures to provide market price information to farmers and thereby remove information asymmetries.

Our ground level surveys of farmers and traders indicate that farmers sell most of their output to village middlemen, but also have the option of selling to other middlemen located in market areas outside the village, if they incur search and transport costs. Village middlemen typically make farmers a take-it-or-leave-it price offer. Only a minority of middlemen report having any prior contractual trading agreements. Farmers are uninformed about the price at which middlemen resell on the wholesale market. In line with these facts, we develop a model of spot transactions, where an uninformed farmer bargains with an informed village middleman. The underlying assumption is that middlemen collude on price offers *within* the village, but village middlemen compete with middlemen located *outside* the village. Middlemen outside the village engage in oligopolistic competition with one another, thereby creating an outside option for the farmer. This outside option varies with the actual wholesale price and is higher than the monoposonistic price for village middlemen, which creates competitive pressure on the

[7]For example, see Antras and Costinot (2010), Antras and Costinot (2011), Chau, Goto, and Kanbur (2009) for the former, and Atkin and Donaldson (2014), Gopinath and Itskhoki (2010), Weyl and Fabinger (2013), Villas-Boas (2007) for the latter. Mortimer (2008) and Bonnet and Dubois (2010) empirically discriminate between linear and nonlinear pricing contracts in vertical relationships between upstream and downstream agents.

village middlemen.

This bargaining game between farmers and village middlemen has a plethora of equilibria, ranging from fully revealing equilibria where the village middleman price offer co-moves monotonically with the wholesale price, to fully non-revealing equilibria where the price offer does not vary at all with the wholesale price, as well as partially revealing equilibria which lie in between. We show that under reasonable assumptions, the fully non-revealing equilibrium is *ex ante* the most profitable for the village middlemen.[8] This is because this equilibrium does not involve the trade breakdowns that inevitably occur in the revealing equilibrium.[9] Irrespective of the realized wholesale price, such trade breakdowns do not occur on the equilibrium path in the non-revealing equilibrium, where middlemen offer the same price to the farmer. Thus our theory provides an explanation for why observed equilibria might be non-revealing, indicating negligible pass-through from wholesale to farmgate prices.[10]

We use the bargaining model to predict the impact of an external intervention that provides farmers with information about prevailing wholesale prices. In particular, the model predicts that such an intervention increases the pass-through of wholesale prices to farmgate prices. The reason is that village middlemen take advantage of their market power to bargain farmers down to their outside option. The intervention affects farmers' information about their outside option, and thereby the price offers that village middlemen make to them. Clearly, whether the effect is positive or negative depends on whether the true wholesale price is high or low: when it is high, treated farmers become aware that their outside option is high, and traders respond by offering them higher prices than they offer to uninformed farmers. When instead it is low, they offer informed farmers lower

[8]These assumptions are: that self-consumption of potatoes is relatively unimportant, and that farmers are risk-averse with respect to the price they receive.

[9]In the revealing equilibrium, the village middleman responds to competitive pressure from middlemen outside the village and offers a price above the monopsony price. To ensure that he does not deviate from this above-monopsony price to the monopsony price, the equilibrium requires that trades break down when a lower price is offered. In other words, farmers reject lower price offers with a high probability.

[10]Our theory has some resemblance to models of relational contracts with private information where pooling can be more efficient than separating equilibria (Halac 2012, Malcomson 2016). However ours is a static trading environment instead of one with implicit contracts.

prices than they offer to uninformed farmers. Thus the model predicts that treatment effects are heterogeneous with respect to the wholesale price realization, and on average, could cancel out.

In a field experiment we conducted in 2008, we randomly assigned 72 (randomly chosen) villages from two potato-growing districts of West Bengal to one of two treatment groups, or a control group. In the two treatment groups of 24 villages each, we provided farmers with daily information about the prevailing potato prices in neighboring wholesale and retail markets. In one variation, called the private information treatment, four randomly selected farmers in the village received the information through phonecalls from our team of telecallers. In the public information treatment, the information was posted publicly in the village. In the control villages, no information was provided. Simultaneously, we collected high-frequency data on potato cultivation, harvest, sales and related revenues and costs, from a random sample of potato farmers in each village. In our analysis of the annual average quantity sold and price received by farmers, we find both the heterogeneous treatment effects and null average effect predicted by the bargaining model.

These predictions turn out to contrast sharply with those based on models based on contracting or search frictions. Contracts that share risk between farmers and middlemen and are not subject to any commitment problems, predict that an information intervention would increase trading volumes when the wholesale price is low. This is because information provision reduces the attendant screening distortions in low price states. This contrasts with the prediction of the bargaining model that the information intervention would lower trading volumes in low-price states. If instead contracts are subject to limited commitment, then providing farmers with market price information would create *ex post* moral hazard in high-price states because farmers would prefer to break the contract and sell at the high price in the spot market instead. In low-price states there would be an impact on the volume traded and farmgate prices only if middlemen lost money in these states. In contrast, the bargaining model predicts a decline in trading volumes and farmgate prices in low-price states even if middlemen earn positive rents in all states. Finally models based on search frictions predict that information reduces the dispersion in farmgate prices within a village, and across different markets outside the village where the farmer can sell at. The bargaining model is consistent with absence of any such effects.

Given this divergence of predictions, we argue that high middleman margins in the West Bengal potato trade cannot be explained as risk premia for insurance they provide to farmers, or to significant search frictions. Our findings also suggest that informational interventions in the West Bengal potato marketing chain are unlikely to significantly reduce average middleman margins, while they could increase pass-through of wholesale to farmgate prices. The underlying issue here is that village middlemen wield considerable market power. This is because the market institutions do not allow farmers to directly access wholesale buyers, and because there are significant monetary and non-monetary barriers to entering the trading business.

The static bargaining model implies that *ex ante* welfare effects of informational interventions on farmers were negligible, and on traders was negative. The *ex post* welfare implications, of course, depend on exact realizations of the wholesale prices. Both *ex ante* and *ex post* welfare effects also depend on whether information affects storage decisions of farmers, an issue we abstract from in the static version of the model. A later section in the paper explains how the model extends to a dynamic setting and examines information treatment effects on storage in our experiment. We find a significant positive storage effect of information treatment only for a small minority of treated farmers who were delivered information directly via distributed cell-phones. As post-harvest wholesale price realizations were unusually low in 2008, these effects on storage further reduced the *ex post* income gains of this group of farmers. The observed treatment effects for other farmers were therefore driven directly by price impacts rather than induced effects on storage. This explains why our empirical analysis of treatment effects focused on the consistency of observed experimental impacts on yearly averages of farmgate prices with the predictions of the static bargaining model.

The paper is structured as follows. Section 2 describes the institutional setting. Section 3 describes the nature of the experiment and the data collected from farmer surveys. Section 4 then presents the bargaining model and the main theoretical results. The empirical results testing these predictions are presented in Section 5. Competing explanations of the empirical results are discussed in Section 6. Section 7 then explains how the model can be extended to incorporate multiple dates and decisions concerning storage by farmers, followed by experimental results concerning storage. Finally, Section 8 concludes the paper. Proofs of theoretical results and supplementary tables are collected in the Appendix.

2 The Context: Potato Production and Sales

Potatoes generate the highest value-added per acre of all cash crops produced in West Bengal (Bardhan and Mookherjee 2011). In the winter, farmers in our two study districts plant more land with potatoes than any other cash crop (Maitra et al. 2015). In these districts potatoes are planted between October and December, and harvested between January and March. 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 can be placed in cold stores, and then sold any time until November, when the new planting season begins. However cold storage technicalities and government regulations require that cold stores be emptied at the end of November, so that potatoes cannot be carried over from one year to the next.

2.1 Farmer-Trader Transactions and Market Structure

The local supply chain is organized as in Figure 1. Our 2006 baseline survey reveals that sample farmers sold 98 percent of their produce to local intermediaries or village traders, who are residents of the same or neighboring villages. 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.[11]

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 district are sold in the Bhubaneswar market in neighboring Orissa, or in the southern state of Andhra Pradesh. As we will discuss in Section 2.3, price movements in the city retail markets explain much of the movement in local *mandi* prices that we observe.

There are on average 10 middlemen operating in a village. They usually buy from a network of farmers who have a track record of selling potatoes of uniform quality and not cheating them by adding potatoes of a lower grade into the sack, or cheating on the weight of the sack.[12] In 2007, sample farmers sold nearly 72 percent of their potatoes to buyers whom they had been selling to for a year or more, and 32 percent to buyers whom they had been selling to for two years or more.

This high incidence of repeat transactions among the same partners raises the possibility, but does not guarantee the existence, of contractual arrangements. For instance, in 2007 sample farmers sold only 21 percent of their potatoes to buyers from whom they had an outstanding loan. Farmers also told us that they were not bound to sell to the trader who had provided them inputs or credit, but were free to sell to someone else and to use the proceeds to repay the loan. Table 1 uses data from surveys of purchasing middlemen in the same set of 72 villages, to throw more light on the nature of the trading mechanism. One third or less of the middlemen reported having any prior contractual agreement with farmers they purchased from. Less than 6 percent reported an explicit contractual understanding about the quantity that would be traded, and only 16 percent reported having an explicit or implicit understanding about the price the trader would

[11] In addition to buying potatoes, village middlemen trade in other seasonal produce and often sell agricultural inputs and provide credit; many of them have a shop in the village. Thus farmers and traders interact face-to-face at a high frequency, making it unlikely that either farmers or village traders incur large search costs of finding each each other. However as we argue below farmers face very high costs of accessing information about the prevailing *mandi* prices.

[12] Village traders typically only weigh the first few sacks of any lot.

pay. In fact nearly a third of them explicitly said that they were free to sell to trader, or that the trader was free to buy from any farmer.

Direct sales to large buyers from distant markets are extremely rare. In informal interviews, these buyers told us that it was "not worth their while" to negotiate small trades with many different farmers whom they did not know personally, and therefore could not trust to provide reliable quality. Instead, one alternative to selling to a particular village trader is to sell to another village trader. However, village traders admit to discussing price offers with each other, and checking with farmers the prices at which they recently sold to others, so it quite possible that they tacitly collude on prices within the village. It is less likely that they collude with traders from other villages or traders at the local markets (called *haats*), since they meet them less frequently. 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 selling to a trader in that market, or waiting to sell later in the year.[13] Our model of *ex post* bargaining with sequential competition between a village trader and a trader at a *haat* builds on these institutional details.

Ultimately, the market power of village middlemen rests on barriers to entry into this line of business. To understand what these barriers are, in a 2012 survey, we asked 72 randomly selected traders operating in our sample villages about the arrangements a hypothetical potential entrant into the trader business would need to make. As we see in Table 2, traders thought the most important requirement to start a potato trading business was capital. The median capital needed was ₹50,000 (mean = ₹94472).[14] Next, they said it was important for the entrant to have apprenticeship experience with a trader, for an average of 3.5 years. An average of 3 years' experience cultivating potatoes was the third-most important requirement. It was also necessary to have prior contacts with at least 25 farmers, and large buyers in at least 3 distant markets. Thus, to enter the business one would need to make not just monetary but also non-monetary investments,

[13] In 2006, sample farmers sold only 1 percent of potatoes in small local markets (*haats*) located on average 5 kilometres outside the village.

[14] The average agricultural loan for planting potatoes in these villages is about ₹8000 (data collected through informal interviews). Thus ₹50,000 is clearly a large amount for the average farmer in this village.

many of which are of the form of reputational capital, which takes time to build.

2.2 Price Information of Farmers

Since transactions between the traders and the buyers from distant markets whom they sell to are often bilateral, information about the trader's resale price at the *mandi* is not in the public domain. Instead, 71 percent of sample farmers reported they learnt about *mandi* prices from the village trader, and 46 percent said this trader was their only source of information (Table 4, Panel E, column 1). About 13 percent reported asking friends and neighbours, and 6 percent received information through the media, although the media reports on much larger wholesale markets, many of which are in different districts, and may sell different varieties.[15] Although public telephone booths, landline phones at home and mobile phones were all available to varying extents, farmers told us in informal interviews that they had no contacts at *mandis* who would share price information with them.[16]

Our fortnightly survey data also indicated substantial information asymmetry between farmers and traders. When we asked farmers what the price in the neighboring market had been recently, their price reports did not match the *mandi* prices (received by the village traders) in the relevant week, but instead were much closer to the prices received by farmers who sold at a *haat* in that week.[17] The average price 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).[18] In other words, they interpreted the "market price" as the price they would receive if they took their potatoes to the *haat*,

[15] When we attempted to match the official data on wholesale prices with the time series of *mandi* prices collected through our project, only 3 *mandis* matched successfully.

[16] Although not in 2007, in 2008 we asked farmers to tell us their estimate of the current market price.

[17] 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.

[18] 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 across all farmers who sold at *haats*.

not the price at which middlemen resold their produce at the *mandi*.

We estimate the extent to which farmers were misinformed about prices by computing the mean squared error of the tracked price they report, relative to the true trader selling price in the *mandi* or *haat* that they reported tracking. In 2008, the mean squared error of the control group farmers was 0.221. This corresponds to a mean absolute deviation equal to 42.5 percent of the true price. In Section 3.3 we discuss the evidence that the information intervention significantly reduced the extent of misinformation.

We received the *mandi* and *haat* price reports from market "insiders", 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 fee.

2.3 The Unpredictability of *Mandi* Prices

The key premise in this project is that farmers have less information about prices prevailing in the *mandi* than traders do. We have described anecdotal evidence that farmers cannot directly collect information from the *mandis*, as well as our empirical finding that farmers were misinformed about the prices at which potatoes were resold in the markets. Below we argue that farmers also could not have extracted much information about *mandi* prices from data that they do observe, such as past farmgate prices or current local yields.

First, there is considerable variation in *mandi* prices from year to year. 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. Second, there is considerable volatility in weekly *mandi* prices both over time and across *mandis*, and a substantial part of the variation remains unexplained even after controlling for location-specific characteristics, seasonality and annual shocks.[19] To see this, consider the analysis

[19] Although in 2008 we collected *mandi* price data from January to November, for 2007, 2011 and 2012 we have these data only for the period May-November, and so this analysis is restricted to the post-harvest period. However in Section 5 we will analyze all sales that occurred in 2008, regardless of

of variance of weekly *mandi* prices for weeks 13 and beyond in 2007, 2008, 2011 and 2012 presented in Table 5. 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 of time within the same year.[20] Finally, different *mandis* follow different patterns from year to year.

It is also unlikely that farmers could infer the current prices at their local *mandi* from readily observable data such as the distance of the *mandi* from the city market, transport cost fluctuations or potato output shocks in their area. The first column in Table 6 presents the result of a regression of weekly *mandi* prices from 2007, 2008, 2011 and 2012, on various factors that could explain the weekly variation: the weekly retail price in the relevant destination city market (Kolkata for Hugli, Bhubaneswar for West Medinipur), and local (annual) potato yields estimated from output data for sample farmers located in each *mandi* area. Year dummies control for annual shocks, *mandi* dummies control for *mandi*-specific factors, and week dummies control for seasonal variation. As we can see, the pass-through from city prices to the prices that traders receive when they sell at the *mandi* is considerable: when the city price increases by ₹1, the *mandi* price increases by 81 paise. The pass-through is high even in 2008, the year of our study (column 2).

However, as column 3 of the table shows, the pass-through from city prices to weekly farmer prices in 2008, controlling for *mandi* dummies and week dummies, is a statistically non-significant 0.02 points. In column 4 we check the pass-through from *mandi* prices to farmer prices, and once again, the coefficient is small (0.04) and non-significant.

These results suggest not only that pass-through from retail prices to farmer prices is limited, but also that it would be very difficult for farmers to back out the prevailing *mandi* price by observing the price that the trader offered them.

timing.

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

2.4 Margins Earned by Traders

Estimating the margins that middlemen earn is not straightforward because they often hold potatoes after buying them, and sell them later in the year when the price is high. However since they have the option of re-selling at the same time as they buy, the difference between their selling and buying prices at the same point of time provides a lower bound to their expected gross margin. Since we do not have data on the actual costs that traders incurred, we use unit cost data for transport, handling and storage from farmer surveys as estimates. Since traders can avail of economies of scale and connections with store-owners and so incur lower unit costs than farmers, these are an upper bound to the traders' costs; subtracting them from gross margins then yields a lower bound to trader net margins.

Lower bounds to trader net margins need to be calculated separately for harvest and post-harvest periods.[21] We present this calculation in Table 3. Using the distribution of quantities sold in the sample in different weeks as weights, we estimate average prices that traders resold potatoes in the harvest and post-harvest seasons. We subtract the average price that farmers received when they sold to village traders, to arrive at the traders' gross margins. However traders also incurred transactions costs, so to estimate the net margin we attempt to subtract these costs. Since we were unable to survey traders in 208, we treat the unit transport, handling and storage costs incurred by sample farmers who sold at *haats* as upper bounds to the unit costs that village traders actually incurred. This is on the plausible assumption that since they deal in much larger volumes than the average trader, village middlemen are able to exploit economies of scale and therefore if anything, their costs are lower.[22]

[21] This is because for potato transactions occurring in the harvest period, storage costs would not be incurred, while transport costs would be incurred: the trader would buy potatoes from the field, 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. (Most cold storage facilities are located near *mandis*.) They would incur storage costs, but no transport costs because these would have been incurred by farmers who had earlier placed them in the store.

[22] Cold stores charge a flat rate regardless of how long the potatoes are stored. Also, since farmers

This generates lower bounds on mean net trader margins in 2008, of Rs. 1.85 per kg at harvest time, and Rs. 1.36 per kg after harvest time. Middlemen therefore earned at least 28 to 38 percent of the *mandi* 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.[23]

3 The Experiment and the Data

Our experiment was conducted in 72 villages chosen through a stratified random sampling procedure in the potato growing areas (blocks) of Hugli and West Medinipur districts. To reduce information spillovers, we ensured that sample villages were at a minimum distance of 10 kilometres from each other.[24] Sample villages in each block were randomly assigned to three groups, resulting in 24 villages in each treatment group.[25] In two groups we conducted two different information treatments, while the third served as the control where no information was provided. In the two treatment groups, we delivered daily information about the prices in one or two nearby *mandis* and the nearest city market. This was the average daily price at which traders re-sold (physical) potatoes to buyers located in markets further away, collected by our field team from market "insiders", as described 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. Every morning for 11 months, the "tele-callers" based in our Kolkata information center relayed the *mandi*

transport potatoes to *haats* that are on average 5 kilometres away from the village, whereas traders transport them to *mandis* on average 8 kilometres away, we make a proportional adjustment and revise traders' unit cost of transport downward accordingly.

[23]These numbers are similar to those found in 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 of the retail price.

[24]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 10 kilometres out of the village. We therefore chose this distance to ensure that information would not spread from information villages to control villages.

[25]Each village was then mapped to the *mandi(s)* that were closest to it, which is where potatoes grown in that village tended to be re-sold by traders. Since most villages in a block have the same one or two *mandis* under their purview, this effectively ensures that under a given *mandi* there are villages randomly assigned to different information treatments.

prices from the previous evening to each of these farmers via mobile phones that were given to them for the purpose of the project. To ensure that the phones were used only for information provision and did not improve the farmers' connectivity more generally, we asked the service provider to block outgoing calls from 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. This prevented the farmer from receiving any incoming calls except from us.[26]

In the 24 public information villages, we delivered the *mandi* price information to a local shopkeeper or phone-booth owner (called the "vendor") in the village. For a nominal fee, he wrote the price information on charts and posted them in three public places in each village.[27]

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

The magnitude of our sample is extremely small relative to the catchment area of a *mandi*, so that it is unlikely that our experiment changed the prevailing *mandi* prices. 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.[28]

[26] Since we had access to the log of calls for each phone, we were able to check that our restrictions were effective.

[27] If farmers asked the tele-callers or vendors why they were being given this information, they were instructed to say this was part of a research study, but that they did not know why this was being done or how farmers could use this information.

[28] 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.

3.1 Data

Our datasets come from surveys conducted with a stratified random sample of 24 potato-growing households in each of the 72 villages in our study.[29] The analysis in this paper is restricted to the 1545 sample farmers who planted either of the two main varieties (*jyoti* and *chandramukhi*) of potatoes in 2008.[30]

A production survey was conducted in February to collect data about the planting and cultivation of potatoes, including area planted, inputs used, output harvested, and allocation of harvest across different uses. The questionnaire also included questions about household demographics, assets, land ownership and credit. Next, 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.[31]

Clearly at the weekly level, farmers solve a dynamic optimization problem to choose when and how much to sell. To analyze the weekly decisions of potato sales we would have to build a dynamic model taking into account the effect of the interventions on farmers' price expectations. Instead, we take advantage of the fact that all potatoes must be sold within a year of being harvested, and simplify the analysis by aggregating the data to the annual level. In Section 7 we examine storage and the inter-temporal allocation of sales.

[29] In 2006 we conducted a census in all sample villages to record which households had planted potatoes that year. We then stratified all potato-growing households by landholding category and drew a random sample from each stratum.

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

[31] When payment was deferred, we followed up with the farmer in subsequent rounds to record the date and the amount of each installment received.

3.2 Descriptive Statistics

Table 4 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 average 8.5 kilometres away from the *mandis* whose price information we provided. About half the villages had a public telephone booth.

As Panel B shows, the average landholding size of sample households was 1.1 acres. Since we drew the sample from a list of households that had been identified as potato-farming households through a house-listing in 2006, it is unsurprising that in 2007 nearly all farmers in the survey reported planting potatoes (Panel C). Among these farmers, nearly 94% had planted the *jyoti* variety 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 these through the year, at an average price of Rupees 2.9. Nearly all of this was sold to traders in the village, and less than 1 percent was sold to traders located outside the village.

For most village characteristics, the pre-intervention differences across treatment groups were small and insignificant. However, although villages were randomly assigned to different treatment groups and the control group, we see that control villages had a much higher probability of having a public telephone box. *Mandi* fixed effects in our regressions will control for such differences at the *mandi* level.[32]

We also test whether all household-level variables in Panels B, C, D and E are significantly different from each other. As the p-values at the bottom of Table 4, show all three tests are rejected at conventional levels of significance.

[32] Sample villages are mapped to the wholesale market whose catchment area they lie in, and in the information interventions, farmers/village vendors received the price information from that market. We define a *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*.

3.3 Effect of Information Treatments on Farmers' Price Information

In the fortnightly trade surveys, we asked farmers about the frequency with which they tracked prices in wholesale and retail potato markets and whom they gathered this information from.[33]

To analyse whether the interventions changed farmers' price tracking behavior, we use the specification

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

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 (Table 7, Panel A, Column 1), the number of days since he last tracked prices (Column 2), and who his source of information is (Column 3). Accordingly, we use a logit specification in Column 1, and a Poisson regression in Column 2. When we asked farmers to report their information source, we attempted to avoid "demand effects" and so 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. If farmers chose the category "other" over all the previous categories, we interpret their report as indicating the price information intervention. We then re-code the variable to an indicator of whether the information was received through the intervention, and then run a logit regression. 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, the four randomly chosen households who received information directly via mobile phone also received a value of 1 for the Phone recipient dummy. Hence the coefficient on

[33] To guard against "demand effects" from asking survey questions that made our intervention salient, these questions were asked only to a randomly selected one-half of the sample. As a result we have these data at the fortnightly level for 853 farmers. As we show in Table A3 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.

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. Control variables include a dummy for the potato variety (*jyoti* or *chandramukhi*), district, and the survey month. For convenience we report exponentiated coefficients in all three columns.

The results in columns 1 and 2 indicate that the intervention did work as planned: farmers who received the interventions were more likely to track market prices and, conditional on tracking prices, to have done so more recently. Column 3 shows that farmers in the information intervention groups were more likely to have received price information from a source in the "other" category. This category includes the tele-callers who provided information to farmers, and the public notice boards. The 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.

Panel B in Table 7 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. The average sum of squares of the normalized error in reported price 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.[34]

In what follows we develop a model where uninformed farmers bargain with informed middlemen in the village, with the outside option of selling to a trader at the local *haat*. We then discuss the predictions of the model and provide empirical evidence that supports them.

[34]The reader may wonder why, if the interventions did not cause farmers to report the actual *mandi* prices, they still 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*, and that this is how they interpreted questions about the "market price".

4 Theory: Bargaining with Asymmetric Information

We start by considering a context where a farmer F with an exogenous stock of potatoes Q meets a village trader VT who makes him a price offer v. VT can resell the potatoes at the wholesale market at price w. The farmer does not know the realization of w, and has beliefs over the realization of w represented by a prior distribution G on support $[\underline{w}, \bar{w}]$ where $\infty > \bar{w} > \underline{w} \geq 0$.[35]

Let the amount the farmer sells at price p be denoted by $q \in [0, Q]$. The remainder $Q - q$ is consumed. The farmer's utility is increasing in sales revenue and consumption, represented as $W(pq + \beta U(Q - q))$ where W is a strictly increasing, smooth concave function satsifying $W^{''} \leq 0$, and U is a strictly increasing, smooth and strictly concave function satisfying $U^{'}(0) = \infty$. $\beta \geq 0$ is a parameter representing the importance of self-consumption in the farmer's utility. If the transaction takes place with VT, the latter's payoff is $(w - p)q$. We assume $\underline{w} > \beta U'(Q)$, so there are always gains from trade.

The game is structured in a way that the farmer first receives a price offer and then decides how much to sell, trading off increased sales revenue against higher self-consumption. Let $q(p)$ denote the farmer's supply function, which maximizes $pq + \beta U(Q - q)$. Let $\Pi(p) \equiv pq(p) + \beta U(Q - q(p))$. Clearly $q(p)$ is strictly positive at any price p satisfying $p > \beta U'(Q)$, strictly increasing and approaches Q as p becomes arbitrarily large. We assume the supply function is weakly concave: $q'' \leq 0$, which includes the case of constant elasticity consumption utility ($U(c) = \frac{c^{1-\sigma}}{1-\sigma}$ with $\sigma > 0$ and different from 1, and $\sigma = 1$ corresponds to log utility).[36]

In this formulation, higher price offers will generate a supply response from the farmer on both extensive and intensive margins. The former refers to the likelihood that the farmer agrees to sell a positive quantity; the latter to the quantity sold, conditional on selling something. When the value β of self-consumption is small, the intensive margin

[35] We consider a finite support to avoid some technical complications.

[36] In the constant elasticity case, the supply function is $q(p) = Q - p^{-\frac{1}{\sigma}}$ if this is positive, and zero otherwise.

becomes relatively less important. as the farmer tends to sell a larger fraction of his output at any given price. In the limiting case where $\beta = 0$, the farmer either sells the entire output Q or nothing at all — the intensive margin vanishes. This corresponds to the case of bargaining over an indivisible good, conventionally considered in the bargaining literature. We incorporate the added complication involved in incorporating both margins in the analysis owing to the need for the model to correspond to the empirical patterns where farmers typically sell part of the output, and in order to utilize observed variation in both margins in response to information treatments in the empirical analysis. As we have seen in the previous section, farmers typically sell a fraction of their output which is close to 1. So many of our theoretical results will correspond to this case, i.e., where β is close to 0.

In the same spirit, we will assume that the composition of W and the profit function, i.e., $W(\Pi(p))$ is concave. That is, farmers do not prefer increasing riskiness of the farmgate price. This requires that W be concave enough to 'counteract' the convexity of $\Pi(p)$. In the case where β equals zero, this requires W to be weakly concave, including the case where the farmer is risk-neutral. Hence our main results depend on the assumption of a minimal level of risk-aversion, with the required "degree of mildness" vanishing as β approaches zero.[37]

In the absence of any competition from other traders, VT will behave monopsonistically. We assume that if there is more than one village trader, they collude perfectly in setting the price offer. They will select the monopsony price $m(w)$, the value of m that maximizes $(w - m)q(m)$. The concavity of q ensures this is a concave maximization problem; hence the monopsony price $m(w)$ satisfies $w = m + \frac{q(m)}{q'(m)}$. As $q(p)$ is concave, the right-hand-side of this equation is strictly increasing; hence $m(.)$ is strictly increasing. Note that as β approaches zero, the monopsony price $m(w)$ approaches zero for every w.

Village traders, however, face price competition from traders located outside the

[37]If $W(y) = \frac{y^{1-\mu}}{1-\mu}$ and $U(c) = \frac{c^{1-\sigma}}{1-\sigma}$ with $\mu, \sigma \geq 0, \neq 1$, we need $\mu > \frac{1}{\sigma}\left(\frac{\beta}{\underline{p}}\right)^{\frac{1}{\sigma}}[Q+\frac{\sigma}{1-\sigma}\left(\frac{\beta}{\underline{p}}\right)^{\frac{1}{\sigma}}][Q-\left(\frac{\beta}{\underline{p}}\right)^{\frac{1}{\sigma}}]^{-2}$, where $\underline{p}$ denotes a lower bound to the price that could be offered by VT. We shall see that such a natural lower bound does exist in the model: the farmer's reservation price in state $\underline{w}$.

village. Owing to greater distance, communication costs, relative lack of social capital or monitoring capabilities, village traders and market traders cannot collude with one another. However, village traders will enjoy the benefit of proximity to farmers located in their own village. This is represented by a first-mover advantage: at the beginning of the game they are costlessly matched with the village farmer and get the opportunity to make a price offer to the latter. Upon receiving this offer, the village farmer will decide whether to accept or reject (besides quantity to be supplied in the event of acceptance). If the farmer rejects, he has the opportunity to visit the market at a search cost of $s > 0$. For simplicity we assume that Q and s are observed by the village trader prior to making an offer.[38]

The market area has a number of traders who behave oligopolistically, and each of whom can also resell the good in the wholesale market at price w. The price that the farmer will get at the market is $h(w)$, strictly increasing in w and satisfying $m(w) \leq h(w) < w$ for all w. The gap between w and $h(w)$ reflects the extent to which competition among market traders is imperfect.[39]

Therefore F who is informed about the realization of w will accept a price offer v from VT at the first stage if and only if $v \geq M(w)$ where for any $w \in [\underline{w}, \bar{w}]$:

$$\Pi(M(w)) = \Pi(h(w)) - s \tag{2}$$

$M(w)$ is the farmer's outside option or reservation price in negotiating with VT when he knows the wholesale price is w. Clearly this function is strictly increasing and smaller than w. We assume that $\Pi(h(\underline{w})) > s$, ensuring that this reservation price is always

[38] Heterogeneity in harvest output and search cost across farmers in the village will account for within-village heterogeneity in the offer price.

[39] A specific example is where there are k market traders arranged equidistant from one another in a concentric circle of unit length, on which farmers are located uniformly, as in Salop (1979). With linear transport cost t per unit distance traversed by farmers, the result of simultaneous price competition between the market traders will yield a price of $h(w)$ which solves for h in the equation $w - h = [\frac{q'(h)}{q(h)} + \frac{k}{t}]^{-1}$.[40] Here $\frac{k}{t}$ is a parameter representing the competitiveness of the market outside the village in which farmers can sell. An alternative scenario which delivers the same conclusion is that there is a single trader in the market area, who is able to sell in the wholesale market at a price higher than w, and $h(w)$ is the monopsony price of this market trader.

well-defined and positive-valued.

The farmer of course does not know the realization of w *a priori*, but may be able to infer something from the price offer made by VT. We now turn to study the game between VT and the farmer at the first stage.

Our first key assumption is that the market traders exert enough competitive pressure on the village trader in the sense that F's reservation price $M(w)$ always exceeds the latter's monopsony price $m(w)$: for all $w \in [\underline{w}, \bar{w}]$

$$M(w) > m(w) \tag{3}$$

In particular, we assume that as β approaches zero, the reservation price for each farmer approaches some strictly positive and increasing function $M^*(w)$. In other words, there is some non-trivial competition between market traders in the case where the farmer's supply responses exhibit no variation on the intensive margin: the farmer has a positive reservation price in bargaining with VT, which exceeds the latters monopsony price (which equals zero when $\beta = 0$).

In what follows we use Weak Perfect Bayesian Equilibrium (WPBE) as the equilibrium concept. Formally, it is a price-offer and acceptance strategy $p(w), a(p)$ for VT and F respectively, with supporting posterior beliefs $G(.|p)$ of F obeying Bayes rule on the equilibrium path, where:

1. $p(w)$ maximizes $a(p)[w - p]q(p)$
2. $a(p)$ maximizes $aV(p) + (1 - a)E_{G(.|p)}[V(M(w))]$ over $[0, 1]$

The outcome of any WPBE is a pattern of state-dependent trades, where in state w: with probability $\alpha(w) \equiv a(p(w))$, F sells $q(p(w))$ to VT, and $q(h(w))$ to a market trader (upon incurring search cost s) otherwise. A necessary condition is that VT is behaving optimally on the equilibrium path, given F's acceptance strategy, i.e., no type w of VT benefits from mimicking the offer of any other type w':

$$w' = w \quad \text{maximizes} \quad \alpha(w')[w - p(w')]q(p(w')) \tag{4}$$

This condition implies the following Lemma, which is useful in classifying the set of all possible equilibria into different categories.[41]

Lemma 1 *In any WPBE, the price offer function $p(.)$ is non-decreasing. If $p(.)$ is locally constant over some subinterval, the same is true for the acceptance probability $\alpha(.)$.*

4.1 Fully Revealing Equilibrium

An equilibrium is said to be *fully revealing* if the associated price offer function $p(.)$ is strictly increasing. In this equilibrium farmer can infer the exact realization of w from the observed price offer. Panel (a) in Figure 3 illustrates this equilibrium.

Proposition 2 *When (3) holds, there exists a fully revealing or separating equilibrium, where VT offers $v(w) = M(w)$ in state w, and the offer is accepted by F with probability $\alpha(w) \in (0, 1)$ which satisfies the differential equation*

$$\frac{\alpha'(w)}{\alpha(w)} = \frac{M'(w)}{w - M(w)}[1 - \frac{(w - M(w))q'(M(w))}{q(M(w))}] \tag{5}$$

The reasoning is straightforward. The equilibrium is supported by off-equilibrium path beliefs wherein any price offer below $v(\underline{w})$ leads F to be believe $w = \underline{w}$ with probability one, and any price offer above $v(\bar{w})$ leads F to be believe $w = \underline{w}$ with probability one. These beliefs imply any price offer below $M(\underline{w})$ will be definitely rejected, and any price offer above $M(\bar{w})$ will be definitely accepted. Any price offer v between $M(\underline{w})$ and $(M(\bar{w})$ will lead F to believe that $w = M^{-1}(v)$, whence the latter will be indifferent

[41] Here is the proof of this Lemma. First note that (4) implies that the expected sale $\bar{q}(w) \equiv \alpha(w)q(p(w))$ is non-decreasing, via a standard revealed preference argument. Next suppose that $p(.)$ is decreasing somewhere: $p(w') < p(w), w' > w$. Then type w would benefit from deviating from $p(w)$ to $p(w')$, as $w - p(w') > w - p(w)$ and $\bar{q}(w') \geq \bar{q}(w')$. Hence $p(.)$ must be non-decreasing. Now suppose $p(w') = p(w)$ for any $w' > w$. Then $\alpha(w') \equiv a(p(w')) = a(p(w)) \equiv \alpha(w)$.

between accepting and rejecting it. So it is optimal for F to randomize his acceptance decision. Finally when the randomization satisfies condition (5), it is optimal for VT in state w to offer price $M(w)$ rather than any other price in the interval $[M(\underline{w}), M(\bar{w})]$.[42]

The assumptions made above ensure that $\alpha(.)$ is strictly increasing. Hence offers will be rejected on the equilibrium path with positive probability. The equilibrium must satisfy the endpoint condition $\alpha(\bar{w}) \leq 1$. The village trader will be better off in every state w, the greater the likelihood that the offers are accepted, while the farmer is indifferent. Hence it makes sense to select the equilibrium corresponding to $\alpha(\bar{w}) = 1$.

The randomization of acceptances in the fully revealing equilibrium according to (5) curbs VT's temptation to lower the offered price in state w from the farmer's true reservation wage $M(w)$ in this state, down to the monopsony price $m(w)$. The existence of this temptation arises from condition (3) and the concavity of VT's payoff in the price. It is deterred since lowering the price offered will result in trade with a lower probability, which offsets the higher profit that VT would earn conditional on the offer being accepted. The possibility that trade will not occur is a 'deadweight loss' arising from VT's incentive compatibility constraint — VT is worse off when the price offer is not accepted, while F is indifferent.

The separating equilibrium has the feature that F endogenously 'learns' the true realization of the wholesale price. If this equilibrium were being played, farmers would be able to predict the wholesale price accurately. Exogenous provision of information would have no effect on the ability of farmers to predict the wholesale price w, or the price $h(w)$ they would get upon selling to a market trader. Nor would it affect the equilibrium price offer and trades. In equilibrium VT's price offers would be rejected by the farmer, who would end up selling in the market with a non-negligible probability. These are all testable implications of the fully revealing equilibrium hypothesis.

[42]Selecting a price $M(\hat{w})$ would lead VT to earn an expected profit of $\alpha(\hat{w})[w - M(\hat{w})]q(M(\hat{w})$. (5) is the first-order condition corresponding to the condition that $\hat{w} = w$ is locally optimal. Standard arguments ensure that it is also globally optimal under the assumptions imposed above.

The rationale for the "competitive pressure" assumption can now be explained. If inequality (3) is reversed for all w, there exists a fully revealing equilibrium where VT always offers the monopsony price $m(w)$.[43] As the monopsony price function is strictly increasing, this equilibrium fully reveals the realization of the wholesale price to F. The reverse of condition (3) ensures that F will accept this offer for sure as it exceeds the farmer's reservation price. Since in every state w the vilage trader attains his monopsony profit, this equilibrium will dominate any other equilibrium from the village trader's point of view (either *ex post* or *ex ante*).

4.2 Fully Non-Revealing Equilibrium (FNRE)

At the other extreme, an equilibrium which reveals no information at all to the farmer involves VT offering the same price $\bar{p}$ irrespective of the realization of w, and this price offer is accepted with some (positive) probability $\bar{\alpha}$. When such an FNRE exists, and $\bar{\alpha} \in (0, 1)$, F must be indifferent between accepting and rejecting. Any such equilibrium would be Pareto dominated by a corresponding one involving the same pooled price $\bar{p}$, which F instead accepts with probability one. For this reason we focus on FNRE of this second kind.[44] The equilibrium is illustrated in Panel (b) of Figure 3.

Proposition 3 *The following conditions are sufficient and (almost) necessary for existence of a fully non-revealing equilibrium, where VT offers the same price $\bar{p}$ irrespective of the realization of w, and this price offer is accepted by F with probability one:*

(FP1) $\underline{v} \geq \bar{p}$, *where* $\bar{p}$ *satisfies* $W(\Pi(\bar{p})) = E_w[W(\Pi(M(w)))]$.

(FP2) If the state is $\bar{v}$, VT does not want to deviate from offering $\bar{p}$ to offering $M(\bar{w})$, when the latter offer is also accepted with probability one.

[43] These are supported by off-equilibrium-path beliefs where any price offer below $m(\underline{w})$ leads F to be believe $w = \underline{w}$ with probability one, and any price offer above $m(\bar{w})$ leads F to be believe $w = \underline{w}$ with probability one.

[44] There may also exist FNRE involving a pooled prices higher than $\bar{p}$ where F is strictly better off accepting than rejecting, and where the price offer is accepted with probability one. Such an FNRE cannot be Pareto compared with the one we focus on below, as F is better off while VT is worse-off. We ignore such FNRE in what follows, on the basis of the assumption that the equilibrium is selected to maximize VT's payoff.

To show sufficiency, we assign the following off-equilibrium-path beliefs: F does not update his beliefs following any price offer $p \leq \bar{p}$, while he believes $w = \bar{w}$ if the price offer is higher than $\bar{p}$. (FP1) then implies that every type of VT is better off trading with F at price $\bar{p}$ compared to not trading with him, while F is indifferent between accepting and rejecting this offer given his prior beliefs. Offering any price below $\bar{p}$ will definitely be rejected by F, as it does not cause F to alter his beliefs concerning what he will get at the market, and F would expect to do better by rejecting the offer and going to the market. Offering any higher price than $\bar{p}$ causes F to believe that $w = \bar{w}$, so VT would have to offer at least $M(\bar{w})$ to induce F to accept. Condition (FP2) ensures type $\bar{v}$ does not benefit from such a deviation. This also implies that no other type of VT benefits from deviating, as their benefits would be smaller than it would be for type $\bar{v}$.

These conditions are also necessary, provided we refine the equilibrium concept to require that F never plays a dominated strategy off the equilibrium path. If VT were to offer him a price above $M(\bar{w})$, accepting this offer strongly dominates the option of refusing it, since F would be strictly better off accepting the offer than rejecting it and going to the market, no matter what the realization of w is. With such a restriction, any price offer above $M(\bar{w})$ would be accepted for sure. Then condition (FP2) is necessary; the necessity of (FP1) is obvious.

In this equilibrium, the price $\bar{p}$ lies between $M(\underline{w})$ and $M(\bar{w})$: it is the reservation price for F when he is uncertain regarding the realization of w, and this uncertainty is represented by his prior beliefs. Hence it lies above the price $M(.)$ in the fully separating equilibrium in low w states, and lies below it in high w states. *Ex post* the farmer is better off in the pooling equilibrium when the wholesale price is low, and worse off when it is high. The farmer's *ex ante* welfare is, however, exactly the same in the two equilibria.

When we compare VT's payoffs in the fully revealing with the fully non-revealing equilibria we must consider a number of conflicting effects. In the FRE trade does not occur some of the time, but in the FNRE trader always take place. Conditional on the occurrence of trade, VT pays a lower price in the FNRE when w is high, and a higher price when w is low. Below we shall discuss which equilibrium generates higher profits for the village middleman *ex ante*.

Note also that the fully non-revealing equilibria will not exist whenever (FP1) or (FP2) fail to hold, whereas the fully revealing equilibrium always exists. An example of this is when $\underline{w}$ is 0 or sufficiently close to 0: the fixed price in a pooling equilibrium has to be positive, so has to be larger than $\underline{w}$; this cannot happen when $\underline{w} = 0$. When the wholesale price is sufficiently low, VT will be unwilling to pay F higher than the wholesale price. Alternately, if the upper bound $\bar{v}$ of the support of the wholesale price is sufficiently large while the pooling price is bounded, condition (FP2) will be violated: the fixed price will be too much below $M(\bar{w})$, and VT will offer a higher price than $\bar{p}$. So if the support of the wholesale price distribution is large enough, a fully non-revealing equilibrium will fail to exist.

However, when this happens, partially revealing equilibria generally exist. We describe these next.

4.3 Step-Function Partially Revealing Equilibrium

A step-function partially revealing equilibrium (SPRE) involves a price offer which is a step function. Panel (c) of Figure 3 illustrates this equilibrium. The support of w is partitioned into a set of consecutive intervals $I_i \equiv [w_i, w_{i+1}], i = 1, \ldots, n$ with $w_1 = \underline{w}, w_{n+1} = \bar{w}$ with VT offering a constant price $\bar{p}_i$ when w is in $[w_i, w_{i+1})$, with $\bar{p}_i > \bar{p}_{i-1}$. On the equilibrium path, F accepts offer $\bar{p}_i$ with probability α_i. The fixed price $\bar{p}_i$ satisfies $W(\Pi(\bar{p}_i)) = E_{w|w \in I_i}[W(\Pi(M(w)))]$, whence F is indifferent between accepting and rejecting it after learning that $w \in [w_i, w_{i+1}]$.

F updates his beliefs restricting the support to I_i when receiving an offer in the interval $(\bar{p}_{i-1}, \bar{p}_i]$. Offers below $\bar{p}_1$ induce the same beliefs as $\bar{p}_1$, while any offer above $\bar{p}_n$ induces F to believe that $w = \bar{w}$. F rejects any offer in the interval $(\bar{p}_{i-1}, \bar{p}_i)$.

Proposition 4 *The following conditions are sufficient and (almost) necessary for a par-*

tially revealing equilibrium (of the kind described above) to exist. For each i:

(PP1) $w_i \geq \bar{p}_i$.

(PP2) If the state is w_{i+1}, VT *is indifferent between offering* $\bar{p}_i$ *and* $\bar{p}_{i-1}$.

(PP3) If the state is $\bar{w}$, VT *does not want to deviate from offering* $\bar{p}_n$ *to offering* $M(\bar{w})$, *when the latter offer is accepted with probability one.*

Conditions (PP1) and (PP3) ensure that the two terminal types $\underline{w}, \bar{w}$ of VT are behaving optimally, given the acceptance strategy of F. Condition (PP2) ensures that the 'corner' type at the intersection of two adjacent pooled intervals is behaving optimally. The single-crossing property then ensures that all other types are also behaving optimally. Conditions (PP1) and (PP2) are necessary for the two terminal types to pool at the end-point prices assigned to them, given the restriction on off-equilibrium-path play to undominated strategies. And the necessity of indifference condition (PP2) follows from the optimality of assigned strategies to intermediate types, which switches from $\bar{p}_i$ to $\bar{p}_{i+1}$ when w transits from slightly below w_i to slightly above.

A partially revealing equilibrium can be viewed as intermediate between a fully non-revealing and fully revealing equilibrium. The price offered by VT varies in a coarse way with the wholesale price: rising when the latter crosses over from one interval to the next, but not within any interval. As in a separating equilibrium, all but the highest price offer have to be rejected with some probability, and acceptance probabilities must rise with the price offer. VT with a wholesale price w near the bottom w_i of interval I_i will be tempted to drop the price offer from $\bar{p}_i$ to $\bar{p}_{i-1}$, since $\bar{p}_i$ must exceed $M(w_i)$, which in turn exceeds $m(w_i)$. The penalty for dropping the price is a higher probability of the lower price being accepted. Within any given interval I_i, a constant price offer is made, and trade takes place with some probability. The ratio of probabilities of F accepting $\bar{p}_i$ and $\bar{p}_{i-1}$ is selected to ensure that condition (PP2) holds. This is analogous to (5) in a fully revealing equilibrium.

There can also be equilibria which are partially revealing in other ways — price offer functions that are mixtures of step-functions and strictly increasing segments. Clearly there is a plethora of possible equilibria varying in the extent of information that is revealed to F.

Since F is always indifferent between accepting and rejecting the price offers made, it is evident that F's *ex ante* welfare is the same between the separating, fully non-revealing and partially revealing equilibria. How VT's ex ante welfare compares across these equilibria is not obvious. We turn to this issue next.

4.4 Comparing Profitability of Alternative Equilibria

We start by comparing the *ex ante* profits earned by VT between the selected FRE and FNRE.

Proposition 5 *If β is sufficiently small, the FNRE defined above generates higher ex ante profit to VT, compared with any FRE.*

The proof of this (and of subsequent Propositions) is provided in the Appendix. The key force driving the result is the loss of profits entailed by the likelihood of trade not occurring at all in the FRE, which is necessary to induce incentive compatibility for VT. The FNRE by contrast always results in trade. Besides this, the FRE results in an sale price that varies with the state, resulting in risk that neither VT nor F likes — VT is better off *ex ante* since his profit function is concave in the price. As F does not benefit from *ex ante* risk, and F attains the same expected utility in both equilibria, the constant price in the FNRE is lower than the average price in the FRE. This lowering of the average price also benefits VT, since the farmer's reservation price is higher than the monopsony price. There is only one countervailing benefit of the FRE relative to the FNRE: it results in the quantity purchased co-moving with the wholesale price, with higher (resp. lower) quantities purchased when the wholesale price is high (resp. low). This benefit is small when the farmer places a low value on personal consumption, as the intensive margin then shrinks. At the same time the "deadweight loss" associated with failure to trade in most states remains bounded away from zero, so the FNRE results in a higher expected profit for VT when β is small enough.

The same logic can be extended to show that any equilibrium where the price offer function is strictly revealing over any given interval (w_1, w_2) of wholesale prices, is *ex ante* dominated by another equilibrium where it is constant over this interval.

Proposition 6 *Consider any WPBE allocation involving price offers which are strictly increasing over some interval* $W \equiv (w_1, w_2)$. *If* β *is sufficiently small, there exists another WPBE allocation with a price offer (and acceptance probability) which is constant over this interval, which generates higher ex ante profit for* VT.

The proof is somewhat more involved than that of the previous Proposition, but the underlying idea is similar. If price offers are locally strictly increasing over an interval, the realization of the wholesale price is revealed to the farmer when they happen to be located in this interval. The local incentive compatibility constraints for VT then necessitate a probability of trade that is strictly increasing over this interval, in order to dissuade VT from shading the price offer slightly. Hence trades must breakdown with some probability over this interval. Moreoever, F must be indifferent between accepting and rejecting price offers in this interval, implying that the price function must coincide with the reservation price function $M(.)$ over this interval. Such breakdowns can be avoided in an alternative WPBE which pools price offers over the interval. Besides, stabilizing the price benefits both parties. The only potential loss entailed in pooling is the lack of flexible adjustment of trade volumes with the wholesale price. As β approaches zero, this loss vanishes.[45]

For low β, therefore, equilibria in which price offers reveal the wholesale price to F either globally or locally happen to generate lower profits compared with equilibria where price offers are pooled over the corresponding domains. This leaves step-function

[45] Note, however, that the requires threshold for β will depend on the specific interval in question. For intervals of a certain minimum probability mass, one can find a uniform upper bound for β.

partially revealing equilibria as the main alternative to a fully non-revealing equilbrium. Our final result below considers the limiting case where $\beta = 0$, and shows that the FNRE is the most profitable equilibrium.

Proposition 7 *Suppose $\beta = 0$, and an FNRE exists. Then the FNRE with a constant price offer $\bar{p}$ which is accepted with probability one, generates the highest ex ante profit amongst all WPBE allocations.*

The proof again extends the same idea to comparing step-function equilibria (SPRE) with the FNRE described above. The variation in price offers over two adjacent intervals necessitates corresponding variations in acceptance probabilities to ensure incentive compatibility. The lower price must be accepted with a strictly lower probability. This trade breakdown can be avoided in a corresponding WPBE which involves a constant price offer over the union of the two intervals. The reduction in price variability is mutually beneficial, and $\beta = 0$ implies that only the extensive margin matters concerning trade volumes. Hence extending the range of price pooling allows VT to earn higher profits. The proof is completed by noting that when $\beta = 0$, Proposition 6 ensures that any WPBE where prices are strictly increasing over any interval cannot maximize the trader's *ex ante* profit.

4.5 Effects of Information Provision

The effects of external provision of price information depends on the prevailing equilibrium. There will be no effect at all if the equilibrium is fully separating. Non-revealing equilibria will be affected. Given the results in the previous section, we assume that the fully non-revealing equilibrium exists and is selected by traders, prior to the intervention.

It is easiest to consider the case where the information provided by the intervention is represented by a partition of the set of possible wholesale prices, i.e., farmers receive a price signal $\sigma(w)$ which takes the form of a step function, taking the value σ_j when $w \in I_j \equiv [w_j, w_{j+1}]$, with $j = 1, \ldots, m$, $\sigma_{j+1} > \sigma_j$ and $w_1 = \underline{w}, w_m = \bar{w}$. The signal alters

F's beliefs: signal realization σ_j informs F that $w \in I_j$. A fully non-revealing equilibrium conditional on this new set of beliefs now involves a different pooled price $\bar{p}_j$ satisfying $W(\Pi(\bar{p}_j)) = E_{w|w \in I_j}][W(\Pi(M(w)))]$. If j is low (resp. high), F learns that the wholesale price is low (resp. high), so that the pooled price is lower (resp. higher) than if F did not receive the signal. The price that F receives now co-moves more with the wholesale price. We therefore expect to see a significant drop in price and traded quantity when the wholesale price is low, and a significant rise in price and traded quantity when the wholesale price is high. This is illustrated in Figure 4. The effects on the average price and quantity may thus be negligible.[46]

The results are also qualitatively similar when the equilibrium prior to the intervention is partially revealing. In such an equilibrium the farmer learns something from the price offer of VT, namely that w belongs to some interval I_i. As long as the external price signal generates a different information partition than the partition that the price offer created, it provides the farmer with new information, and thus affects the equilibrium allocation. The price offers in the new equilibrium then co-move more with the wholesale price.

Similar predictions obtain even when the price signal does not alter the support of the farmer's beliefs, if it satisfies a monotone likelihood property such that low values of w are correlated with low values of the signal. Given a signal σ which induces the farmer's beliefs over w to be updated to $G(.|\sigma)$, the intervention results in a pooled price $\bar{p}(\sigma)$ satisfying $W(\Pi(\bar{p}(\sigma))) = E_{\{G(w|\sigma)\}}[W(\Pi(M(w)))]$. If σ and w are positively correlated, high (resp. low) realizations of w and σ tend to occur together with high probability, causing $\bar{p}$ to co-move with w. Compared to before the intervention, the farmgate price and sales now co-move with the wholesale price, and are lower (resp. higher) when the wholesale price is lower (resp. higher) than average.

However the model predicts that information provision leaves the farmer's *ex ante* wel-

[46]However, because $W(\Pi(.))$ is concave, the effects are not necessarily zero. If $W(\Pi(.))$ were strictly concave, the effect on the average price is positive.

fare unaffected. Conditional on signal σ_j, the farmer's welfare is $E_{w|w \in I_j}][W(\Pi(M(w)))]$, so the unconditional *ex ante* welfare is $E[W(\Pi(M(w)))]$. This is a general property of all equilibria, both before and after the provision of information. The preceding arguments indicate that the effect on village trader's welfare is negative if β is sufficiently small. Hence information provision results in an ex ante Pareto inferior outcome.

5 Experimental Results

We now turn to empirical tests of the theoretical predictions above.

5.1 Average Treatment Effects

We start by estimating the effect of the interventions on the farmers' sales and revenues. For each farmer we know each variety produced and sold, and the self-reported quality of potatoes in each transation. Our data thus measure how many kilograms of potatoes a given farmer sold in 2008, of a particular variety (*jyoti* or *chandramukhi*) and a particular quality (high or low), the gross revenue he received for these potatoes, and the net (of transport, handling and storage costs) revenue and price per kilogram he received. All regressions include dummies for the potato variety and quality, so that we can assured that our results are not driven by farmers/traders responding to the intervention by adjusting either the variety or quality of potatoes that they sell/buy.

Table 8 shows the average effects of the information intervention on annual quantity sold and the annual average of farmgate price. This allow us to examine the predictions of the static bargaining model, which abstracted from the dynamics of pricing across different periods of the year, and storage decisions of farmers.[47]

The regression specification follows equation 1, where y_{ikqv} is the dependent variable: annual quantity of variety k and quality q sold by farmer i in village v, and net price received, which is the ratio of the annual revenue received to the quantity sold.[48] Private

[47]In Section 7 we show how the static model can be extended to incorporate these dynamic considerations, and subsequently investigate experimental impacts on storage.

[48]Note that we discount the revenue for delays between the time of sale and the date when payment

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, the four randomly chosen households who received information directly via mobile phone 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. Besides 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 village level to account for correlated error terms across different farmers in the same village. Standard errors are clustered at the village level.

The identifying assumption here is that access to information is exogenous to farmer or *mandi* characteristics that might drive sales and revenues. This assumption is delivered by the randomization of the information treatment. Recall also from Table 4 that there are no significant differences in observable characteristics of the villages in the three treatment groups.

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. In column (2) we include *mandi* fixed effects. This reverses the sign of the private information and the public information coefficients, and they all remain insignificant, consistent with the theoretical predictions of the bargaining model.[49] Columns (3) and (4) show that there is also no significant average impact of the intervention on farmgate prices. Figure 2 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. in line with our regression results, there is no discernible difference between the different farmgate price series.

is received.

[49]Since the estimated effects on quantity and farmgate prices with *mandi* fixed effects are negative for the private information treatment farmers who don't receive phonecalls, we think it unlikely that the true effects are positive but simply not detected due to a lack of statistical power.

5.2 Heterogeneous Treatment Effects

The second prediction of the *ex post* bargaining model in Section 4 also says that the intervention would have increased the volatility of the quantity farmers sold and the price they received per kilogram. In other words, informing farmers about the *mandi* price would have increased the quantity they sold and price they received if the *mandi* price was high, and lowered it if the *mandi* price was low. To examine this we use the 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. Once again, standard errors are clustered at the village level.

For these heterogeneous effects to be identified, it must be the case that the *mandi* price is uncorrelated with the error term in the regression. In particular, it is important that variation in *mandi* prices was not correlated with variation in unobserved characteristics that might also affect the pass-through of prices. Note first that our experiment affected a small fraction of villages supplying to each market, so wholesale prices were unlikely to be affected by our treatments.[50] As Table A2 shows, within district, *mandis* with above and below the median price were not significantly different in distance from the retail market, access to metalled roads, agricultural wage rates, or presence of industry/manufacturing. There is some evidence (only in Hugli district) that the average yield was slightly higher in villages under the above-median *mandi* price, and that residents

[50] Recall that the block-stratified assignment of villages to treatment category ensures that under a given *mandi* there are villages randomly assigned to different information treatments. Also, the randomization took place before 2008 *mandi* prices were realised, and it follows from Section 2.3 that previous years' prices could not have predicted 2008 prices.

were less likely to have landline phones. However, these differences will be controlled for in our regressions by the *mandi* fixed effects.[51] Below we also discuss a robustness check that circumvents this concern.

The results in Tables 9 and 10 correspond to quantity sold and price per kilogram, respectively. The different columns in this table use different specifications of the *mandi* price and different samples. Column 1 uses the *mandi* price for each farmer-variety combination in the sample, averaged over those weeks in which the farmer sold the variety. Thus it represents the average resale price the trader could have received for potatoes he purchased from this farmer, which is the relevant price with respect to which we must measure the fluctuations in farmer outcomes.

In Column 1, as expected we see a positive coefficient on the *mandi* price average, although it is not significant. The intercept effect on both the private and public information treatments are 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.[52]

The weights used in the farmer-specific *mandi* price average in Column 1 are 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 concern is addressed in Column 2 by instead using an average where the *mandi* prices in the different weeks of the year are weighted by the volume of potatoes sold in that week by sample farmers in control villages in that district. This average is exogenous to the farmer's decision to sell, but may be less relevant to the farmgate price. We continue to see a large and statistically significant negative intercept

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

[52] The results indicate that for a (phone non-recipient) farmer facing the 10th percentile of *mandi* price, the private information intervention caused sold quantity to go down by a statistically significant 1090 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, the private and public information caused farmers to sell an additional 1158 kg (or 30 percent) and 723 kg (or 19 percent) respectively, although these two positive effects are not statistically significant.

effect and positive slope effect of the private information interventions. The signs are similar for the public information treatment, although the slope coefficient is not precisely estimated.

As a robustness check, column 3 presents estimates that use a different price regressor. Note that in the bargaining model, the information intervention has an effect because it informs the farmer that the *mandi* price is either higher or lower than the expected price. To test this idea directly, instead of using the actual *mandi* price as the regressor we use the deviation of the 2008 *mandi* price from the predicted price, using weekly *mandi* prices from other years for which we have data (2007, 2011 and 2012) to generate the prediction. Under standard rational expectation assumptions, this *mandi* price "shock" ought to be orthogonal to farmers' *ex ante* price information and other relevant characteristics.[53] Note the intercept effect of the interventions now measure the effect of the treatment for farmers selling in states where the expected *mandi* price equalled the actual (rather than a hypothetical price of zero, as in the previous specifications). According to the model, in this case the intervention can have no effect on the equilibrium. The interpretation of the slope coefficient remains the same: it estimates the effect of the intervention when the actual price is above the expected price.

As expected, we see in column 3 that the intercept terms are non-significant. The effects of the information treatments on the slope coefficient are positive, and the one on the private intervention is statistically significant. The effect of the price deviation (see the first row) is negative and significant, which is consistent with the model. Since the actual price is positively correlated with the expected *mandi* price, a positive price deviation relative to a low expected price may still imply a lower actual price and therefore a smaller supply response than a negative price deviation relative to a high expected price.[54]

[53] Since the explanatory variable is itself derived from estimates from other regressions, we report cluster-bootstrap standard errors, where the *mandis* are defined as the clusters.

[54] For example, suppose the farmer's "low" expected *mandi* price is a price between 0 and 3. If the intervention informs him that the true price is 2.8, this is a positive price deviation. If instead he held a "high" expectation of the *mandi* price, i.e. he thought the price was above 3, and then the intervention informs him that the true price is 3.2, this is a negative price deviation. However he will supply a larger

Next, we instrument the *mandi* price with the interaction of the city price and the distance between the *mandi* and the city. This addresses the concern that *mandi* price changes may be endogenous to the intervention. If the city price is unaffected by the price in any given *mandi*, then the exclusion restriction is satisfied. As we know from Section 2.3, there is considerable pass-through from the city price to the *mandi* price, and so it is unsurprising that the instruments are not weak.[55] As we see in Column 4, our results for the private information treatment are quantitatively and qualitatively similar when we use the instrumented *mandi* price instead of the actual.

6 Testing Alternative Models

We now discuss whether the experimental results are consistent with alternative models of the farmer-trader trading mechanism.

6.0.1 Contracts with Full Commitment

An *ex ante* contract would specify, for each possible realization of the wholesale price w, as reported by the trader to the farmer, the quantity that the farmer sells and the price, or the total revenue, the middleman pays. This would allow the middleman and farmers to share price risk. The middleman margins could then represent risk premia on such insurance.[56] A risk-neutral middleman would insure risk-averse farmers perfectly, by paying them a constant price regardless of the wholesale price. Since the middleman bears all the residual risk, he has no incentive to understate the wholesale price; his private information does not create any distortions. While this would be consistent with the observed lack of pass-through of the wholesale price to the farmgate price, it also implies that the experiment would have no impact at all. This contrasts with our result that the information provision increased pass-through.

quantity of potatoes in the negative price deviation state than in the positive price deviation state.

[55] They pass the Kleinberg-Paap test for weak instruments with an F-statistic of 24.17.

[56] This is a similar set-up as implicit wage-employment contracts where workers do not know the price at which employers sell the firm's product (Hart 1983).

Asymmetric information generates distortions only if middlemen are also risk-averse, so that in the equilibrium contract, farmers also bear some of the risk associated with wholesale price fluctuations. This causes some of the fluctuations in the wholesale price to pass through to the farmgate price. This creates an incentive for the middleman to understate the wholesale price, so as to persuade the farmer to accept a lower price. To keep him honest, traded quantities would be distorted downwards when the wholesale price is low, and would be set at the efficient level when the price is at the maximum (the standard no-distortion-at-the-top result). Information interventions that reduce the asymmetry of information would reduce this screening distortion, and cause the quantity traded to increase when the wholesale price is low, while there would be no effect when the price is high. Thus risk-sharing contracts with asymmetric information would predict a positive average treatment effect on quantity transacted; the treatment effect would especially be positive in low-market-price states, and would vanish in high price states. This is clearly inconsistent with our experimental results, which show a significant negative impact on quantity traded in low-price states.

6.0.2 Contracts with Limited Commitment

Limited-commitment contracting models have been used to explain insurance and marketing contracts in a range of developing country contexts. In these models, the possibility of ex post moral hazard implies that some, but not all, of the price risk can be shared between the farmer and the middleman (Ligon, Thomas, and Worrall 2002; **?**, Blouin and Machiavello 2013, Machiavello and Morjaria 2015 and Saenger, Torero, and Qaim 2014. A middleman who commits to providing farmers with a minimum price incurs losses when the wholesale price falls below the farmgate price floor. If farmers were able to sell directly at the market at the wholesale price, then informing them that the realized wholesale price is high would increase the likelihood that they renege on the *ex ante* contract. The intervention then causes the farmgate price to co-move more with the wholesale price, which is seemingly in line with our empirical results.

However, this explanation is only valid if farmers can sell directly on the wholesale spot market, which we have seen they cannot. Also, if middlemen break even on average, then limited-commitment contracting requires that they earn losses in low wholesale-price states which are recouped through profits in high price states.[57] However we see no evidence that farmgate prices are ever higher than the wholesale price (net of transport and storage costs). Figure6 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 wholesale 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 the 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 bounds of the trader net margin at the four quartiles of 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.

6.0.3 Standard Oligopoly Models

Standard trade and industrial organization models of price pass-through in vertical supply chains assume monopolistic competition in the spirit of Dixit and Stiglitz (1977). They involve a simultaneous move game where middlemen (who may be differentiated on non-price dimensions) select their respective prices (see e.g., Atkin and Donaldson 2014, Gopinath and Itskhoki 2010, Weyl and Fabinger 2013 and Villas-Boas 2007). Per-

[57] When the information intervention reduces their high-price state profits, this causes them to make losses overall, causing the insurance arrangement to unravel.

fect competition and perfect collusion are limiting special cases. This would correspond to a variant of our model where village and market traders make simultaneous price offers to the farmer. The farmer responds by selecting one of the offers and a corresponding quantity to sell, or else remains in autarky. Providing information to farmers would not change anyone's payoff function: farmer payoffs depend only on the price offers of the traders since they cannot sell directly in the market themselves, and traders know their resale price prior to the intervention. Hence, unlike the significant heterogenous treatment effects that we observe, this class of models predicts that the information interventions has no effect.

Finally, models with costly search frictions a la Salop and Stiglitz (1977) predict that if information interventions decreased farmers' search costs, then price dispersion would decrease across farmers and sales locations. The increased arbitrage that is facilitated might also raise average farmgate prices. Jensen (2007) and Goyal (2010) confirmed these predictions in Indian contexts where producers can sell directly in wholesale or retail markets. We have argued above that in our context farmers cannot sell directly in the wholesale or retail market, and also that search costs between middlemen and farmers tend to be negligible. For this reason, we do not expect any effects on price dispersion either across different farmers within a village, or across prices in neighboring markets that farmers can sell outside the village.[58] Table 11 verifies this. Using either variance or range of prices as measures of dispersion, we find no evidence that either intervention caused farmgate prices to become more similar within the village or, the *haat* price to become more similar across *haats*.

[58]However, in one respect the two kinds of models make a similar prediction: a narrowing of the gap between farmgate and *haat* prices. We do not test this prediction directly owing to the paucity of data on *haat* prices at which farmers can sell, since we have data only on actual sales which constituted a small and endogenously selected set of transactions.

7 Extension of the Model to a Dynamic Setting, and Effects on Storage

Our theoretical model considered a static context where farmers can sell their output at a single date, after which all unsold stocks are consumed. In practice, farmers have the option of spreading sales between multiple dates, from the time of the harvest until the end of the year when the cold stores have to be cleared. We abstracted from the dynamics of these storage and timing-of-sale decisions. In such a dynamic setting, farmers have more options: instead of selling either to village or market traders at a given date, they can choose to sell at a later date. This makes farmer supply more elastic with respect to price offers than in the static context, which affects village traders' strategic pricing decisions. Also, improved access to information increases the pass-through of wholesale prices to farmgate prices, which could benefit farmers by allowing them to time their sales better, and thus change their returns from storage.

Below we extend of our bargaining model to a two period context in a simple way. This extension shows conditions under which the results of the static model continue to hold. It will become evident how the results can be extended to incorporate an arbitrary (finite) number of dates when trading can occur. The model also helps explain how storage decisions of farmers are affected by the information treatments; these are then examined empirically.

7.1 The Bargaining Model with Two Dates

To simplify the analysis, we abstract from the self-consumption option by assuming that $\beta = 0$. There are two dates $t = 1, 2$.[59] Date 1 corresponds to the harvest date. The harvest output is normalized to 1, while q_t denotes the fraction of output sold at $t, t = 1, 2$. All output must be sold by the end of the year. Since there is no value for

[59]The model can be extended in a straightforward fashion to more than two dates, using backward induction; the equilibrium will involve the village middleman making a non-revealing price offer at every date which equals the expected reservation price of the farmer.

self-consumption, $q_2 = 1 - q_1$. The farmer's prior belief concerning the wholesale price w_1 at date 1 is represented by a distribution function $G_1(.)$ on support $[\underline{w}, \bar{w}]$. Owing to year-specific shocks, the prices at the two dates could be correlated; $G_2(w_2|w_1)$ denotes the conditional distribution over date 2 wholesale price w_2 conditional on w_1. At each date t, the farmer's outside option of selling to market traders outside the village is represented by the same reservation price function $M(w_t)$. At date 1, the farmer has an additional outside option: not selling to either village or market middlemen, by storing the crop and waiting to sell at $t = 2$. The wholesale price w_2 at date 2 is measured net of storage costs, so in what follows we can abstract from such costs.

Farmers are credit-constrained, resulting in payoff function $W(y_1) + \delta W(y_2)$ where y_t denotes sales revenue realized at t, $W(.)$ is strictly concave and strictly increasing satisfying $W'(0) = \infty$, and $\delta \in (0, 1)$ is a discount rate. Middlemen are risk-neutral, and can smooth incomes perfectly across the two dates by borrowing and lending at a constant interest rate i.

We proceed via backward induction. Consider the subgame where at the beginning of date 2, following sale of q_1 at price p_1 at date 1. Since $t = 2$ is the last date, the analysis of the static model applies to trades at this date. The equilibrium in the absence of any information provision to farmers is a FNRE where the farmer sells $1 - q_1$ to the village trader at a price of $p_2^* = E[M(w_2)|p_1]$.

Now consider how the farmer will react to a price offer of p_1 at date 1. If the equilibrium offer is non-revealing, a necessary condition for this offer to be accepted is that $p_1 \geq E[M(w_1)]$. If this condition holds, the farmer will decide to sell q_1^* which maximizes $W(p_1 q_1) + \delta W(p_2^*(1 - q_2))$, and is thereby characterized by the first order condition

$$p_1 W'(p_1 q_1^*) = \delta p_2^* W'(p_2^*(1 - q_1^*)) \tag{6}$$

This generates a supply function $q_1^*(p_1; p_2^*)$ over the range $p_1 \geq E[M(w_1)]$, and which takes the value zero outside this range. The comparative statics of q_1 with respect to p_1

is ambiguous in general, owing to conflicting wealth and substitution effects. The wealth effect is represented by the concavity of W, causing $W'(p_1 q_1)$ to be decreasing in p_1 for any q_1. The p_1 term that pre-multiplies W' represents the substitution effect. The net effect depends on the curvature of W. If $W = \frac{y^{1-\theta}}{1-\theta}, \theta > 0, \neq 1$, then q_1 is increasing (resp. decreasing) in p_1 depending on whether θ is smaller (resp. larger) than one. In what follows we assume that $\theta > 1$, so the wealth effect dominates. Then the farmer supply function is 'backward-bending'.[60]

Continuing to restrict attention to non-revealing price offers, the (constant) price offer that maximizes *ex ante* profits of the village trader solves the following problem: choose p_1 to maximize $(E[w_1]-p_1)q_1^*(p_1;p_2^*)+\frac{E[w_2]-p_2^*}{1+i}[1-q_1^*(p^1;p_2^*)]$, subject to $p_1 \geq E[M(w_1)]$.

If $E[w_1 - M(w_1)] < \frac{E[w_2]}{1+i} - p_2^*$, the village middleman would want to purchase nothing at $t = 1$. In this case there would be a shortage of potatoes on the market at date 1, causing w_1 to rise until this inequality is reversed. In equilibrium there must be positive purchases by middlemen at both dates, and $E[w_1 - M(w_1)] \geq \frac{E[w_2]}{1+i} - p_2^*$ must hold. Then it is profitable for the village trader to purchase at $t = 1$, and offer $p_1 \geq E[M(w_1)]$. Since the farmer supply function is backward-bending, it is not profitable for the village trader to offer a price exceeding $E[M(w_1)]$. Hence $p_1 = E[M(w_1)]$ will be offered at $t = 1$, just as in the static model.

The justification for confining attention to non-revealing price offers is also the same as in the static model. As in the latter, the village middleman wants to lower the price offered as much as is consistent with the farmer agreeing to sell to him at $t = 1$, which requires $p_1 \geq E[M(w_1)]$. Separating equilibria will give rise to failure to trade with some probability, which will result in a loss of profit for traders.

Now consider the effect of informational interventions. As in the static model, there will be greater pass-through of the wholesale price to the farmgate price at every date. For simplicity consider information in the form of a binary signal at each date σ_t which

[60] The case of log utility which corresponds to $\theta = 1$ can also be included; here the supply function is inelastic.

is either low (L) or high (H). The signal is low when w_t lies between $\underline{w}$ and $\hat{w}$, and is high otherwise, where $\hat{w}$ lies in $(\underline{w}, \bar{w})$. The farmgate price p_t^k at each date will depend on the signal realization $k = H, L$; it will satisfy $p_t^L < p_t^* < p_t^H$ where p_t^* denotes the pre-intervention price. The proportion of output sold by the farmer at the harvest will now satisfy the first order condition

$$p_1^k W'(p_1^k q_1) = \delta[\alpha_k^H p_2^H W'(p_2^H(1-q_1) + (1-\alpha_k^H)p_2^L W'(p_2^L(1-q_1)] \tag{7}$$

where α_k^H denotes the probability assigned by the farmer that the date 2 price will be high, upon observing signal $k = H, L$ at date 1. Under the plausible assumption that the wholesale price shocks at the two dates are positively correlated, $\alpha_H^H \geq \alpha_L^H$.

If w_1 and w_2 are independent, the right-hand-side of (7) is independent of k, and the the farmer will sell a larger proportion when the first period signal is low compared to when it is high. But if they are positively correlated, the farmer also becomes more pessimistic about the post-harvest price when the date 1 signal is low, thus raising the value of storage. The net result is then ambiguous: the farmer may then sell less at date 1 when the wholesale harvest price is low. In general, the model makes no prediction about how harvest sales will vary with the wholesale price at the time of the harvest.

When we compare the storage decision of farmers without and with the intervention, an additional source of ambiguity is the fact that when the farmer has better information, then the higher pass-through from the wholesale price to the farmgate price in the post-harvest season increases the risk of storing the potatoes. This too is ambiguous: while the precautionary demand for savings would increase storage, risk-aversion would lower it. The model therefore places no restriction on how storage varies with the information treatment, or with the harvest wholesale price.

Column 6 in Table 9 shows the information treatment effects on the proportion of output sold immediately following the harvest in our experiment. We see that in the absence of the interventions, the proportion sold at harvest time is decreasing in the harvest time wholesale price, as well as the land owned by the farmer. Both of these are consistent with our model above, on the plausible assumption that farmers who own more land are less credit constrained.[61] The information interventions have a negative effect on the proportion of harvest sales; this effect is significant only for those who received the phones in the private information treatment villages. There were no significant interactions of the information treatments with the harvest time wholesale price.

We thus see a significant effect of the information treatment only for the small proportion of farmers who received the information directly through the distributed cell phones. These farmers were induced to store 17% more of their harvest output. For all the other treated farmers, the point estimate of the effect on storage is small (3%) which is statistically insignificant. Unlike most years, in 2008 prices failed to rise after the harvest and so the returns to storage turned out to be unexpectedly low. This contributed to the limited average treatment effect on the yearly average farmgate price for phone recipients. For all other treated farmers, the effects on storage were insignificant. Thus we do not believe that impacts on storage account for the pattern of observed treatment effects.

However, the general point is reinforced: the effect of the information treatments depends on the particular realizations of *mandi* prices. The static model already predicted that the treatment effects would be positive (resp. negative) if wholesale prices were high (resp. low). This pattern is reinforced further when we take dynamic effects on storage into account. However, we also found that storage effects are unlikely to have accounted for the observed heterogeneity of treatment effects for the majority of treated farmers who were not phone recipients. This explains why we abstracted from dynamic effects in our empirical analysis in Section 5 above.

[61] It is easily verified that with $W(y) = \frac{y^{1-\theta}}{1-\theta}$, the proportion of output sold at the harvest in control villages satisfies $\frac{q_1}{1-q_1} = \frac{1}{\delta}(\frac{p_1}{p_2})^{\frac{1}{\theta}-1}$. Given $p_2 \geq p_1$, it follows that q_1 is increasing in θ. Wealthier farmers will have a lower θ, hence they will sell a smaller proportion during the harvest.

8 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. Unlike other settings where producers have direct access to markets, large transactions costs and regulations prevent farmers in our context from selling to wholesale buyers directly, so that they must rely on local trade intermediaries (Cohen 2013). Our findings are novel in that they show that price fluctuations may not pass through from traders to farmers even in a setting where they bargain with each other. This is in contrast to conventional explanations that invoke risk-sharing arrangements. In particular, in our setting insurance premia are unlikely to account for the large middleman margins; instead they reflect barriers to entry into the trading business, and farmers' limited access to markets. This suggests that in contexts such as ours, improved access to price information is unlikely to have the positive outcomes on average farmer prices that we have seen elsewhere. Instead, greater attention needs to be focused on understanding why farmers lack access to markets.

References

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

Antras, Pol, and A. Costinot. 2010. "Intermediation and Economic Integrations." *American Economic Review* 100 (2): 424–428.

———. 2011. "Intermediated Trade." *Quarterly Journal of Economics* 126 (3): 1319–1374.

Atkin, David, and Dave Donaldson. 2014. "Who's Getting Globalized? The Size and Implications of Intranational Trade Costs." Yale University and MIT.

Bardhan, Pranab, and Dilip Mookherjee. 2011. "Subsidized Farm Input Programs and Agricultural Performance: A Farm-level Analysis of West Bengal's Green Revolution, 1982-1995." *American Economic Journal: Applied Economics* 3:186–214.

Bardhan, Pranab, Dilip Mookherjee, and Masatoshi Tsumagari. 2013. "Middleman Margins and Globalization." *American Economic Journal: Microeconomics* 5 (4): 81–119.

Basu, Jyotish Prakash. 2008. *Marketing Efficiency and Marketing Channel: An Analytical Perspective of a Less Developed Region*. Kolkata: Minerva Publications.

Blouin, Arthur, and Rocco Machiavello. 2013. "Tropical Lending: International Prices, Strategic Default and Credit Constraints among Coffee Washing Stations." University of Warwick.

Bonnet, Celine, and Pierre Dubois. 2010. "Inference on Vertical Contracts between Manufacturers and Retailers allowing for Nonlinear Pricing and Resale Price Maintenance." *RAND Journal of Economics* 41 (1): 139–164.

Chau, N. H., H. Goto, and Ravi Kanbur. 2009. "Middlemen, Non-profits and Poverty." IZA Discussion Paper No. 4406.

Cohen, Amy J. 2013. "Supermarkets in India: Struggles over the Organization of Agricultural Markets and Food Supply Chains." *University of Miami Law Review* 68, no. 20.

Dixit, Avinash K., and Joseph E. Stiglitz. 1977. "Monopolistic Competition and Optimum Product Diversity." *American Economic Review* 67 (3): 297–308.

Fafchamps, Marcel, and Ruth Hill. 2008. "Price Transmission and Trader Entry in Domestic Commodity Markets." *Economic Development and Cultural Change* 56:724–766.

Fafchamps, Marcel, and Bart Minten. 2012. "Impact of SMS-Based Agricultural Information on Indian Farmers." *The World Bank Economic Review*, pp. 1–32.

Gopinath, Gita, and Oleg Itskhoki. 2010. "In Search of Real Rigidities." Harvard University and Princeton University.

Goyal, Aparajita. 2010. "Information, Direct Access to Farmers, and Rural Market Performance in Central India." *American Economic Journal: Applied Economics* 2 (3): 22–45.

Halac, Marina. 2012. "Relational Contracts and the Value of Relationships." *American Economic Review* 102 (2): 750–779.

Hart, Oliver. 1983. "Optimal Labour Contracts under Asymmetric Information: An Introduction." *Review of Economic Studies* 50 (1): 3–35.

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

Ligon, Ethan, Jonathan P. Thomas, and Tim Worrall. 2002. "Informal Insurance Arrangements with Limited Commitment: Theory and Evidence from Village Economies." *Review of Economic Studies* 69:209–244.

Machiavello, Rocco. 2010. "Development Uncorked: Reputation Acquisition in the New Market for Chilean Wines in the UK." University of Warwick.

Machiavello, Rocco, and Ameet Morjaria. 2015. "The Value of Relationships: Evidence from a Supply Shock to Kenyan Rose Exports." *American Economic Review*. Forthcoming.

Maitra, Pushkar, Sandip Mitra, Dilip Mookherjee, Alberto Motta, and Sujata Visaria. 2015. “Financing Smallholder Agriculture: An Experiment with Agent-Intermediated Microloans in India.” Boston University.

Malcomson, James M. 2016. “Relational Incentive Contracts with Persistent Private Information.” *Econometrica* 84 (1): 317–346. Note.

McMillan, Margaret, Dani Rodrik, and Karen Welch. 2002. “When Economic Reform Goes Wrong: Cashews in Mozambique.” NBER Working Paper Number 9117.

Morisset, Jacques. 1998. “Unfair Trade? The Increasing Gap between World and Domestic Prices in Commodity Markets During the Past 25 Years.” *World Bank Research Observer* 12 (3): 503–526.

Mortimer. 2008. “Vertical Contracts in the Video Rental Industry.” *The Review of Economic Studies* 75 (1): 165–199.

Saenger, Christoph, Maximo Torero, and Matin Qaim. 2014. “Impact of Third-Party Enforcement of Contracts in Agricultural Markets: A Field Experiment in Vietnam.” *American Journal of Agricultural Economics.*

Salop, Steven, and Joseph Stiglitz. 1977. “Bargains and Ripoffs: A Model of Monopolistically Competitive Price Dispersion.” *The Review of Economic Studies* 44 (3): 493–510.

Salop, Steven C. 1979. “Monopolistic Competition with Outside Goods.” *The Bell Journal of Economics* 10 (1): 141–156.

Villas-Boas, Sofia B. 2007. “Vertical Relationships Between Manufacturers and Retailers: Inference with Limited Data.” *The Review of Economic Studies* 74 (2): 625–652.

Weyl, E. Glen, and Michal Fabinger. 2013. “Pass-through as an Economic Tool: Principles of Incidence under Imperfect Competition.” *The Journal of Political Economy* 121 (3): 528–585.

Table 1: Self-reported contracting between farmer and trader

	oldest continuous seller (1)	newest supplier (2)
Prior agreement existed	0.326	0.246
	(0.039)	(0.036)
Nature of agreements:		
explicit agreement on the quantity of purchase	0.056	0.042
	(0.019)	(0.017)
Explicit agreement on the price	0.014	0.035
	(0.010)	(0.016)
No explicit agreement but implicit understanding about price	0.146	0.070
	(0.030)	(0.022)
Understanding that farmer would not sell to anyone else	0.215	0.141
	(0.034)	(0.029)
Understanding that trader would buy from farmer	0.118	0.113
	(0.027)	(0.027)
Farmer free to sell to anyone	0.236	0.155
	(0.036)	(0.030)
Trader under no obligation to buy from farmer	0.049	0.014
	(0.018)	(0.010)
Trader dictated date of harvest	0.007	0.007
	(0.007)	(0.007)

Standard errors in parentheses. Traders could select multiple options, so percentages add to more than 100.

Table 2: Barriers to Entry into the Potato Trading Business

	Mean (1)	Median (2)
Capital (Rs.)	94471.83	50000
	(8640.44)	
Apprentice experience in phoria business (years)	3.65	3.5
	(0.14)	
Experience in potato cultivation (years)	3.64	3
	(0.191)	
Farmers one needs prior contact with (number)	32.03	25
	(2.57)	
Traders one needs prior contact with (number)	6.39	5
	(0.525)	
Different markets one needs to have contacts in (number)	3.575	3
	(0.142)	

Data are from a 2012 survey where we asked a random sample of traders operating in our sample villages about the arrangements a hypothetical potential entrant into the trader business would need to make.

Table 3: Lower Bounds on Average Middleman Margins

	Harvest period (1)	Post-harvest period (2)
Traders sold at	4.81	4.83
Traders bought at	2.22	2.11
Traders' gross margin	2.59	2.72
Transport costs	0.39	0.00
Handling costs	0.35	0.45
Storage costs	0.00	0.91
Traders' net margin	1.85	1.36

The price that traders sold at is the average *mandi* price per kilogram we collected through market "insiders". The price that traders bought at is the average price per kilogram farmers in our survey received when they sold to traders. All transactions costs are averages per kilogram of costs incurred by farmers when they sold at *haats*, and are considered to be upper bounds to the costs traders would incur in order to buy and sell. Transport costs are adjusted upwards to account for the fact that traders transport potatoes longer distances on average than farmers do. Details are in footnote 22.

Table 4: Baseline Characteristics of Sample Villages and Households

	Total (1)	Control (2)	Private info. (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	1244.84	790.14	454.70
	(224.5)	(282.7)	(376.7)	(496.8)	*0.429*	*0.432*	*0.778*
Fraction of harvest consumed	0.046	0.049	0.041	0.048	-0.001	-0.009**	0.007*
	(0.002)	(0.003)	(0.002)	(0.004)	*0.81*	*0.01*	*0.07*
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*
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

continued on next page

Table 4 – Continued

	Total	Control	Private information	Public information	Public v. Control	Private v. Control	Public v. Private
	(1)	(2)	(3)	(4)	(4)-(2)	(3)-(2)	(4)-(3)
	(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	0.000	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)					*0.283*	*0.255*	*0.408*

Table 5: Analysis of Variance of Weekly *Mandi* Prices

Source	MSE	F
	(1)	(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*	

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

Table 6: Pass-through of City Prices to *Mandi* and Farmer Prices

	Weekly *mandi* price		Weekly farmgate price	
	all years	2008	2008	2008
	(1)	(2)	(3)	(4)
City price	0.809***	0.663***	0.023	
	(0.009)	(0.048)	(0.068)	
Mandi price				0.043
				(0.048)
Local yield ('000 kg/acre)	-0.030			
	(0.020)			
Year 2008	0.401***			
	(0.067)			
Year 2011	1.384***			
	(0.083)			
Year 2012	2.254***			
	(0.073)			
Constant	-0.587***	0.346	1.768***	1.727***
	(0.185)	(0.245)	(0.342)	(0.204)
Mandi dummies	Yes	Yes	Yes	Yes
Week dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	No	No	No
Observations	*2,691*	*790*	*596*	*596*
R-squared	*0.977*	*0.913*	*0.530*	*0.531*

The unit of observation is a *mandi* in a week. In columns 1 and 2 the dependent variable is the mean weekly *mandi* price, in columns 3 and 4 it is the mean weekly price received by farmers in the catchment area of the *mandi*. Robust standard errors are in parentheses. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table 7: Effect of Interventions on Farmers' Tracking Behavior and Precision of Information

Panel A: Effect on Price Tracking Behavior

	Track wholesale price	Days since tracked	Source of informa-tion "other"
	(1)	(2)	(3)
Private information	0.805	0.692***	3.530**
	(0.378)	(0.069)	(2.085)
Phone recipient	1.818**	0.796***	11.161***
	(0.549)	(0.041)	(5.987)
Public information	8.596***	0.736***	52.173***
	(5.696)	(0.081)	(33.083)
Land	1.578***	0.988	0.932
	(0.209)	(0.012)	(0.071)
Constant	8.197***	4.945***	0.005***
	(4.431)	(0.501)	(0.004)
Observations	*11,719*	*10,267*	*10,267*
Prob $> \chi^2$	*0.000*	*0.000*	*0.000*
Pseudo R-squared	*0.159*		*0.302*

Panel B: Effect on Error in Tracked Price

	Mean	N
	(1)	(2)
Control	0.221	3046
Private information:		
Phone non-recipient	0.190	2588
Phone recipient	0.179	688
Public information	0.181	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*	

In Panel A, dependent variables are farmers' reports of whether they tracked prices in wholesale markets, the days since they last tracked prices, and their source of information, for a given potato variety, in the past fortnight. Columns 1 and 3 present odds-ratios of binary logit regressions and column presents the odds-ratios from a Poisson regression. In column 3, we recode the farmer's reports of their source of information into a binary variable indicating "experimental intervention" or not. Further details are in the text. Dummy variables for potato variety, district and survey month are included in all columns. Standard errors in parentheses are clustered at the village level. In Panel B, the normalized "error" is the 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. The reported means are the mean sums of squared normalized errors. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

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

	Quantity sold (kg)		Net price received (Rs/kg)	
	(1)	(2)	(3)	(4)
Private information	457.64	-30.71	-0.08	0.02
	(552.92)	(531.37)	(0.13)	(0.11)
Phone	639.89	567.28	0.09	0.08
	(417.83)	(433.75)	(0.10)	(0.09)
Public information	230.54	-289.75	-0.10	-0.05
	(522.08)	(512.66)	(0.12)	(0.11)
Land	2,251.88***	2,215.65***	-0.10***	-0.08***
	(174.77)	(178.39)	(0.02)	(0.02)
Constant	2,817.06***	3,034.08***	2.17***	2.33***
	(551.66)	(452.42)	(0.12)	(0.09)
Observations	*2,318*	*2,318*	*2,318*	*2,318*
R-squared	*0.353*	*0.387*	*0.332*	*0.400*
Mandi fixed effects	no	yes	no	yes
Mean DV	3855		2.021	
SE DV	213.3		0.0325	

In columns 1 and 2 an observation records the quantity of potatoes a farmer sold in a week of a particular variety and quality. Revenue (net of transport, handling and storage costs) is discounted to account for the implicit interest cost of delays from the time of sale to the receipt of payment, and is then divided by the quantity sold to arrive at the net price received in columns 3 and 4. In columns 1 and 3 we include dummy variables for variety, quality and district of farmer's residence. In columns 2 and 4 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 village level. $^{***}: p < 0.01,^{**}: p < 0.05,^{*}: p < 0.1$.

Table 9: Heterogeneous Impacts of Interventions on Quantity Sold

	Farmer-specific average	Weighted average	Deviation from expected *mandi* price	Instrumented *mandi* price	Long-term relationships	Fraction sold at harvest time
	(1)	(2)	(3)	(4)	(5)	(6)
Price regressor	76.6		-252.2***	205.6	-819.3*	-0.05***
	(242.8)		(93.6)	(657.7)	(476.0)	(0.02)
Private info	-3,155.5**	-3,910.5**	562.5	-4,109.4*	-5,838.1*	-0.03
	(1,358.7)	(1,774.3)	(676.3)	(2,303.9)	(3,144.5)	(0.11)
Private information × Price regressor	708.2**	913.9**	827.6**	932.3*	1,429.5*	0.00
	(320.5)	(429.3)	(344.9)	(534.7)	(815.1)	(0.02)
Phone	1,418.3	-66.8	621.8	-2,048.8	3,344.0	-0.14*
	(1,419.8)	(1,578.9)	(664.6)	(3,706.1)	(4,040.3)	(0.07)
Phone × Price regressor	-200.9	145.0	-68.9	855.7	-724.8	0.03
	(332.1)	(411.2)	(338.0)	(1,021.2)	(1,058.4)	(0.02)
Public info	-2,946.1**	-3,173.8*	-140.1	-4,153.1	-6,570.7***	-0.03
	(1,263.4)	(1,776.2)	(541.7)	(2,741.3)	(2,435.1)	(0.10)
Public information × Price regressor	602.4**	663.5	145.2	829.1	1,599.8***	0.00
	(287.9)	(413.2)	(200.6)	(649.9)	(563.6)	(0.02)
Land	2,186.8***	2,198.2***	2,253.3***	2,601.4***	2,463.8***	-0.03***
	(181.7)	(178.2)	(162.3)	(236.9)	(405.4)	(0.01)
Constant	2,794.0**	3,084.0***	3,158.3***	3,612.9	6,241.7***	0.70***
	(1,078.8)	(423.0)	(558.0)	(3,495.6)	(2,060.1)	(0.09)
Observations	*2,300*	*2,317*	*2,283*	*1,508*	*443*	2,291
R-squared	*0.392*	*0.390*	*0.362*	*0.447*	*0.515*	0.358
Mean DV	3872	3859	5019	3872	3780	0.324
SE DV	214.9	213.5	172.9	214.9	437.1	0.0132

In columns 1-5, an observation records the total quantity of potatoes of a particular variety and quality sold by an individual farmer over the whole year. In column 6 it records the fraction of the harvested quantity that was sold immediately upon harvest. 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 relevant *mandi* price averaged over the weeks when the farmer sold potatoes of that variety. In column 2 it is the relevant *mandi* price averaged over all weeks in the year, with each week weighted in proportion to the quantity sold that week by sample farmers in control villages in that district. In column 3 it is the average deviation of the relevant *mandi* price in 2008 from the predicted *mandi* price for 2008, where the prediction is from a linear regression of weekly *mandi* prices for 2007, 2011 and 2012 on *mandi* dummies, period dummies, year dummies and their interactions. In column 4 the sample is restricted to farmers who likely were in long-term relationships with buyers, as assessed from their reports in 2010 of selling to a buyer whom they had been selling to for longer than 5 years. The price regressor in column 5 is the same as in column 1. In column 6 the price regressor is the mean *mandi* price the farmer faced during the harvest season. In column 4, in the (unreported) first stage we instrument the *mandi* price with the city retail price and its interaction with the distance between the *mandi* and the city. The Kleibergen-Paap F-statistic for weak instruments is 24.17, i.e. we do not find evidence for weak instruments. All columns include dummies for the quality of potatoes sold, and column 3 also includes dummies for the potato variety. Columns 1, 2, 4, 5 & 6 include dummies for the *mandi* whose catchment area the farmer resides in. Standard errors in parentheses are clustered at the village level in columns 1, 2, 4, 5 & 6, and are village-cluster bootstrapped in column 3. $^{***}: p < 0.01, ^{**}: p < 0.05, ^{*}: p < 0.1$.

Table 10: Heterogeneous Treatment Effects of Information Interventions on Price Received

	Farmer-specific average	Weighted average	Deviation from expected *mandi* price	Instrumented *mandi* price	Long-term relation-ships
	(1)	(2)	(3)	(4)	(5)
Price regressor	0.2**		0.0	0.5***	0.2
	(0.1)		(0.0)	(0.2)	(0.2)
Private information	-0.6*	-0.7*	0.1	-0.5	0.4
	(0.3)	(0.4)	(0.1)	(0.4)	(0.7)
Private information × Price regressor	0.1*	0.2*	0.2***	0.1	-0.1
	(0.1)	(0.1)	(0.1)	(0.1)	(0.2)
Phone	0.0	0.0	0.1	0.3	-0.3
	(0.1)	(0.1)	(0.1)	(0.3)	(0.2)
Phone × Price regressor	-0.0	0.0	-0.0	-0.1	-0.2
	(0.1)	(0.1)	(0.0)	(0.1)	(0.2)
Public information	0.0	0.0	0.2	0.5	1.1
	(0.3)	(0.3)	(0.1)	(0.4)	(0.8)
Public information × Price regressor	0.1	-0.1	-0.1	-0.1	0.7
	(0.3)	(0.4)	(0.1)	(0.1)	(0.7)
Land	-0.1***	-0.1***	-0.1***	-0.1***	-0.1**
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Constant	1.6***	2.3***	2.2***	-0.4	1.4
	(0.3)	(0.1)	(0.1)	(0.9)	(0.9)
Observations	*2,300*	*2,317*	*2,283*	*1,508*	*443*
R-squared	*0.423*	*0.406*	*0.356*	*0.339*	*0.513*
Mean DV	2.015	2.018	2.151	2.015	2.131
SE DV	0.0325	0.0325	0.0203	0.0325	0.111

Notes below Table 9 apply. Revenue (net of transport, handling and storage costs) is discounted to account for the implicit interest cost of delays from the time of sale to the receipt of payment, and is then divided by the quantity sold to arrive at the net price received.

Table 11: Effects of Information Intervention on Price Dispersion

	Within the village				Across villages	
	Variance of gross price received	Range of gross price received	Variance of net price received	Range of net price received	Variance of haat price	Range of haat price
	(1)	(2)	(3)	(4)	(5)	(6)
Private information	-0.134	0.176	-0.106	0.239	0.241	0.070
	(0.154)	(0.253)	(0.152)	(0.248)	(0.386)	(0.262)
Public information	-0.049	0.306	0.009	0.373	1.235	0.351
	(0.161)	(0.288)	(0.161)	(0.275)	(0.818)	(0.318)
Constant	0.648***	2.543***	0.671***	2.645***	0.914***	0.854***
	(0.138)	(0.225)	(0.136)	(0.217)	(0.266)	(0.184)
Observations	*100*	*100*	*100*	*100*	*458*	*458*
R-squared	*0.068*	*0.109*	*0.079*	*0.114*	*0.480*	*0.337*

Columns (1)-(4) report regressions of measures of within-village dispersion of the average annual prices that farmers received for each variety. Variety dummies are included. Robust standard errors are in parentheses. Column (5) & (6) report regressions of measures of across-*haat* dispersion of *haat* prices within a week, for each variety. Variety and week dummies are included. Standard errors in parentheses are clustered at the village level.

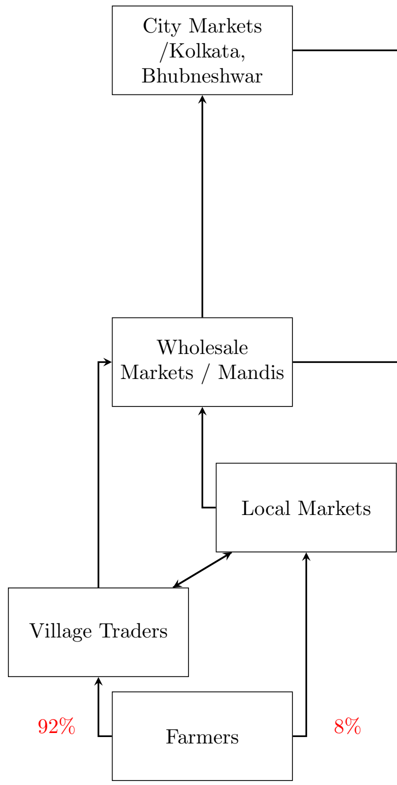


Figure 1: Potato Supply Chain

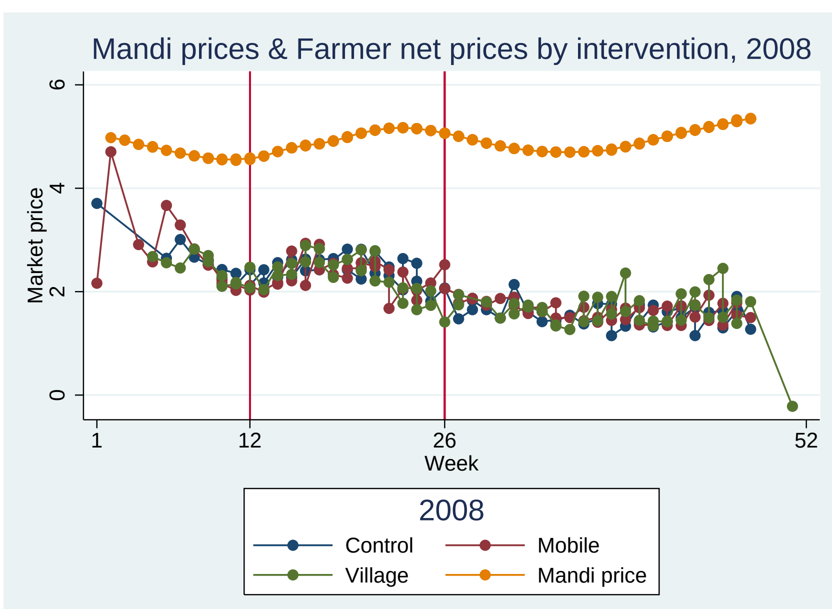
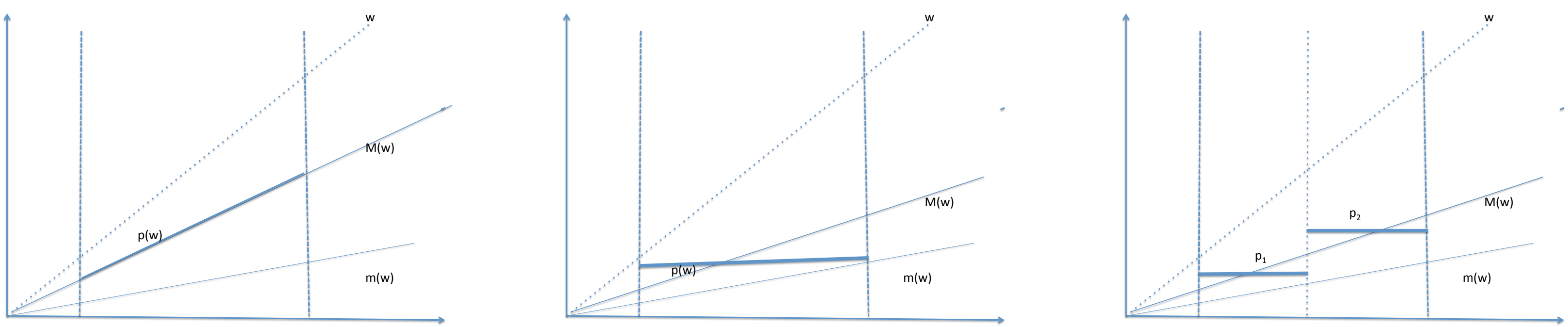


Figure 2: Intervention Impacts



(a) Fully Revealing Equilibrium

(b) Fully Non-revealing Equilibrium

(c) Partially Revealing Equilibrium

Figure 3: Equilibria in the Bargaining Model

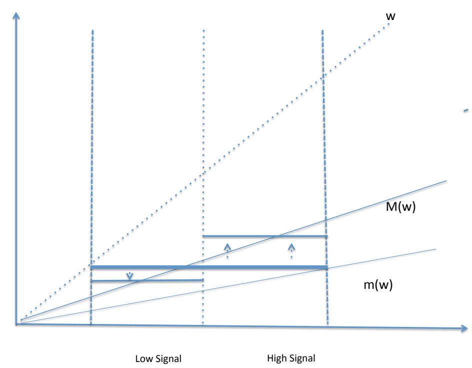


Figure 4: Effect of Intervention on Fully Non-revealing Equilibrium

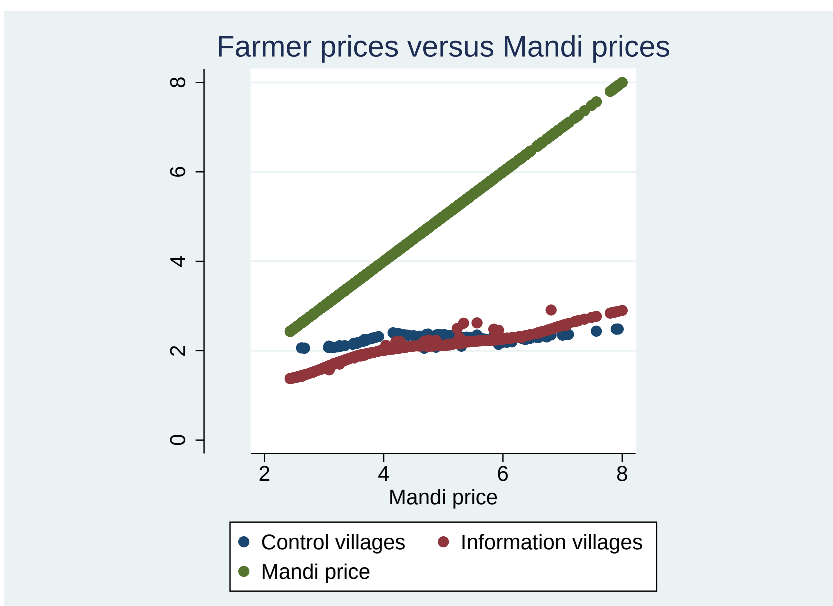


Figure 5: Co-movement of Farmer Prices with *Mandi* Prices

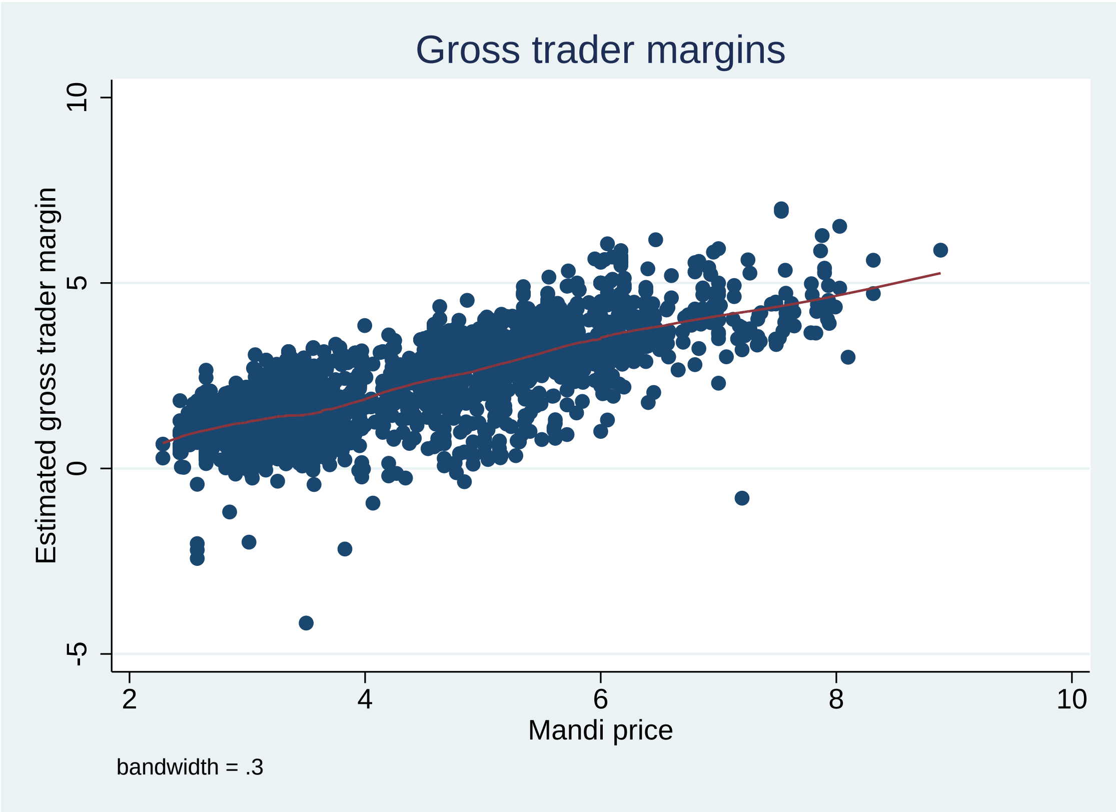


Figure 6: Gross Trader Margins

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

Theory Appendix

Proof of Proposition 5: The *ex ante* profit of VT in the FNRE and FRE respectively given consumption benefit parameter β are given by

$$\Pi^N(\beta) \equiv E[(w - \bar{p})q(\bar{p};\beta)] \tag{8}$$

$$\Pi^R(\beta) \equiv E[(1 - \alpha(w;\beta))\{w - M(w;\beta)\}q(M(w;\beta);\beta)] \tag{9}$$

Asβ approaches 0, $M(w;\beta)$ approaches $M^*(w) \in (0,w)$ and $m(w;\beta)$ approaches 0 for any w. Moreover, $q(p;\beta)$ approaches Q for all $p > 0$. And $\alpha(w;\beta)$ approaches $\alpha^*(w)$, where

$$\frac{\alpha^{*\prime}(w)}{\alpha^*(w)} = M^{*\prime}(w)\frac{1}{w - M^*(w)} \tag{10}$$

so $\alpha^*(.)$ is strictly increasing, with $\alpha^*(\bar{w}) = 1$.

Since $W(\Pi(\bar{p})) = E[W(\Pi(M(w))]$, the concavity of $W(\Pi(.))$ implies via Jensen's inequality that

$$\bar{p} \leq \bar{M}(\beta) \equiv E[M(w;\beta)] \tag{11}$$

Hence

$$\Pi^N(\beta) \geq E[(w - \bar{M}(\beta))q(\bar{p};\beta)] \longrightarrow QE[(w - M^*(w)] \tag{12}$$

as $\beta \to 0$.

On the other hand,

$$\Pi^R(\beta) \longrightarrow QE[(1 - \alpha^*(w))\{w - M^*(w)\}] \tag{13}$$

which is strictly smaller than the lower bound to the limiting FNRE profit given at the right end of (12), since $1 > \alpha^*(w)$ for all $w < \bar{w}$. This completes the proof of Proposition 5.

Proof of Proposition 6: Any other WPBE involves offer strategies in which the set of types can be partitioned into intervals $W_i = (w_i, w_{i+1}), i = 1, \ldots, n$ with $\underline{w} = w_1, \bar{w} = w_{n+1}$ such that it is either strictly increasing or locally constant over W_i. As long as this equilibrium is not an FNRE, the price offer must be strictly lower on intervals $W_1, \ldots W_{n-1}$ than at w_{n+1}. To ensure incentive compatibility it must be the case that offers will be accepted with probability strictly less than one on intervals $W_1, \ldots W_{n-1}$. Hence over these intervals, F must be indifferent between accepting and rejecting.

The same will be true in interval W_n if the price function is strictly increasing over W_n. If it is constant over W_n, and is accepted with probability one, F is at least as well off accepting it rather than rejecting it. If F is strictly better off, the offer p_n can be reduced slightly to p'_n and will still be accepted with probability one. This will raise VT's profits when the type of VT is in W_n. Some types from other intervals $W_{n-1}, W_{n-2}, ..$ may now be induced to deviate to offering p'_n. So we can rearrange the intervals so that W_n is expanded (all the types offering p'_n) while other intervals below are shrunk or dropped to take account of the types who chose to deviate to p'_n from some $p_i, i = n-1, ..$ F's beliefs must now be readjusted accordingly. Since the set of types that are now added to W_n correspond to lower values of w, this only serves to lower F's reservation price. Hence it will continue to be optimal for F to accept p'_n with probability one. This argument shows that we can find another WPBE generating higher profit for VT, if F is strictly better off from accepting p_n to rejecting it. Hence we can limit attention to WPBE's in which F is indifferent between accepting and rejecting every price offer that is made on the equilibrium path.

Let P denote the set of elements i of the partition over which the price offer is constant (denoted $\hat{p}_i$), and S the remaining set of elements over which the price offer is strictly increasing. Let F_i denote the prior probability of W_i. Then the expected profit of VT in the non-FNRE is

$$\Pi^R \equiv Q[\sum_{i \in P} F_i \alpha_i [\hat{w}_i - \hat{p}_i] + \sum_{i \in S} \int_{w_i}^{w_{i+1}} \alpha(w)[w - p(w)]dG(w)] \tag{14}$$

where $\hat{w}_i$ denotes the mean of w conditional on $w \in W_i$, and $\alpha(w), p(w)$ denote the acceptance probability and price over intervals in S. Since the equilibrium is not FNRE, there exists at least one element i over which acceptance probabilities are strictly less than one. Hence

$$\begin{aligned}
\Pi^R &< Q[\sum_{i \in P} F_i[\hat{w}_i - \hat{p}_i] + \sum_{i \in S} \int_{w_i}^{w_{i+1}} [w - p(w)]dG(w)] \\
&= Q[\sum_{i \in P} F_i[\hat{w}_i - \hat{p}_i] + \sum_{i \in S} F_i[\hat{w}_i - \hat{p}_i]] \\
&= Q[\sum_{i} F_i[\hat{w}_i - \hat{p}_i]] \\
&= Q[\hat{w} - \hat{p}]
\end{aligned}$$

where $\hat{p}_i$ for $i \in P$ denotes the mean price offer conditional on $w \in W_i$, and $\hat{p}$ denotes the unconditional mean price offer.

Now consider the FNRE with a constant price offer $\tilde{p}$ satisfying

$$W(\Pi(\tilde{p})) = E[W(\Pi(M(w))] \tag{15}$$

Since for every W_i, F is indifferent between accepting the price and rejecting it, the right-hand-side of (15) equals the expected payoff of the farmer in the original equilibrium, given by $E[W(\Pi(p(w))]$. Hence

$$W(\Pi(\tilde{p})) = E[W(\Pi(p(w))]. \tag{16}$$

Since $W(\Pi(.))$ is concave, it follows that $\tilde{p} \leq \hat{p}$. Hence using (15), the expected profit in the original equilibrium is smaller than expected profit $Q[\hat{w} - \tilde{p}]$ in the FNRE. This concludes the proof of Proposition 6.

A Additional Tables

Table A1: 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 A2: Tests of balance in *mandi* characteristics by relation to median *mandi* price

	Hugli			W. Medinipur		
	Below median	Above median	p-value	Below median	Above median	p-value
	(1)	(2)	(3)	(5)	(6)	(7)
Retail price (Rs/kg)	4.91	4.91	*1.000*	7.78	7.78	*1.000*
	(0.00)	(0.00)		(0.00)	(0.00)	
Distance from retail market (km)	0.51	0.45	*0.262*	3.22	3.23	*0.882*
	(0.02)	(0.05)		(0.05)	(0.05)	
Average yield (kg/acre)	10.58	10.08	*0.074*	9.80	9.05	*0.202*
	(0.09)	(0.27)		(0.29)	(0.47)	
Agricultural wages for males (Rs/day)	56.04	53.4	*0.638*	52.74	55.56	*0.675*
	(3.52)	(4.20)		(4.16)	(4.37)	
Pct. households with landlines	0.07	0.10	*0.022*	0.03	0.06	*0.589*
	(0.00)	(0.01)		(0.02)	(0.05)	
Pct. villages with metalled roads	0.60	0.58	*0.856*	0.12	0.07	*0.640*
	(0.09)	(0.11)		(0.08)	(0.07)	
Pct. villages with factories/mills	0.56	0.54	*0.896*	0.56	0.42	*0.521*
	(0.11)	(0.11)		(0.13)	(0.13)	

Standard errors in parentheses.

Table A3: Heterogeneous Treatment Effects of Interventions on Households Not Asked About Price Tracking Behavior

	Quantity Sold (1)	Net Price (2)
Price regressor	-1.3	0.212***
	(322.4)	(0.072)
Private information	-2,944.8*	-0.428
	(1,678.5)	(0.314)
Private information × Price regressor	544.5	0.121*
	(381.9)	(0.071)
Phone	2,609.0	-0.096
	(2,029.4)	(0.446)
Phone × Price regressor	-479.9	0.027
	(445.9)	(0.102)
Public information	-3,972.9**	0.358
	(1,676.5)	(0.328)
Public information × Price regressor	766.8**	-0.074
	(376.9)	(0.077)
Land	2,002.4***	-0.076***
	(201.2)	(0.018)
Constant	3,520.8**	1.396***
	(1,408.7)	(0.319)
Observations	*1,139*	*1,139*
R-squared	*0.405*	*0.472*
Mean DV	4060	2.033
SE DV	348.5	0.0453

Notes for Table 9 Column 1 apply. The sample is restricted to farmers who were randomly chosen not to be questioned about price-tracking behavior.