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

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Abstract

This paper investigates how potato farmers in West Bengal sell their crop to local traders, the determinants of farmgate prices and margins earned by traders. We specifically examine the role of asymmetric information regarding prices in neighboring wholesale markets where local traders resell these potatoes. Farmers in randomly chosen villages were provided information about daily wholesale prices. In one treatment the information was provided on public notice-boards, in the other it was relayed privately to randomly chosen farmers. Net of marketing costs, traders earn margins in the range of 55 to 100% of farmgate prices. Information provision resulted in no change in average margins, but the private information intervention caused farmgate prices and traded quantities to co-move more with wholesale prices. The evidence is inconsistent with long term implicit contracts allowing risk to be shared between farmers and traders. Instead, the results can be explained by a model of ex post bargaining, in which low outside options of farmers prevent informational interventions from having significant impacts.

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1 Introduction

It is often argued that farmers in developing countries are unable to get a remunerative price for their produce. This lowers the profitability of agriculture and prevents diversification into cash crops and integration into the world economy. Large gaps between retail and producer prices for export goods have been documented: The average margin between consumer prices in the US and world prices for beef, coffee, oil, rice, sugar and wheat increased by 83 percent between 1975 and 1994 [Morisset, 1998]. These large gaps are also associated with limited pass-through of world price increases to the producers. Fafchamps and Hill [2008] find that when the export price of Ugandan coffee increased in 2002-03, wholesale prices also rose, and the gap between wholesale and farmgate prices widened. McMillan et al. [2002] claim that no more than 40-50 percent of the increased cashew export prices in the 1990s went to farmers in Mozambique.

The evidence points to the important role of trade intermediaries, or middlemen, in agricultural marketing and trade. More specifically, middlemen margins might limit the pass-through of the benefits of trade liberalization to primary producers. Acknowledging their role may help us understand why globalization has been accompanied by increased inequality [Bardhan et al., 2010]. However, there is not much micro-level empirical evidence on the actual margins earned by these middlemen, and their determinants. What are the relationships between agricultural producers and the middlemen whom they sell to? How do these affect the prices that farmers receive, the returns to crop diversification, and the pass-through of price changes? The answers to these questions can help to understand the impact of different interventions, and in turn can inform public policy aimed at increasing producer prices, improving agricultural production and reducing rural poverty.

An important source of middlemen margins may be the asymmetry of price information between farmers and middlemen. If middlemen have more accurate information about the prevailing price in the market, then they have the incentive to understate this price when buying from farmers and can lower the price that farmers receive. Removing this information asymmetry could improve farmer prices. Alternatively, farmers may deal directly and anonymously with markets, and improved information about the prevailing price in the market could improve producer prices. If so, there is low-hanging fruit for public policy makers: disseminating price information to farmers using cellphones or other low-cost IT-based interventions may improve farmers' ability to obtain a higher farmgate price, and in turn increase production of cash crops and the pass-through of the benefits of globalization to the poor.

In South Indian fishing markets, Jensen [2007] finds that the availability of cellphone technology allow fishermen to find out the prevailing price before choosing which coastal markets to steer their boats to, significantly reducing price dispersion. Aker [2010] finds that mobile phones allow grain traders in Niger to search across multiple markets, reduce price dispersion on grain prices by 10 to 16 percent, and improve trader and consumer welfare. Goyal [2010] finds that the introduction of free internet kiosks showing daily agricultural information (and the entry of a new corporate buyer) significantly increased average market prices for soybeans in Central India. In contrast, more recent work by Fafchamps and Minten [forthcoming] finds that providing farmers in Western India with free subscriptions to a daily SMS service providing (among other things) price information for important crops had no impact on the average prices they received, although it did increase the likelihood that farmers sold at a wholesale market instead of selling to an itinerant trader. In discussing their findings, the authors speculate that the contracting relationship between farmers and traders, and the traders' comparative advantage at transporting produce may be the factor driving their results. If markets are not truly anonymous and trust between farmer and trader is important (say, due to trade credit or quality concerns) then more accurate price information may not improve farmers' outcomes since traders do not compete with one another.

The conflicting empirical evidence suggests that the effect of price information on farmer outcomes may be highly context-specific. In markets where intermediaries play a relatively unimportant role, increased access to information may have relatively straightforward effects. In markets where intermediaries exist due to market imperfections (e.g. credit constraints, quality control or branding) the effects can be quite different. Much again might depend on the nature of contracting between farmer and trader. This paper attempts to shed light on these aspects.

We report on a field experiment we conducted in 72 villages in two districts of West Bengal, where we provided potato farmers with daily price information from neighboring wholesale markets. We examine the impact of our intervention on both the average producer price, and the co-movement of producer price and market price. First, our data suggest that middlemen margins are significant in potatoes: on average they constitute between 25-30 percent of the wholesale market price, while farmgate prices are approximately 45 percent of this price (the rest being accounted by transport, handling and storage costs). Only about 20 percent of increases in wholesale prices pass through to farmers. Our information intervention appears not to have changed these margins on average. This is true both of the private and the public information intervention. However, the private intervention caused producer prices to co-move more with wholesale market prices. Quantities traded also exhibited the same tendency to co-move more with wholesale prices. When wholesale prices were below (resp. above) average, the intervention therefore made farmers worse (resp. better) off ex post. Moreover, farmer revenues become more volatile as a result of the intervention.

To interpret the empirical results, we develop and test alternative models of bilateral contracts between farmers and traders. The results turn out to be inconsistent with predictions of long term (ex ante) contracting models. Specifically, the latter predict that quantities traded will unambiguously increase with a reduction in asymmetric information, owing to a reduction in screening distortions. This contrasts with the finding that quantities traded fell significantly as a result of the interventions when wholesale prices were low. The increased volatility of farmer revenues and prices is also inconsistent with the view that middlemen margins represent risk premia for insurance provided to farmers. A reduction in informational asymmetries would be expected to reduce constraints on such insurance, and thus reduce volatility of farmer prices and revenues.

Instead the empirical results are consistent with a model of ex post bargaining, in which the trader makes a take-it-or-leave-it price offer to the farmer after observing the wholesale price, and the farmer responds with a quantity that he wishes to sell. This mirrors anecdotal evidence we have from detailed conversations in the field: farmers report that although they do borrow from traders during the planting season, they are free to sell to any trader who approaches them. They describe a potato sale as a process where they are approached by a trader who makes them a price offer. They are free to either sell or not, and can decide upon the quantity. Although they do sometimes carry their produce to the market, they do this rarely, and only if they know a trader at the market who would buy from them. The market is not anonymous: the larger traders at the market have concerns about product quality and prefer to buy from their own acquaintances and aggregators.

In particular, the ex post bargaining model helps explain why price information interventions may not have significant average effects, while increasing co-movement of farmgate prices and quantities sold with wholesale prices. This is essentially a model of signaling (rather than screening), whereby traders in the village may potentially reveal their information about the wholesale price through the farmgate price they offer the farmer. The farmer subsequently decides whether to accept this offer, or go to the wholesale market and sell to a different trader there. In equilibrium, village traders offer prices that leave farmers indifferent between accepting and not, with a suitable fraction of farmers subsequently rejecting the offer. We show there exists a fully revealing (separating) equilibrium in which all of the traders' information is revealed through their price offers. There also exist a continuum of partially revealing equilibria in a neighborhood of the fully revealing equilibrium. The range of such partially revealing equilibria depends on the extent of prior informational asymmetry. Our interventions enhanced the information available to the farmer, inducing the partially revealing equilibrium to move closer to the fully revealing equilibrium. Hence farmgate prices and quantities co-moved more with the wholesale price as a result of the intervention. We show other predictions of the ex post bargaining model are also consistent with the facts: farmers obtain a higher price if they sell to a trader at the wholesale market, the likelihood of selling to a trader at the wholesale market is higher when the wholesale market is higher, and traders earn higher margins when transport costs rise.

The main implication of these findings is that high middlemen margins and low pass-through of wholesale price changes to farmers result from weak formal and informal institutions in marketing arrangements for potato farmers in West Bengal. The main weakness of formal instititutions is the lack of centralized wholesale markets where farmers and traders have equal access. Consequently trade is heavily reliant on reciprocal buyer-seller relationships, owing to problems of trust arising from quality uncertainty and trade credit. These informal farmer-trader relationships involve ex post bargaining over prices, rather than ex ante long term agreements which would have generated greater gains for farmers from the informational interventions. The lack of access of farmers to selling directly in the wholesale markets also prevented them from realizing gains from better information regarding price movements in these markets. Their outside option in bargaining with their usual trader in the village is to sell to a different trader in the wholesale market, both of whom are able to realize a substantially higher price from selling in the wholesale market.[1]

The paper is organized as follows. The next section describes the context of potato production

[1] Our findings echo the conclusions of previous work: In his 1998-99 study of 136 potato farmers in 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.

and trades in West Bengal. This if followed by a description of the informational interventions we implemented, and of the survey data collected. We then explain the predictions of ex ante contract models, and thereafter test them. This is followed by an exposition of the ex post bargaining model, and describe the concordance between its predictions and the facts. We conclude with a summary of the results and principal implications.

2 The Empirical Context: Potato Production and Sale in West Bengal, India

The state of West Bengal accounts for about 40 percent of the total volume of potatoes produced in India. It is the leading crop in the two districts in our study: Hugli and West Medinipur. The large majority of farmers sell their potatoes to local traders (known as *phorias*) who re-sell them in neighbouring wholesale markets (*mandis*) to larger traders. These large traders in turn sell them in the large retail markets in the capital, Kolkata or in neighbouring states such as Orissa and Andhra Pradesh.

Potatoes are a winter crop; they are planted between October and December, and harvested between January and March. They are storable and so not all potatoes harvested need to be sold upon harvest. Farmers have the option of placing potatoes in home stores (from where they would have to be sold within two or three months) or in cold stores, where they can survive until October, when the new planting season begins. In our data from 2008, 42 percent of the amount produced was sold immediately upon harvest. Some is allocated to home consumption, saved for seed, or lost to spoilage. Of the amount still remaining, about 37 percent was put into home stores, and the remaining 63 percent was put into cold stores.

Cold stores are privately owned in these areas, and space is widely available. The person placing the potatoes in the cold store pays a fixed rental rate per bag, plus a handling fee. The rent is not dependent on the duration for which potatoes are stored, presumably because once potatoes are released from the cold store, there are no new potatoes that can be stored mid-way through the season in the space that becomes available, and so this space must remain un-utilized. The cold-storage gives a receipt for the potatoes that have been placed in the cold store, and these receipts are called potato "bonds". These bonds are also traded. To release potatoes, the holder of a bond must visit the cold store and request that the potatoes be removed from the cold store. They are then thawed and dried, before they can be sold.

The predominant method to sell potatoes is to sell to local intermediaries: 72 percent of the potatoes sold by our sample farmers in 2007 were sold to small traders (*phorias*), another 11 percent to other larger traders, and 8 percent to moneylenders through bilateral transactions. *Phorias* aggregate potatoes and sell them up the chain to larger traders: they might be entrepreneurs selling to large traders on a case-by-case basis, or might be commissioned agents of the large trader, responsible for sourcing potatoes for him. Most *phorias* have a network of farmers from whom they buy on a regular basis – farmers who have a track record of selling uniform quality potatoes and not cheating them by mixing potatoes of different grades into their sacks. Payment for potatoes is often delayed, and so farmers also prefer to sell to traders who they have a good record of trade credit repayment. However anecdotal evidence suggests that farmers and traders are not bound to trade exclusively with each other: farmers are free to change the trader they sell to, at any point.

2.1 Price Information

Phorias are also an important source of information about market prices: 62 percent of the farmers in our sample reported in 2007 that they learned about potato prices from the phoria. Note that telecommunication is available: 51 percent of the villages in our sample had telephone booths, 23 percent of the households reported they had landline phones and 33 percent had mobile phones in 2007. Note also that 33 percent of the farmers reported that they found out about prices from their local neighbouring market. It is tempting to conclude from this that farmers can access market price information and there is no information asymmetry. However, this conclusion is no longer straightforward once we realize that farmers enter bilateral transactions with traders, and so the market price that is relevant for a given farmer is the price that the trader would receive when he sold potatoes bought from him, in the market. In the absence of an anonymous market where the farmer can directly sell to, the prevailing price in the market is not a relevant price for the farmer. Given this, even if the technology exists to find out the market price, there may not be much gained from learning it.

Consistent with this, farmers appear not to track market prices, but the price that they expect to receive if they were to make a sale, with the knowledge that the market price is the price at which phorias sell to larger traders (*arraddars*) whereas they cannot sell to *arraddars* directly.

This is revealed in their answer to our question about what the prevailing potato price is. The price they report (mean: Rupees 2.30 per kg) is much closer to the gross price they receive (mean: Rupees 2.15 per kg) than to the average mandi price (Rupees 4.77 per kg).

There is also reason to believe that it is difficult to forecast mandi prices accurately. The graph in Figure 9 plots weekly averages of mandi price data for jyoti potatoes using the government's Agmark mandi price data set for West Bengal. The data clearly show that price paths over the course of the year can vary considerably: in particular, in 2008 jyoti prices fell in these mandis instead of rising as they did in the previous three years. This large year-to-year variation is also apparent in Table 2, which shows an analysis of the variance in weekly mandi prices from the second half of 2007, all of 2008 and the first half of 2010. There is considerable variation in mandi prices across different mandis, and over time: both the mandi dummies and weekly dummies explain significant fractions of the total variation in mandi prices (see column 1), however these two factors together can explain only 25 percent of the total variation. Allowing for mandi-specific weekly time variation (column 2) does not improve the fit much. Instead, as column 3 shows, annual variation in mandi prices is substantial: once year dummies are included, 87 percent of the variation can be explained. It is clear that from year to year the mandi prices for potatoes can fluctuate quite substantially. Given this, farmers cannot know ex ante what kind of year any given year would be, and subsequently what price the phorias will receive for potatoes and in turn what price they can expect to receive. By providing daily price information from the mandis as the prices unfolded, our intervention could have helped farmers to learn about the "type" of year this year was, and hence reduced their information asymmetry.

3 The Intervention

Our experiment was conducted in 72 villages drawn through stratified random sampling from two potato-growing districts of West Bengal, Hugli and West Medinipur. In each of these villages, we surveyed a stratified random sample of 24-26 farmer households. The villages were divided into three groups of 24 villages each. Villages were selected such that they were at a minimum distance of 8 kilometres from each other, so as to avoid information spillovers. In the control villages, we did no intervention of any kind. In the other two groups, we delivered daily price information about the potato prices in up to two nearby local wholesale markets and the nearest metropolitan market. We hired an agent in each market who surveyed leading buyers to find out what price they had made purchases at the end of each trading day. The agent then called in these prices to an information center located in Kolkata. Both bond and spot prices were reported, for the two major varieties of potatoes sold in that market.[2] Price information was delivered daily from June to November 2007 and from January to November 2008.

In the 24 private information villages, the price information was given individually to 4 randomly selected survey households. To deliver this price information, we gave each of these households a mobile phone. Each morning, our "tele-callers" based in our Kolkata information center made phone calls to each of these farmers and relayed the market prices from the previous evening. The mobile phone was to be used merely as a device for relaying price information to the farmer, and was not meant to improve the farmer's connectivity to the outside world. For this reason, we requested the service provider to block all outgoing calls from this phone. They also changed the phone settings so that it was not possible to find out the phone number by pressing keys on the instrument itself. Finally, we did not inform the farmer of the phone number for his phone. In this way we aimed to prevent the farmer from receiving any incoming calls except from us. Since we had access to the log of calls for each phone, we were able to check that our restrictions were effective.[3]

In the 24 public information villages, we delivered the market price information to a single individual (called the "vendor") in the village. This person was usually a local shopkeeper or phone-booth owner. For a nominal fee, he wrote the price information on charts and posted them in three public places in each village. These were places that we expected farmers to pass by as they went about their daily business. Each chart had room to write down 7 days' worth of information: this was so that farmers could see how prices were changing and detect short-term trends if there were any. At the end of 7 days the chart was changed.

Our tele-callers were given strict instructions not to reveal our research question to the information recipients. In cases where the farmers asked them why they were being given this information, they were instructed to say that they were part of a research study where price information was being relayed to farmers, but that did not know why this was being done or how farmers could use this information. The village vendors were also given the same instructions.

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[2]The two most common varieties of potatoes grown are jyoti (accounting for 70 percent of potatoes produced) and chandramukhi (accounting for 20 percent). All our regressions are run on only these two varieties, with a variety dummy included.

[3]Except for a few initial situations where farmers tried to download ringtones (a feature that was subsequently blocked as well), our plan succeeded without exception.

4 The Data

Our data come from surveys of 1599 households from the 72 villages in our sample.[4] The sample consists of farmers who planted potatoes in 2007. In 2007, we did three types of surveys: In February-March, in addition to household demographics, assets, land ownership and credit, we asked them about the crops they had planted until the end of December 2006 and input use. We call this the production survey. In June we asked farmers about their harvest of potatoes and their sales after the harvest. From July to November, we did fortnightly surveys to ask them about subsequent sales, from home stores and cold stores (called trading surveys). In 2008, we did a production survey in January-February. This was followed by fortnightly harvest and trading surveys from March until November.

Unfortunately we realised in 2007 that by the time we started delivering price information in June, farmers had sold about 80% of the potato harvest already. In fact several households had no stocks of potatoes left. This greatly dampened the effectiveness of our intervention; for this reason this paper only reports data from the 2008 round of the intervention and surveys. All villages and households were in the same treatment or control group in 2008 as they had been in 2007. However it should be borne in mind that the effects we report are the cumulative effect of the 2008 intervention as well as the 2007 one.

4.1 Descriptive Statistics

Summary statistics for our sample are presented in Table 3. Standard errors are not clustered. The mandis that we were providing price information for, were on average 8.5 kilometres away from the villages were our sample farmers resided. This distance was higher in Medinipur West (9.65 km) than in Hugli (7.26 km) probably because Medinipur West is more sparsely populated. The average farmer had a small landholding at just over 1 acre. Cultivated land in 2008 was slightly above this, due to leasing in. Thirty percent of the annual cultivated area was devoted to potatoes. Given that potatoes can only be planted in the fall season, this implies that a substantial fraction of the fall cultivation of our sample farmers, is potatoes. As stated earlier, villages are have telecommunication links: 51 percent of the villages in our sample had telephone

[4]Although we collected a larger sample of 1726 farmers, we analyze here data only for producers of the jyoti and chandramukhi varieties of potatoes, which together account for about 90 percent of the potatoes grown by the sample in 2008.

booths where one could make a phonecall for a fee, 23 percent of the villages had landline phones and 33 percent had cellphones. Connectivity is better in the district of West Medinipur than in Hugli. Despite this, 62 percent report that they rely on the phoria for price information, although 33 percent also collect price information from neighbouring markets. Only 14 percent state that their friends are the source of their information. This reliance on the *phoria* for price information mirrors the fact that almost all farmers sell to phorias (or larger traders or moneylenders). Only 7 percent reported that they sold at least once in the market directly. These fractions change only slightly in 2008: unlike Fafchamps and Minten [forthcoming], there is no evidence that our intervention caused farmers to sell in the market more often than before.

Table 4 shows how these descriptives vary by treatment groups for data collected before the intervention began in June 2007. This allows us to check that the sample was balanced across treatment groups. As can be seen, the differences across treatment groups before the intervention are mostly small and insignificant. Exceptions are that the control villages were more likely to have a public phone booth and that the control group farmers were more likely to report that they learned about potato prices from the *phoria*. Taken together these two features do not indicate a clear pattern that control group farmers should have had better information about market prices.

Table 1 show patterns in the mandi prices and prices received by control group farmers in 2008, depending on whom they sold to. As can be seen, on average farmers receive only about 45 percent of the mandi price.[5] The margin between mandi price and farmer price is larger in Medinipur (65 percent) than in Hugli (47 percent). The margin varies slightly by whom they sell to: farmers selling to the market directly receive a slightly higher gross price than those who sell to the *phoria*. However this difference is reversed when transport costs are accounted for, since the farmer is more likely to have to incur transport costs when they sell to the market. We also asked farmers if they tracked potato prices, and if so, what the price was when they last tracked it. Note that farmers' tracked prices were much closer to the prices they received than the actual mandi prices (i.e. the prices at which phorias sold to larger traders in the market). Our interpretation is that when asked to report the mandi price, most of them interpreted the question to mean the price they themselves were likely to get if they were to take their potatoes to the mandi, rather than what the phorias were getting.

The graphs in Figure 9 allow us to see how mandi prices (in the mandis relevant to our sample)

[5]This is computed as $\frac{\text{mandi price - farmer price}}{\text{mandi price}}$.

changed over the course of the year. We consider two potato varieties here: jyoti and chandramukhi. Farmers in Hugli grow more jyoti and farmers in Medinipur grow more chandramukhi (put numbers here). The year 2008 was a bad year for jyoti producers: a large harvest prevented prices from rising through the year. In contrast, the prices for Chandramukhi potatoes rose significantly. Turning to Figure 9 we see that the price path for chandramukhi potatoes is reflected in the graph for Medinipur, whereas in Hugli the mandi prices were essentially flat.[6] The yellow curve depicts tracked prices and we can once again see that they are substantially below mandi prices and much closer to the prices that farmers receive. The prices that farmers receive from phorias are substantially below the mandi price and fall even lower as the year progresses. Prices received from selling to the market follow a similar path, although they are higher on average. The pattern of farmer prices is similar in both Hugli and Medinipur, even though mandi prices rose in Medinipur instead of staying constant. Figure 9 shows how farmer prices (net of transport costs) varied by treatment group. There is no significant difference between the average prices received by control group farmers and either of the two intervention groups. The gap between the mandi price and the net farmer prices allows us to do a rough calculation of the middlemen margins. Note that this margin is not reduced by the intervention.

As can be seen, these prices are in the range of Rupees 4.5 to 5.5 during the entire period from week 12 (end of March) to week 50 (end of November). In contrast, net farmgate prices (the blue, green and maroon lines) are lower at about Rupees 2 towards the beginning of the period, falling towards Rupees 1.5 towards the end. This gap of about Rupees 2.5 to 3 can be accounted for by transport, handling and storage costs, as well as middlemen margins as can be seen from the equation below:

$$\text{Mandi price} = \text{Net farmgate price} + \text{Transport, storage and handling costs} + \text{Middleman margin}$$

Although we did not interview traders directly, we can estimate an upper bound for the transactions costs they might incur by using the cost data provided to us by farmers.[7] Based on farmer reports, transport costs are 24 paise per kilogram, handling and other costs are 35 paise per kilogram and storage costs are 89 paise per kilogram on average. This allows us to estimate

[6] There are very few price observations at the very beginning and end of the year since few potatoes are traded during those times.

[7] The farmers' reports of these costs are likely to be an upper bound since there may be economies of scale in potato transport and handling.

the middleman margin as

$$\text{Middleman margin} = \begin{cases} \text{Rs.}4.5 - 2.5 - 0.24 - 0.35 = \text{Rs.}1.41 & \text{per kg when sold from field or home stores,} \\ \text{Rs.}5.5 - 1.5 - 0.24 - 0.35 - 0.89 = \text{Rs.}1.52 & \text{per kg when sold from cold stores.} \end{cases}$$

This rough calculation suggests that middlemen margins range from 27 to 30 percent of the wholesale market price, and 55 to 100 percent of the farmgate price, depending on when in the year they sold the crop.

5 Theoretical Analysis: Ex ante contracts

Before examining the impact of our intervention, we organize our thinking by presenting a theoretical analysis of the bilateral contracting between farmer and trader in our context. The information intervention is modeled as moving a farmer from asymmetric information about the prevailing price in the market, to symmetric information. We consider first ex ante contracts, where the price and quantity are determined simultaneously.

A farmer F has an exogenous quantity $\bar{q}$ of potatoes to sell to a trader T, who can re-sell it at a price of v (net of transport costs). T is informed about the realization of v. The farmer receives a signal σ concerning the realization of v. Conditional on this signal, the farmer's beliefs are represented by a distribution function $G(.|\sigma)$ with support $[\underline{v}, \bar{v}]$, which has a density $g(.|\sigma)$ which is assumed to be positive throughout the interior of the support. We impose the standard regularity condition that the inverse hazard rate $\frac{1-G}{g}$ is non-increasing in v. The farmer can sell directly in the market at an additional cost of t relative to the trader, i.e., the farmer would obtain a price of $v - t$ if he were to sell directly. In this section we take t to be exogenous and independent of v. It is the existence of this differential cost that motivates the farmer to sell to the trader. It can represent differences in transport cost (owing to economies of scale) and in marketing connections at the mandi.

If the farmer sells q to the trader at a price of p, his ex post payoff is $pq + u(\bar{q} - q)$, where u is strictly increasing and strictly concave. The trader's ex post payoff equals $(v - p)q$. Their risk attitudes are represented by von-Neumann Morgenstern utility functions $\mathcal{U}$ and $\mathcal{V}$ respectively, which are strictly increasing and concave. For most part we shall assume that both parties are risk neutral. Later in this section we shall argue that the main predictions of the model continue to apply when they are risk-averse.

The farmer's supply function $q^*(p)$ is defined by the solution to $\max_{q \leq \bar{q}}[pq + u(\bar{q} - q)]$. Let $\Pi(p)$ denote the corresponding profit function. The ex post autarky payoff for the farmer is then $\Pi(v - t)$.

We follow the approach of Myerson and Satterthwaite (1983) and analyze incentive efficient bilateral contracts. Let λ denote the welfare weight of the trader relative to the farmer. This represents the relative bargaining power of the trader. The case of a perfect monopsony corresponds to one where $\lambda = \infty$, i.e., where the farmer has no welfare weight at all. At the other extreme is perfect competition, where $\lambda = 0$. Whether λ is larger or smaller than one affects the nature of optimal contracts.

The timing of moves is as follows. The contract is designed at an ex ante stage, when neither trader or farmer have acquired any information about prices. It can be thought of as an implicit long-term contract, applicable to trading over many successive points of time. Whatever competition exists operates at this ex ante stage. So the ex ante contract is designed to maximize a weighted sum of ex ante expected payoffs of the trader and the farmer, with λ being the relative welfare weight of the trader. The Revelation Principle applies to this context, so without loss of generality attention can be confined to the following trading mechanism.

On any given date, the farmer receives a signal of the mandi price v at which the trader can re-sell the potatoes, while the trader observes the actual realization of v. At this (interim) stage there is asymmetric information. The trader and farmer then independently decide whether to participate in the trade. If either of them decides not to, there is no trade. If both agree to participate, the trader makes a report $\tilde{v}$ of the price he has observed to the farmer. The contract specifies prices and quantities to be traded as a function of the farmers signal and the price report made by the trader: they exchange $q(\tilde{v})$ units of the good for an amount of money $r(\tilde{v})$ paid by the trader to the farmer. The price $p(\tilde{v})$ is defined by the ratio $\frac{r(\tilde{v})}{q(\tilde{v})}$.

The optimal contract $q(v|\sigma), r(v|\sigma)$ solves for functions $q(v), r(v)$ that maximize

$$\int_{\underline{v}}^{\bar{v}} [\mathcal{U}(r(v) + u(\bar{q} - q(v))) + \lambda \mathcal{V}(vq(v) - r(v))] dG(v|\sigma) \tag{1}$$

subject to the incentive constraint

$$vq(v) - r(v) \geq vq(v') - r(v') \quad \text{for all} \quad v' \in [\underline{v}, \bar{v}] \tag{2}$$

and the participation constraints

$$vq(v) - r(v) \geq 0 \tag{3}$$

and

$$\int_{\underline{v}}^{\bar{v}} \mathcal{U}(r(v) + u(\bar{q} - q(v)))dG(v|\sigma) \geq \int_{\underline{v}}^{\bar{v}} \mathcal{U}(\Pi(v - t))]dG(v|\sigma) \tag{4}$$

5.0.1 Symmetric Information

We consider as a benchmark the case where the farmer's signal σ is the same v observed by the trader. Here the distribution G is degenerate, concentrated entirely at the true value v. The efficient contract with symmetric information then maximizes

$$\mathcal{U}(r(v) + u(\bar{q} - r(v))) + \lambda\mathcal{V}(vq(v) - r(v)) \tag{5}$$

subject to

$$vq(v) \geq r(v) \geq \Pi(v - t) - \mathcal{U}(\bar{q} - q(v)) \tag{6}$$

Lemma 1 *With symmetric information, the optimal contract is* $q^F(v) = q^*(v)$ *and* $r^F(v) = vq^*(v) - s(v)$ *where* $s(v)$ *maximizes* $\mathcal{U}(\Pi(v) - s) + \lambda\mathcal{V}(s)$ *subject to* $\Pi(v) - \Pi(v - t) \geq s \geq 0$.

All proofs are provided in Appendix P. The logic is simple: the quantity traded is the farmer's supply response to the price v, since this maximizes the overall surplus $vq + u(\bar{q} - q)$ of the two parties. Then the financial transfer between the parties divides up this surplus according to their relative welfare weights.

5.0.2 Asymmetric Information

Return to the problem with asymmetric information. Standard manipulations (e.g., using Mirrlees [1986]) show that the incentive and participation constraints (2, 3) for the trader are equivalent to the following constraint:

$$r(v) = vq(v) - \int_{vl}^{v} q(\tilde{v})d\tilde{v} - \underline{V}, \quad \underline{V} \geq 0 \quad \text{and } q(v) \text{ nondecreasing.} \tag{7}$$

This is a convenient representation of the constraints imposed by asymmetric information. $\underline{V}$ can be interpreted as the ex post payoff which will be earned by the trader in state $\underline{v}$, and $\int_{vl}^{v} q(\tilde{v})d\tilde{v}$ is the additional rent earned by the trader in state v owing to asymmetric information. The interim participation constraint states that $\underline{V}$ must be non-negative. The monotonicity of q is a consequence of the single-crossing property, wherein an increase in q is more valuable to the trader when v is higher.

This enables us to substitute out the transfers and reduce the asymmetric information contract problem in terms of $q(v)$ and $\underline{V}$ alone, which must maximize

$$\int_{\underline{v}}^{\bar{v}} [\mathcal{U}(vq(v) + u(\bar{q} - q(v)) - \int_{\underline{v}}^{v} q(\tilde{v})d\tilde{v} - \underline{V}) + \lambda\mathcal{V}(\int_{\underline{v}}^{v} q(\tilde{v})d\tilde{v} + \underline{V})]dG(v|\sigma) \tag{8}$$

subject to $\underline{V} \geq 0$ and that $q(v)$ is non-decreasing. The trader's surplus $\underline{V}$ in state $\underline{v}$ is selected purely on distributive grounds; hence its optimal value will depend on λ. The monotonicity constraint on $q(v)$ will turn out not to bite owing to the assumption on the monotonicity of the inverse hazard rate. So we shall ignore it from now on. Hence the problem reduces essentially to selecting the quantities traded $q(v)$ to maximize (8) in an unconstrained fashion.

Proposition 2 *Suppose both parties are risk-neutral. Then the optimal contract with asymmetric information (i.e. where $g(v|\sigma) > 0$ for all $v \in [\underline{v}, \bar{v}]$) satisfies*

$$q(v|\sigma) = q^*(v - \mu\frac{1 - G(v|\sigma)}{g(v|\sigma)}) \tag{9}$$

for some $\mu \in [0, 1]$, which is strictly positive (unless $\lambda > 1$ and t exceeds some threshold t^*). If $\lambda < 1$, μ equals $(1 - \lambda)$. The transfer satisfies

$$r(v|\sigma) = vq(v|\sigma) - \int_{\underline{v}}^{v} q(\tilde{v}|\sigma)d\tilde{v} - \underline{V} \tag{10}$$

The result states that asymmetric information causes quantities traded to shrink in general, relative to the symmetric information benchmark. In state (v, σ) the trader earns a markup of $\mu\frac{1-G(v|\sigma)}{g(v|\sigma)}$. Effectively the trader understates v by this markup, and offers a net price of $v - \mu\frac{1-G(v|\sigma)}{g(v|\sigma)}$ to the farmer, who responds to this with his optimal supply response. The markup causes the farmer to supply less compared with the case of symmetric information, a consequence of the trader's monopoly over information regarding v. The bargaining power of the two parties (i.e, welfare weight λ and t which defines the outside option of the farmer) affects this markup only through μ, the weight applied to the inverse hazard rate of G.

The main implication of the result is that asymmetric information causes an inefficient shrinkage of quantities traded, except in the case where the trader has greater bargaining power ($\lambda > 1$) and t is large, i.e., the farmer's outside option of going to the market directly is low enough. We shall refer to this as the *unconstrained monopsony* case, as it corresponds to situations where the trader acts as a monopsonist, and the participation constraint (4) of the farmer is not binding. In this case, the efficient quantity gets traded in each state ($q(v) = q^*(v)$), while the 'fixed fee' $\underline{V}$ is set equal to

$$\underline{V}^*(t) \equiv \int_{\underline{v}}^{\bar{v}} [\{v - \frac{1 - G(v|\sigma)}{g(v|\sigma)}\}q^*(v) + u(\bar{q} - q^*(v)) - \Pi(v - t)]dG(v|\sigma) \tag{11}$$

so that the farmer is indifferent between participating or not (i.e., (4) is met with equality). As all the surplus goes to the trader, the incentive constraints do not bite as they do not generate any externalities. The threshold t^* is defined by the property that $\underline{V}^*(t^*) = 0$.

If $t < t^*$ this solution is no longer feasible: i.e., the farmer's outside option of selling in the market directly binds. In such cases, an inefficient contraction in trade volume must occur: $\mu > 0$ is chosen so that

$$\int_{\underline{v}}^{\bar{v}} [\{v - \frac{1 - G(v|\sigma)}{g(v|\sigma)}\}q^*(v - \mu\frac{1 - G(v|\sigma)}{g(v|\sigma)}) + u(\bar{q} - q^*(v - \mu\frac{1 - G(v|\sigma)}{g(v|\sigma)})) - \Pi(v - t)]dG(v|\sigma) = 0 \tag{12}$$

while the fixed fee $\underline{V}$ is set at zero. We refer to this as the *constrained monopsony* case.

In the case where the farmer has greater bargaining power — the *competitive* case – with $\lambda < 1$, the fixed fee $\underline{V}$ is set at zero, and $\mu = 1 - \lambda$. Hence trade volumes are inefficiently low in either the competitive or constrained monopsony cases. This is in order to limit the tendency of the trader to understate v: if the trader claims that v is low then trade volumes shrink more than they would under symmetric information. The lower the v, the greater the shrinkage of traded volumes.

Having thus characterized the optimal contract, we now examine the comparative static effect of varying the information of the farmer. The simplest way to do this is to compare the optimal contracts with asymmetric and symmetric information respectively.

In the unconstrained monopsony case, the quantity traded is unaffected by asymmetric information, and so are transfers. In the other two cases, quantities traded are uniformly lower, except when $v = \bar{v}$. Moreover q co-moves more with v under asymmetric information — owing to the strategic reduction in trades when the trader reports low v. Conversely, *going from asymmetric to symmetric information either has no effect at all (in the case of an unconstrained monopsony), otherwise it raises the level of traded quantities, while reducing the extent to which they co-move with v.*

What happens to prices? Suppose we are in the competitive case. Under symmetric information $p^F(v) = v$, but with asymmetric information

$$p(v) = v - \frac{1}{q(v)} \int_{\underline{v}}^{v} q(\tilde{v}) d\tilde{v} \tag{13}$$

So if traded quantities are always strictly positive, the level of prices must be lower everywhere with asymmetric information: $p(v) < v$, except at $\underline{v}$ where $p(\underline{v}) = \underline{v} = p^F(\underline{v})$. This is just the statement that the trader earns information rents, despite farmers having disproportionate bargaining power. Moreover, on average prices must co-move less with v under asymmetric information, in the sense that $p(\bar{v}) - p(\underline{v}) < \bar{v} - \underline{v} = p^F(\bar{v}) - p(\underline{v})$. It is harder to provide a condition for the slope of p to be uniformly lower under asymmetric information, as the comparison can go either way in general.[8] Hence in the competitive case we only get a general result concerning the level of prices, but not the extent to which they co-move (except 'on average').

Even with respect to the level of prices, the results are sensitive to the allocation of bargaining power. For instance, in the constrained monopsony case, better information can lower the price that the farmer receives. At $v = \underline{v}$, under symmetric information the price is $p^F(\underline{v}) = \underline{v} - \frac{\Pi(\underline{v}) - \Pi(\underline{v}-t)}{q^*(\underline{v})}$ which is lower than the price with asymmetric information $p(\underline{v}) = \underline{v}$. Asymmetric information may reduce the traders ability to extract monopsony rents from the farmer.

Hence the more robust prediction of the ex ante contract model is the effect on quantities traded, in which levels rise and co-movement falls as a result of better information. Indeed, this same result holds also in the case of risk-aversion (see [Hart, 1983]). The same logic applies: traded volumes shrink relative to the first-best when traders report a low mandi price in order to discourage them from under-reporting. Efficient trade volumes are determined by the tradeoff

[8] This requires $\int_{\underline{v}}^{v} q(\tilde{v}) d\tilde{v}$ to be rising in v at a faster rate than $q(v)$. This condition may or may not be satisfied, depending on the slope of q at v.

between ex post efficient trade and the need to limit information rents accruing to traders.

To what extent do these results concerning the effects of reduced informational asymmetry hold locally, i.e., when we have a slight reduction in the asymmetry? This is a more complex question, compared with the 'global' comparison above. Suppose that the noise in the farmer's signal σ is indexed by a parameter n, so a higher n corresponds to a less informative signal. Let the optimal quantity traded be denoted $q(v|\sigma, n)$ in the state where the trader observes v, the farmer observes a realization σ of his signal, which has noise n. We have seen above that

$$q(v|\sigma, n) = q^*(v - \mu \frac{1 - G(v|\sigma, n)}{g(v|\sigma, n)})) \tag{14}$$

The effect of a change in n on either q or q_v depends on where the effect is being evaluated, in particular the signal realization σ relative to the true state v since the effect of n on the inverse hazard rate depends on this.[9] For any given true state v, the realization of the signal will be random. One should perhaps be interested in the average effect, while averaging over different possible signal realizations. This generates an additional complication: a change in v is likely to change the realized values of the signal, if the signal is informative. The 'total' effect should incorporate this dependence.

However, we argue now using a specific example that the same prediction concerning the effect of asymmetric information on traded quantities continues to hold for local changes. Suppose that G is uniform on the support $\sigma - \frac{n}{2}, \sigma + \frac{n}{2}$ which is a subset of $[\underline{v}, \bar{v}]$, and $u(c) = \log c$. To guarantee interior solutions for quantity, assume that $\underline{v} > \frac{1}{\bar{q}}$. Then

$$q(v|\sigma, n) = \bar{q} - [(1 + \alpha)v - \alpha(\sigma + \frac{n}{2})]^{-1} \tag{15}$$

Then $q_n(v|\sigma, n) < 0$ while $q_{vn}(v|\sigma, n) > 0$ for all v, σ, n, i.e., for any fixed signal realization σ an improvement in the farmer's information (lower n) will raise the quantity traded and lower the slope of q with respect to v. Moreover, the same is true if we incorporate the effect of changes in v on the signal realization itself, in the following sense. Let $Q(v|n) \equiv q(v|v, n)$, i.e., the quantity traded when the farmer observes a realization of the signal which is the true state v. Then $Q_n < 0$ while $Q_{vn} > 0$. In this example, the price is

$$p(v|\sigma, n) = v - \int_{\sigma - \frac{n}{2}}^{v} \frac{\bar{q} - [(1 + \alpha)\tilde{v} - \alpha(\sigma + \frac{n}{2})]^{-1}}{\bar{q} - [(1 + \alpha)v - \alpha(\sigma + \frac{n}{2})]^{-1}} d\tilde{v} \tag{16}$$

[9] An added complication is that in the case of a constrained monopsony, μ depends on a Lagrange multiplier whose value would depend on n.

and we see that $p_n < 0$, while p_{vn} is difficult to sign. Improved information then raises the price.

6 Empirical Anslysis

We now turn to the data to examine the effects of the information intervention. The empirical analysis will be presented as follows. First, we show that our intervention changed farmers' information sources and information set, thus confirming that our intervention did take place as planned. Next, we analyze the impact of the intervention on the farmers' quantities sold and price received. Finally, we examine the effects on area planted, quantity harvested, and the allocation of quantities into storage. Given that the intervention began in 2007 and farmers knew that it was going to continue throughout 2008, farmers could have changed their planting, input and sales decisions in anticipation of the effects of the information they would have. We will then take these results together and interpret them with reference to the ex ante contracting theory described above.

6.0.3 Effect on farmers' price information

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

Table 6 shows the average response to the question "who is your source of information?" for farmers who reported that they did track potato prices.[10] As mentioned earlier,*phorias* are an important source of information: in the control group villages, farmers report 74 percent of the time that their source is the trader. The information intervention reduced this reliance on the *phoria*: in the private information villages the *phoria* was the source of information 59 percent of the time, and in the public information villages this number went down further to 42 percent.

[10]Note that not all farmers track prices, and this margin may also have changed as a result of the intervention; more on that below.

As one might expect, the private information intervention increased the likelihood that farmers got price information from their friends and neighbors (from 16 percent to 22 percent). However the most dramatic change in information source occurred in the public information villages, where farmers reported that 37 percent of the time they tracked prices through "other" sources. This category was chosen instead of a long list of categories offered in the questionnaire, including friends, relatives, neighbours, caste members, traders, members of local government, NGO employees, cooperative members, and government officials. We therefore believe that this "other" category includes our public information posting in the village.[11] The results thus indicate that our intervention did receive the attention of the sample farmers, and they did use it to follow prices.

In fact, the fortnightly data allow us to see how the source of information changed over time. It is possible that farmers care more about tracking prices at certain times of the year, for example, when prices tend to be more volatile. In addition, they may stop tracking prices once they have sold off all their stocks. Our intervention delivered price information throughout the year, but farmers may have paid more or less attention at different times depending on the circumstances. Finally, there may also have been learning over time: as farmers learned about our intervention they may have switched their source of information. Figure 9 shows that among those in the control group who track prices, there is movement in favour of the trader as time since harvest passes. It is possible that in the harvest period farmers are involved in high-volume sales over a relatively short duration and information may flow more freely within the village. In contrast, in the post-harvest period sales are likely to be low frequency events and the trader might be the only source of information. However, this shift in favour of the trader over time does not occur in the private information group: the probability of relying on the trader is lower to start with (this lower starting point is probably due to the fact the intervention is continuing from 2007), and remains roughly constant over the year. In the public information group, the likelihood of getting information from the trader drops in the post-harvest early period (until July, when home stores are exhausted) and then remains low. This could be an indication of learning over time.

Table 7 presents regressions run on this same sample of farmers, with one observation for each fortnight in which we ask the question. We include as controls a dummy for each fortnight to control for seasonal changes in price information tracking behavior. Column 1 indicates that

[11] The question did not include our posting or the mobile phone call we made in the private information villages, as categories in this question to avoid making our intervention more salient through our questionnaire.

the public information treatment increased wholesale price tracking: farmers were more likely to report that they tracked prices in villages where we posted daily price information in public locations. With private information we do not see any change in aggregate, although column 2 shows that those farmers who received phonecalls from us were more likely to report that they tracked prices. Column 3 shows that both treatments reduce the time since they last tracked the price by roughly 0.7 to 0.8 of a day.

Finally, we check if the intervention changed farmer's information about what the price was. Before interpreting this regression it is useful to consider the exact phrasing of the question in our questionnaire. We asked farmers "Do you keep track of retail prices? Do you keep track of wholesale prices?" and if they reported yes to either question, they were asked the name of the market where they tracked prices, the variety they tracked prices for, the number of days since they had last tracked the price, the price when they had last tracked it, and their source of information. We did not specify if farmers should report the price that *phorias* received when they sold in the market, or the price that the farmers would themselves receive if/when they sold in the market. Given the large mean gap between the tracked prices reported by intervention farmers, and the mandi prices that we were reporting in our public postings and phonecalls, we infer that farmers were reporting to us the prices they would receive if they were to sell in the market. Our intervention caused public information farmers to revise this prices upwards: they reported prices that were on average 26 paise higher (this translates to about 12.5 percent higher over a baseline of Rupees 2 per kg) than the control group farmers. We see no such change for private information farmers.

7 Testing Predictions of the Ex Ante Contracting Model

7.0.4 Effect on quantity sold and price received by farmers

Next, we examine the effect of the interventions on the farmers' sales and prices received. We have detailed data about potato sales transactions collected through fortnightly surveys. However, to analyse the data at the weekly level we must model the dynamics of farmer decisions of whether and when to sell, and the non-stationarity across different times of the year because their stocks and the time horizon over which they are optimizing changes week-by-week. In addition, we would have to account for seasonal changes of the market price and the role of future price expectations.

Putting this aside for future work, in this paper we focus on aggregate sales and average price received within the year. All potatoes must be sold within the year (potatoes stored at home perish within a few months of harvest, and all potatoes must be removed from cold storage in November to allow for annual cleaning), and thus by aggregating over all transactions within the year for each farmer[12] we avoid modeling the dynamics and the endogeneity of the sales decision.[13] By aggregating in this manner, we shall be examining effects of across-mandi variations in the mandi price v. As discussed above, our analysis of variance shows that mandi prices vary substantially from year to year. Year dummies explain by far the highest proportion of the variation in mandi prices in our data. It is therefore clear that farmers cannot predict the average annual mandi price ex ante.

The effects on the annual total quantity sold, average price received (net of transactions costs paid by the farmer) and the average tracked price are shown in Tables 8, 9 and 10. The unit of observation is a farmer-variety-quality combination. We include variety and quality dummies, as well as a district dummy for Medinipur. In addition we 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. The regression specification is as follows:

$$y_{ijq} = \beta_0 + \beta_1 \text{Private information}_i + \beta_2 \text{Phone recipient}_i + \beta_3 \text{Public information}_i + X_{ijq} + \epsilon_{ijq}$$

where $y_i t$ is the dependent variable: price received, quantity sold or the tracked price reported for farmer i, variety j and quality q. Private information and Public information are dummy variables to indicate which treatment group the farmer was in. Private information farmers could also be phone recipients in which case they would also receive a value 1 for the Phone recipient dummy (this dummy is included in column 2). In that case private information should then be interpreted as the effect on farmers whose village received the private information treatment but who did not personally receive phonecalls. Instead any effect on their outcomes would occur through the spread of information from the phonecall recipients through to them. In Table 8 we

[12] In fact, for each farmer we know each variety that he produced and the amount of his harvest of each variety that was of high or low quality. Our data are thus at the level of farmer-variety-quality.

[13] Another way to avoid the dynamics and endogeneity issues is to focus on weekly sales occurring late in the year, when farmers must sell most of their remaining stocks and so the issue of future price expectations is not so important. We can then examine the effects of weekly variations in prices. However even with this there will be selection effects: farmers' price expectations in the past will have determined whether they still have unsold stocks at the end of the year. However we can check if our main results hold in this specification.

see in columns 1 and 2 that although the sign of the coefficient is positive for all intervention dummies, the coefficients are not significantly different from zero. Next, in columns (3) and (4) we include mandi fixed effects into the regressions. This way we are now comparing the effect of the intervention across different treatment groups within the catchment area of the same mandi. This reverses the sign of the coefficients, but they remain non-significant. This contradicts the prediction of the theory outlined above, which predicted that the aggregate quantity sold should increase as a result of the intervention.

Table 9 show that analogous to the findings of Fafchamps and Minten [forthcoming], there is also no impact of the intervention on the average net price. Note however that the theory shows does not deliver clear predictions about the average impact on prices. Instead we should be looking at the effects of the intervention on the co-movement of quantity and price with the mandi price. (Confining attention to average quantity and prices, the result is still consistent with the unconstrained monopsony version of the theory.) These results are presented in Table 11. The regression in column (1) now takes the following form:

$$y_{it} = \beta_0+\beta_1 p_{imt}+\beta_2\text{Private information}_i+\beta_3\text{Public information}_i+\beta_4\text{Private}_i\times p_{imt}+\beta_5\text{Public}_i\times p_{imt}+X_{it}+\epsilon_{imt}$$

The intervention dummies now indicate how the intercept of price and quantity changed as a result of the intervention (in other words, when the mandi price was a hypothetical value of zero), whereas the interaction terms indicate the co-movement of the dependent variable with the mandi price. As column (1) shows, the private information treatment had a significant effect on quantities traded. The intercept fell (although the coefficient is not significant) and the slope increased, thus indicating increased co-movement of quantity sold with the average mandi price. This result becomes sharper when we focus on the effect on phone non-recipients, and becomes even stronger when we include mandi fixed effects in column (3) and (4). Furthermore, even the public information intervention significantly increased co-movement in the mandi fixed effects regressions. Using this linear specification, we can also estimate the different effects depending on whether mandi prices were high or low. As the total effects in the bottom panel of the table show, the results indicate that in mandis where average prices were low, the information intervention caused farmers to reduce quantity sold (this is significant in columns (3) and (4)) whereas in mandis where average prices were high, the intervention caused farmers to increase quantity sold. Note that this finding contradicts the predictions of all of the versions of the ex ante theory developed above, which predicted that the intervention should reduce the comovement of quantity sold with mandi price.

Consider next columns (5) – (8) which use the net price received as the dependent variable. As can be seen, the co-movement of farmer prices with mandi prices increases as a result of the private information intervention in columns (5) and (6) and this impact is larger when mandi fixed effects are included (columns 7-8). Public information does not have a significant effect. This pattern can be seen again when we consider the effects at the 10th percentile and 90th percentile of mandi prices in the panel below. These results are also inconsistent with the prediction of the competitive version of the theory, where prices always rise, if at all.

Finally, we turn to the effects on farmer decisions to plant, quantities they produced, and the allocation of harvest into sales versus non-sales, and their storage decisions. Since farmers faced the same interventions in 2007 and expected them to continue into 2008, they could have formed expectations about the impact of the intervention. As seen in the price path graphs from historical price data, in a ”normal” year, potato prices rise through the course of the year. As seen above, the private information intervention increased co-movement of farmer prices with mandi prices, and thus by selling at times when prices were high, farmers could have received higher prices. (Note this argument relies on the inter-temporal nature of the price variation, which is not what our regressions above are exploiting.) If so, they may have been incentivized to increase their potato production, and to store potatoes and sell them later in the year. Tables 14 and 15 support this idea. Although the area planted with potatoes did not increase, and increase in quantity harvested is not significant, we find significant impacts of the private information on the yield of potatoes. The percentage of harvest sold does not increase, but there is evidence that farmers in the public information intervention decreased the percent sold in the earlier periods of the year (although this reduction is not significant) and increased the percent sold in the later period of the year (when prices typically would have risen) by 11 percentage points. Unfortunately for them these high price expectations were not realized because in 2008 prices failed to rise over time. This pattern of behaviour is also inconsistent with the unconstrained monopsony version of the ex ante theory.

Our results lead us to conclude that the information treatments did affect farmers' sources of information significantly, caused them to believe that market prices were higher, and to expect to receive higher prices for their produce. They also increased the comovement of quantity sold with mandi price. These results are not consistent with models of ex ante contracts.

8 An Alternative Hypothesis: Ex Post Bargaining

Instead, the evidence that information treatments increased co-movement of both q and p suggests that farmers are always on their supply curve, i.e. they have the option to select q ex post after observing the trader's offers of p. Therefore, we consider ex post bargaining as an alternative explanation.

Field interviews are consistent with the view of ex post bargaining. Almost universally, when asked about how they negotiate with traders, farmers say that they react to price offers made by traders, and decide whether and how much to supply. They assert that there have no ex ante long term contract arrangements with the traders, and that they make no forward commitment to sell any predetermined quantity. Village traders are unwilling to commit to a price offer: they like to wait to see what v is and then make an offer. Farmers respond with a decision of how much to sell at this price.

This introduces a key difference from the screening model of ex ante contracts: we now have a signaling game, as the privately informed party makes the first move with a price offer. In theory, this price offer could reveal his information about v to the farmer. This signaling effect will be incorporated into the model.

What can the farmer do if he does not sell to the trader who made the price offer? This depends on the extent of competition: whether he can solicit competing offers from other traders. This complicates the model considerably. In the data we see multiple village traders co-existing, but farmers tend to sell to the same trader repeatedly. This could be due to credit and quality reputation issues which were mentioned in the introduction, although we have abstracted from them in the theory. There could also be tacit collusion among village traders, or market segmentation which restricts inter-village competition.

However, the farmer has the outside option of taking his crop to the mandi and selling it there. Our detailed field interviews reveal that when farmers sell directly in the mandi they usually cannot receive the same price that the village traders receive. The mandi is not a centralized market. Wholesalers buy from village traders, not from farmers directly. Again this relates to problems with trust concerning quality and credit. Village traders are referred to as 'aggregators'. Wholesalers say it is not worth their time to enter into small transactions with large number of individual farmers they don't know personally: they prefer to delegate the sourcing of potatoes the intermediate aggregators.

As described before, in the data we see that only about 5 percent of potatoes sold by the farmer are sold by him at the mandi. We also saw that when farmers sell the market they receive prices substantially below v, and much closer to farmgate prices. Field interviews with farmers who sell in the mandi indicate that they sell to other traders in the mandi that they know, who are different from their regular village trader. They also mention the problem that they have to incur the cost of transporting their crop to the mandi, and the search cost of finding a trader at the mandi to sell it to. There is potential here for hold-up: the mandi trader knows that in the case of disagreement the farmer will have to take the crop back to the village. This lowers the bargaining power of the farmer.

Despite this, the option of selling in the mandi to a different trader there improves the bargaining power of a farmer vis-a-vis his regular village trader. It creates a form of sequential competition between the vilage trader and the mandi trader. Since the mandi brings together traders from other villages in the neighboring area; it is difficult for traders located in different villages to collude.

This motivates the following model of ex post bargaining, with three players: TV (trader in the village), TM (trader in the mandi) and F (farmer).

Stage 0: TV and TM learn the realization of v, F has beliefs over v represented by distribution function G, and has a given quantity $\bar{q}$ available to divide between sales and consumption (or stock).

Stage 1: TV offers F price p

Stage 2: F responds with either no, or yes and a quantity $q_1 \leq \bar{q}$ for sale to TV at the offered price. In this case F consumes $\bar{q} - q_1$ and the game ends. If F rejects, the game continues.

Stage 3: F takes $q_2 \leq \bar{q}$ to the mandi, and approaches TM (who observes q_2).

Stage 4: TM offers price m.

Stage 5: F decides on $q \leq q_2$ to sell to TM at the offered price, carries back the rest to the village and consumes $\bar{q} - q$.

If TV buys from F, the former incurs a cost of w in transporting each unit from the village to mandi: so he gets net $v - w$ after selling in the mandi. F incurs a unit transport cost which is higher by t, i.e. is $t + w$.

In this section we simplify by assuming that the farmer's supply elasticity is constant (i.e., $q^*(p) = Kp^\epsilon$ for some $K, \epsilon > 0$. To avoid some technical difficulties, we assume there is no upper bound to v, i.e., $\bar{v} = \infty$.

We will focus on two classes of equilibria of this model: a perfectly revealing (separating) equilibrium, and a set of partially revealing (pooling) equilibria.

In the separating equilibrium, the initial price offer by TV will reveal the realization of v to the farmer. From that point onwards, there will be no asymmetric information between the traders and the farmer on the equilibrium path. Subsequently, if F were to reject TV's offer, he will take $q_2 = q^*(\frac{\epsilon}{1+\epsilon}(v+t+w))$ to the mandi, following which TM will offer a price $m(v)$ defined by

$$m(v) = \frac{\epsilon}{1+\epsilon} v - \frac{t+w}{1+\epsilon}. \tag{17}$$

Anticipating this, the following price $p(v)$ if offered by TV would make the farmer indifferent between accepting it and rejecting it and then going to the mandi, assuming that the farmer knows the actual realization of v. It is defined by the solution to the following equation:

$$\Pi(p(v)) = [m(v) - t - w] q^*(\frac{\epsilon}{1+\epsilon} v + \frac{\epsilon(t+w)}{1+\epsilon}) + u(\bar{q} - q^*(\frac{\epsilon}{1+\epsilon}(v+t+w)). \tag{18}$$

In the separating equilibrium this price will be offered by TV, which will reveal v to the farmer because $p(v)$ is strictly increasing in v. The farmer will accept it with probability $\alpha(v)$, given by the solution to the following differential equation

$$\frac{\alpha'(v)}{\alpha(v)} = \frac{1}{v - t - p(v)} - \frac{q^{*\prime}(p(v))}{q^*(p(v))} \tag{19}$$

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

The price $p(v)$ offered by the village trader will take advantage of the fact that if the farmer were to reject, he would have to incur costs of transporting his crop to the mandi. So it will be lower than $m(v)$, the price the farmer would receive in the mandi. And the price offer $m(v)$ in the mandi itself would take advantage of the costs the farmer would incur in transporting the crop back to the village if it were to be rejected. These transport costs therefore drive a wedge between the price the farmers get and what the traders get.

Proposition 3 *Consider arbitrary beliefs $G()$ held by F over v with support $[\underline{v}, \infty)$, conditional on the realization of the signal observed by F which is common knowledge between F, TV and TM. There exists a separating Bayesian perfect equilibrium in which TV offers $p(v)$ at stage 1, F accepts this at Stage 2 with probability $\alpha(v)$. If F rejects, he takes $q_2(v) = q^*(m(v) + \frac{t+w}{1+e})$ to the mandi, whereupon TM offers $m(v)$ and F sells $q_2(v)$ to TM at this price. A price offer of $p \geq p(\underline{v}))$ leads F to believe that $v = p^{-1}(p)$ with probability one, and any price offer below $p(\underline{v})$ leads him to believe $v = \underline{v}$ with probability one. The price offered by TV $p(v)$ is lower than $m(v)$ which is offered by TM. $\alpha(v)$ is strictly decreasing if*

$$\epsilon < 1 + \frac{w}{t} \tag{20}$$

This equilibrium does not depend on the specific beliefs G held by the farmer.

We now turn to another class of equilibria which are not fully revealing. Village traders make price offers that locally do not vary with v, thereby concealing information about small variations in v from the farmer. However, the price offer can jump up by a discrete amount at some thresholds of v, so some information is revealed: that v lies in a specific range.

Proposition 4 *Consider arbitrary beliefs G held by F over v, conditional on the realization of the signal observed by F which is common knowledge between F, TV and TM. There is a continuum of partially pooling Bayesian perfect equilibria with the following features. There is an interval partition ($\underline{v} = v_0 < v_1 < v_2 ...$) of the set of possible v values, and associated prices $r_1 < r_2 < r_3 < ..$ with TV offering r_i if $v \in (v_{i-1}, v_i)$ at stage 1. The price offer r_i is accepted by F with probability β_i, where*

$$\beta_i = \frac{(v_{i-1} - r_{i-1} - t)q(r_{i-1})}{(v_{i-1} - r_i - t)q(r_i)}\beta_{i-1} \tag{21}$$

and $\beta_1 > 0$ is arbitrarily chosen. If F rejects, he takes a quantity $q_{2i} \in (q_2(v_{i-1}), q_2(v_i))$ to the mandi, where TM offers him a price $M(v) = \min\{n(q_{2i}), m(v)\}$, F then sells $Q_2(v) = \min\{q_{2i}, q^*(M(v) + t + w)$, and carries back the rest to the village. Here $n(q)$ denotes the so-

lution for p in $q^*(p+t+w) = q$. A price offer from TV of $p \in (r_{i-1}, r_i]$ for $i \geq 2$ leads F to update his beliefs on the event that $v \in [v_{i-1}, v_i]$, while any price offer below r_1 leads F to believe that $v = \underline{v}$ with probability one.

The thresholds v_i and offers r_i depend on G, the farmer's prior beliefs, as the farmer is indifferent between accepting and rejecting TV's offer (on the equilibrium path), conditional on the information communicated by the offer.

Note that the price offers $M(v)$ made by TM in the mandi are full revealing if q_{2i} is low enough. The willingness of TM to make price offers is not affected by considerations of how much information will be contained in the offer, since there is no other trader the farmer can approach after TM. The price offers made by TV in the pooling equilbria are some kind of rough average of the price offers in the separating equilibrium, since they are tied down by a similar indifference property between acceptance and rejection for the farmer. The average is rough, since the price offer made by TV conceals information about v from the farmer, which in turn affects what the farmer expects from going to the mandi. It consequently affects the amount of crop he takes there; he may end up taking less than what TM is actually prepared to buy at price $m(v)$. Or he may end up taking more, and has to cart back the excess to the village. The outside option payoff of F from rejecting TV's offer is therefore not the same as in the separating equilibrium, and is itself influenced by the offer.

There are many such pooling equilibria, varying with regard to the extent of information communicated by TV's price offer at Stage 1. For any given extent of asymmetric information and a given pooling equilibrium of this kind, there also exist other pooling equilibria which communicate more information to F through the price offers. Here the intervals of the induced information partition of F tend to be narrower, and the price offers are closer to those in the separating equilibrium.

The pooling equilibria are sensitive to how much asymmetric information there is to start with. The class of pooling equilibria converge to the separating equilibrium as the extent of asymmetric information tends to vanish. Since a formal statement and proof of this property involves some technical details, we provide a heuristic account.

Suppose we adopt the following way of measuring the imprecision of F's beliefs. Take any realization v^* of v. Consider any interval $(v^* - \nu, v^* + \delta)$ that contains v^*. Define $R(v^*, \nu, \delta)$ to be the price which if offered by TV and accepted by F would give F the same expected payoff as going to the mandi, with beliefs corresponding to the Bayesian update of G, given F's information that $v \in (v^* - \nu, v^* + \delta)$.[14]

Next, define $D(v^*, \nu, \delta) = ||p(v^*) - R(v^*, \nu, \delta)||$. This can be interpreted as the gap between the price that would have been offered by TV in the separating equilibrium in state v^* and the price that would be offered by TV in a partially pooling equilibrium in which one of the intervals is $v_{i-1} = v^* - \nu$ and $v_i = v^* + \delta$.

Note that as F's prior information G becomes more precise and concentrated around v^*, $R(v^*, \nu, \delta)$ moves closer to $p(v^*)$, for any v^*, ν, δ, and tends to 0 as F's information tends to the full information disstribution completely concentrated at v^*.

Now use

$$D = \sup_{v^*, \nu, \delta} D(v^*, \nu, \delta)$$

as a measure of imprecision of F's prior information.[15] As F's information becomes more precise, D becomes smaller and tends to 0 as F's information tends to full information.[16] But D is an upper bound to the gap between the price offered by TV between the separating equilibrium and any partially pooling equilibrium of the type described above. As F's information becomes more precise, some of the partially pooling equilibria will therefore be eliminated, while those sufficiently close to the separating equilibrium will continue to survive.

8.1 Evidence for the Predictions of the Ex Post Bargaining Model

What does this model predict? As long as F is not perfectly informed, there are multiple equilibria, including the separating equilibrium and a continuum of partially pooling equilibria. It should be noted that there are other equilibria outside these two kinds, so predictions are highly context-specific. We focus therefore on providing an equilibrium explanation of what we see in the data.

[14] Here 'going to the mandi' means the payoff from the continuation game in which F first selects a quantity q_2 to take to the mandi, with TM subsequently offering the price $M(v) = \min\{p(q_2), m(v)\}$ if the true realization is v, and F then selling $\min\{q_2, q(M(v) + \frac{t+w}{1+e})$ to TM.

[15] We abstract here from technical details with the precise assumptions needed for this to be a valid measure. Specifically, D needs to be finite valued, since the support over v is unbounded. Suitable assumptions on finiteness of second moments of relevant distributions are needed.

[16] Provided D is bounded, the weak convergence topology on beliefs will imply pointwise convergence of price offers.

First, for either kind of equilibrium, the farmgate price is lower than the farmer mandi price for any v. And the farmer tends to reject the village trader's offer more often and sell in the mandi as v becomes higher (provided (20) holds, which will indeed be the case if $m'(v) < 1$). We saw this pattern in the graph in Figure 9, where throughout the year, farmers who sold in the market received higher prices than farmers who sold to phorias. This is shown more rigorously in Table 16, where controlling for mandi price, district and land ownership, farmers who sell at the market receive a higher price than those who sell to the *phoria* or other traders/moneylenders.

Second, as F's information becomes more precise owing to information treatments, the effects depend on which equilibrium we start with.

If we start in the separating equilibrium, it continues to be an equilibrium, in which case the information treatment has no effect. The offers made by TV effectively revealed v to F, so external information about v is superfluous.

But if we start in a partially pooling equilibrium, farmgate prices do not perfectly co-move with v: within any of the intervals in the partition the farmgate price is constant. Increasing the precision of F's information enough will eventually cause this equilibrium to break down. Within the class of equilibria of the two types above, we must move to an equilibrium with greater co-movement of farmgate prices with v. But the extent to which co-movement rises depends on how closely they were co-moving to start with, i.e., how close the initial equilibrium was to the separating equilibrium.

Irrespective of which equilibrium we start with, we do not expect to see a significant average impact of better information on farmgate prices. This is because the equilibria have the feature that the behavior of the trader at the mandi does not change as the farmer's information becomes better (except insofar as the farmers information affects what q_2 he takes to the mandi, and this may fall below what TM is willing to buy). TM is willing to buy at price $m(v)$, as long as the farmer brings along the quantity that constitutes an optimal supply response to this price. And the price offered by TV is constructed to make the farmer indifferent between selling to him and going to TM. So the average price offered by TV will not change materially as a result of the information treatment.

Hence we do not expect to see an average impact on farm-gate prices, while there may be increased co-movement of farmgate prices with v. Again, our findings described earlier are consistent with these predictions: in Table 9 we saw no effect of the intervention on the average price received by farmers, whereas in Table 12 we saw that the intervention caused prices received by farmers to co-move more with mandi prices.

Third, if information treatments have an effect on p for any given v, they will also affect q in the same direction as a result. Again, this is consistent with our finding that co-movement with mandi prices increased for both quantity sold by farmers and price received.

Fourth, if transport costs rise and everything else is unchanged, $m(v)$ shifts down, and the gap between $p(v)$ and $m(v)$ increases (if we are in the separating equilibrium or a close enough pooling equilibrium to start with). Hence middlemen margins are higher. This is reflected in the difference between the middleman margins in Hugli and Medinipur. In Medinipur, which is less densely populated and where distances to the market are higher, farmers receive a smaller proportion of the mandi price than in Hugli.

Moreover, for given endpoint $\alpha(\underline{v})$, $\alpha(v)$ will fall for each $v > \underline{v}$. So F will accept the village trader's offer less and go to the mandi more frequently. In Table 3 we found that farmers in Medinipur were more likely to visit the mandi than in Hugli.

9 Conclusion

We have reported results of a field experiment providing market price information to potato farmers in West Bengal. In contrast to previous work showing that increased access to information has straightforward positive average effects on producer prices and reduced price dispersion across markets, we find that the effects of price information are conditional on the nature of the contracts written between farmer and trader, and conditional on the prevailing market price. Our theoretical analysis suggests that instead of looking merely at the average impact of the intervention, it is instructive to look at how quantities sold and producer prices co-move with the market prices. In our context of potato production in West Bengal, we find that mandis are not anonymous centralized markets: farmers cannot sell directly at the mandi and expect to receive the mandi price. Field interviews suggest that credit and quality issues prevent large traders and farmers from trading with each other directly, and therefore the middleman's role continues to be important. Although receiving price information through our intervention improves the farmers' knowledge of mandi prices, he is unable to receive that price even when he transports his potatoes to the market directly. He must also face a hold-up problem in that a non-sale must mean he must incur the additional cost of transporting the potatoes back from the market. Faced with such limited outside options, farmers' average revenues from sales to their regular buyer does not increase significantly in response to a price information intervention.

Our data allowed us to examine the nature of the mechanism by which farmers enter into trades with middlemen. Despite the existence of trade credit as well as input credit from traders, the evidence allows us to reject models of long term ex ante contracts which require parties to commit in advance to trades conditioned on ex post information about prices. This is consistent with what was reported to us in interviews with farmers and traders. Farmers do not appear to pre-commit to selling to particular traders, and traders do not appear to be pre-committing to a price. Instead there is ex post bargaining between farmer and trader. Here there is some competition between traders: the farmer is not compelled to sell to any given trader. Yet the farmer's outside options are limited in the bargaining between any given local trader-farmer pair: the farmer can reject a price offered by the local trader and take his potatoes to the mandi where he sells to a different trader. The competition is limited both by the sequential and spatially separated form of the two trading options, requiring the farmer to carry his potatoes to the market and then subject to whatever price is offered there. Anticipating these limited outside options, the village trader offers a price to the farmer that makes the farmer indifferent between accepting and rejecting.

The underlying cause of ineffectiveness of price information provision to farmers is the weakness of both formal and informal marketing institutions. Farmers do not have the option of taking their potatoes to the mandi and selling there on par with other traders. This owes to the fact that the wholesale potato markets in West Bengal are not centralized, where anyone can bring their goods for sale and receive the same market-clearing price as any other supplier (controlling for variety and quality). Many other parts of India do involve centralized wholesale markets for agricultural commodities: for example in Maharashtra or Madhya Pradesh where government agents placed in these markets evaluate the quality of produce brought by farmers and then supervise auctions in which the produce is sold at market clearing prices. Mandis in West Bengal still feature decentralized trades between large buyers and local traders engaged in bilateral long term personalized relationships. This creates entry barriers for farmers or other newcomers who intend to sell in these markets.

Consequently farmers are forced to sell to local traders, also on a bilateral personalized basis. These informal trading relationships however involve ex post bargaining rather than long term commitment to trading rules. Despite the multiplicity of traders within any village or market, farmers are locked into selling to particular traders at any given location owing to the importance of reputations on either side for trustworthy behavior. Some limited competition arises between traders in different locations, allowing them to earn large margins that grow disproportionately when wholesale prices rise. These informal relationships do not allow any risk-sharing or trade commitments. Reducing the extent of informational symmetry regarding wholesale prices then has no significant impact on farmgate prices on average, and expose farmers to greater volatility.

With regard to policy implications, the analysis of this paper highlights the importance of the role of government in organizing wholesale markets that reduce entry barriers for farmers or newcomers. Encouraging entry into marketing by retail chains integrating backwards via forms of contract farming is another way of trying to increase forces of competition that will both help farmers realize a higher price and deliver higher outputs. Any of these policy options are subject to other hazards: possibility of collusion among government regulators and buyers of produce in wholesale markets in the former case, and possibilities of predatory pricing by retail chains.

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Appendix P: Proofs

Proof of Lemma 1. Define $s(v) \equiv vq(v) - r(v)$, so the efficient contract selects $s(v)$ and $q(v)$ to maximize $\mathcal{U}(vq(v)+u(\bar{q}-qv)-s(v))+\lambda\mathcal{V}(s(v)$ subject to $vq(v)+u(\bar{q}-q(v)-\Pi(v-t) \geq s(v) \geq 0$. The result now follows. ∎

Proof of Proposition 2. With risk neutrality, the objective function (8) reduces to

$$\int_{\underline{v}}^{\bar{v}} [\{v + (\lambda - 1)\frac{1 - G(v|\sigma)}{g(v|\sigma)}\}q(v) + u(\bar{q} - q(v)) + (\lambda - 1)\underline{V}]dG(v|\sigma) \tag{22}$$

If $\lambda > 1$ it is optimal to set $\underline{V} = \underline{V}^*(t)$, while if $\lambda < 1$ it is optimal to set $\underline{V} = 0$.

In the former case, the objective function (22) reduces to

$$\lambda \int_{\underline{v}}^{\bar{v}} [vq(v) + u(\bar{q} - q(v))]dG(v|\sigma) - (\lambda - 1) \int_{\underline{v}}^{\bar{v}} \Pi(v - t)dG(v|\sigma) \tag{23}$$

so the problem is to maximize

$$\int_{\underline{v}}^{\bar{v}} [vq(v) + u(\bar{q} - q(v))]dG(v|\sigma) \tag{24}$$

subject to

$$\int_{\underline{v}}^{\bar{v}} [\{v - \frac{1 - G(v|\sigma)}{g(v|\sigma)}\}q(v) + u(\bar{q} - q(v)) - \Pi(v - t)\}dG(v|\sigma) \geq 0. \tag{25}$$

The unconstrained optimum involves $q(v) = q^*(v)$, which satisfies constraint (25) if and only if $t \geq t^*$. If $t < t^*$, the solution is as depicted in Proposition 2 with $\mu = \frac{\alpha}{1+\alpha}$, where α is the Lagrange multiplier on constraint (25).

If $\lambda < 1$, the result is immediate, as $\underline{V}$ is optimally set at zero then. ∎

Proof of Proposition 3. Working backwards from Stage 5, suppose F had taken q_2 to the mandi and received a price offer of m from TM. How much would he want to sell at this price? This corresponds to selecting $q \leq \bar{q}$ to maximize $mq - (t + w)(q_2 - q) + u(\bar{q} - q)$. The 'effective' price received by F is now $m + t + w$, since anything not sold here will have to be transported back at an additional cost of $t + w$. The solution to this is $q(q_2, m) = q^*(m + t + w)$ if $q_2 \geq q^*(m + t + w)$, and q_2 otherwise. Note here that the farmer's beliefs regarding v do not matter at Stage 5, since the only option he has at this stage is to either sell to TV at the offered price m or consume the rest.

Now move to Stage 4, where TV is approached by F with stock q_2. Let $n(q_2)$ be defined by the solution to m in $q^*(m+t+w) = q_2$. Any price m bigger than $n(q_2)$ is dominated by the price $n(q_2)$ since it would result in the same traded volume q_2 but at a higher price. Any price m lower than $n(q_2)$ will result in traded volume of $q^*(m+t+w)$ at price m. Hence TV selects a price $m \leq n(q_2)$ to maximize $(v-m)q^*(m+t+w)$.

Given the constant elasticity form that q^* takes, the solution to this problem is as follows:

$$m(v, q_2) = \frac{\epsilon v - t - w}{1+\epsilon} \tag{26}$$

provided $q_2 \geq q^*(\frac{\epsilon v - t - w}{1+\epsilon} + (t+w)) = q^*(\frac{\epsilon}{1+\epsilon}(v+t+w))$, and $n(q_2)$ otherwise. Note again that this decision doesn't depend on beliefs held by F.

We move back to Stage 3, and suppose that F has decided to reject TV's offer. What decision should he make regarding q_2? Here his beliefs regarding v matter, since they affect what he expects TM to offer at Stage 4. Suppose that F believes that the realization of v is $\tilde{v}$ with probability one. A choice of $q_2 \leq q^*(\frac{\epsilon}{1+\epsilon}(\tilde{v}+t+w))$ will result in a sale of q_2 to TM at a price of $n(q_2)$, and an expected payoff of

$$\mathcal{P}(q_2, \tilde{v}) \equiv n(q_2)q_2 + u(\bar{q} - q_2) - (t+w)q_2. \tag{27}$$

Given the definition of the function $n(.)$, it follows that

$$\mathcal{P}(q_2, \tilde{v}) = \Pi(n(q_2) - t - w) - x$$

which is (locally) strictly increasing in q_2. Hence any $q_2 < q^*(\frac{\epsilon}{1+\epsilon}(\tilde{v}+t+w))$ is strictly dominated by $q_2 = q^*(\frac{\epsilon}{1+\epsilon}(\tilde{v}+t+w))$.

Now consider any $q_2 > q^*(\frac{\epsilon}{1+\epsilon}(\tilde{v}+t+w))$. This will lead to a sale of $q^*(\frac{\epsilon}{1+\epsilon}(\tilde{v}+t+w))$ to TM at a price of $m(\frac{\epsilon}{1+\epsilon}\tilde{v} - t - w)$, with the excess transported back to the village. Hence it is optimal for F to select $q_2 = q^*(\frac{\epsilon}{1+\epsilon}(\tilde{v}+t+w))$ if he decides to go to the mandi. And going to the mandi results in an expected payoff of

$$[m(\tilde{v}) - t - w]q^*(\frac{\epsilon}{1+\epsilon}(\tilde{v}+t+w)) + u(\bar{q} - q^*(\frac{\epsilon}{1+\epsilon}(\tilde{v}+t+w)) \tag{28}$$

At Stage 2, then, if TV offers a price $p(\tilde{v})$ where $\tilde{v} \geq \underline{v}$, the farmer believes the realization of v is $\tilde{v}$ with probability one and expects a payoff equal to (28) from going to the mandi. The farmer is indifferent between accepting and rejecting the offer, by construction of the function

$p(\tilde{v})$. Hence it is optimal for the farmer to randomize between accepting and rejecting the offer, and in the event of accepting F will sell $q^*(p(\tilde{v}))$ to TV. And offering any price less than $p(\underline{v})$ leads the farmer to believe that $\tilde{v} = \underline{v}$ with probability one, so such an offer will surely be rejected.

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

$$\mathcal{W}(\tilde{v}|v) = \alpha(\tilde{v})[v - t - p(\tilde{v})]q^*(p(\tilde{v})) \tag{29}$$

It remains to check that it is optimal for TV to report truthfully in this revelation mechanism. Now $\mathcal{W}_v(\tilde{v}|v) = \alpha(\tilde{v})q^*(\tilde{v})$, so if we define $X(v) = \mathcal{W}(v|v)$ we see that $X'(v) = \alpha(v)q^*(p(v))$, so

$$X(v) = X(\underline{v}) + \int_{\underline{v}}^{v} \alpha(\tilde{v})q^*(p(\tilde{v}))d\tilde{v} \tag{30}$$

which implies that

$$\alpha(v)[v - t - p(v)]q^*(p(v)) = \alpha(\underline{v})[v - t - p(\underline{v})]q^*(p(\underline{v})) + \int_{\underline{v}}^{v} \alpha(\tilde{v})q^*(p(\tilde{v}))d\tilde{v} \tag{31}$$

Differentiating with respect to v, this local incentive compatibility condition reduces to the differential equation (19).

A sufficient condition for global incentive compatibility (see [Mirrlees, 1986]) is that $\mathcal{W}_v(\tilde{v}|v) = \alpha(\tilde{v})q^*(p(\tilde{v}))$ is non-decreasing in $\tilde{v}$. This is equivalent to $\alpha'(v)q^*(p(v)) + \alpha(v)q^{*'}(p(v))p'(v) > 0$ for all v. Condition (19) implies $\alpha'(\tilde{v})q^*(p(\tilde{v})) + \alpha(v)q^{*'}(p(v))p'(v) = \frac{\alpha(v)p'(v)q^*(p(\tilde{v}))}{v-p(v)}$ which is strictly positive.

That $p(v) < m(v)$ is obvious from the definition of $p(v)$. The unconstrained monopsony price p for TV (which maximizes $(v - t - p)q^*(p)$) equals $\frac{\epsilon}{1+\epsilon}(v - t)$, which exceeds $m(v)$ if (20) holds. Hence if this condition holds, the monopsony price exceeds $p(v)$, implying that $\frac{q^{*'}(p(v))}{q^*(p(v))} > \frac{1}{v-p(v)}$, so $\alpha(v)$ is strictly decreasing. ∎

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

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

Construct the endpoints $\{v_i\}$ of the partition and the prices $\{r_i\}$ iteratively as follows. Define the function $\tilde{p}(v^*, x)$ by the property that $\Pi(\tilde{p}(v^*, x)) = Y(v^*, x)$, the price which if offered by TV would make F indifferent between accepting and rejecting, conditional on knowing that $v \in [v^*, v^* + x]$. By definition, then, $\tilde{p}(v^*, 0) = p(v^*)$. Select $v_0 = \underline{v}$. Given v_{i-1}, select $r_i \in (p(v_{i-1}), \tilde{p}(v_{i-1}, \infty))$. Select $v_i = v_{i-1} + x_i$ where x_i is defined by the property that $\tilde{p}(v_i, x_i) = r_i$. By construction, F is indifferent between accepting and rejecting a price offer of r_i from TV, conditional on the information that $v \in [v_{i-1}, v_i]$.

The rest of the argument is straightforward. With β_i's following (21), TV in state v_{i-1} is indifferent between offering prices r_{i-1} and r_i. This implies that any type $v \in [v_{i-2}, v_{i-1})$ prefers to offer r_{i-1} rather than r_i. Moreover, the single-crossing property of TV's payoffs with respect to the state v implies that each type is selecting offers optimally in the set $\{r_i\}_{i=1,2,..}$. And offering a price between r_{i-1} and r_i is dominated by the price r_i, since it corresponds to the same probability β_i of acceptance by F, and a lower profit for TV conditional on acceptance. ∎

Table 4: Analysis of variance of mandi prices

Source	MSE	F-statistic	MSE	F-statistic	MSE	F-statistic
Year					4744.16	1952.18 ***
Market dummies	68.70	10.11 ***	66.65	4.96 ***	66.09	27.20 ***
Week dummies	55.17	8.12 ***	56.72	4.22 ***	31.67	13.03 ***
Market dummies x Week dummies			0.48	0.04	0.59	0.24
Observations	*1837*		*1837*		*1837*	
R-squared	*0.25*		*0.28*		*0.87*	

Note: Price data were collected through "vendors" we identified in wholesale potato markets neighbouring our sample villages. Vendors were paid a daily fee for calling our information centre in Kolkata each evening to report the average price at which potatoes were transacted, separately for each variety sold in that market. The results above use weekly averages of these prices for the months June-November in 2007, January - November in 2008 and January - June in 2010.

Table 1: Analysis of Variance of Mandi Prices

Table 1: Descriptive Statistics, by district

		Hugli	Medinipur West	Overall
Distance to mandi (km)		7.26	9.65	8.52
		(1.08)	(0.89)	(0.70)
Village has a PCO box (2007)		0.26	0.74	0.51
		(0.08)	(0.07)	(0.06)
Owned land (2008) (acres)		0.83	1.37	1.12
		(0.03)	(0.04)	(0.03)
Cultivated land (2008) (acres)		0.98	1.47	1.25
		(0.03)	(0.04)	(0.03)
Fraction of area planted with potatoes (2008)		0.35	0.23	0.29
		(0.01)	(0.01)	(0.01)
Households with landline phones (2007)		0.16	0.28	0.23
		(0.01)	(0.01)	(0.01)
Households with cell phones (2007)		0.28	0.37	0.33
		(0.02)	(0.02)	(0.01)
Source of information				
	Phoria	0.58	0.66	0.62
		(0.02)	(0.02)	(0.01)
	Market	0.32	0.34	0.33
		(0.02)	(0.02)	(0.02)
	Friends	0.07	0.19	0.14
		(0.01)	(0.01)	(0.01)
Sold atleast once to phoria/ML/OT (2007)		0.98	0.94	0.96
		(0.00)	(0.01)	(0.00)
Sold atleast once to market (2007)		0.03	0.10	0.07
		(0.01)	(0.01)	(0.01)
Sold atleast once to phoria/ML/OT (2008)		0.98	0.90	0.94
		(0.01)	(0.01)	(0.01)
Sold atleast once to market (2008)		0.06	0.20	0.13
		(0.01)	(0.01)	(0.01)
Fraction of sold potatoes sold to (2007)				
	phoria/ML/OT	0.98	0.93	0.95
		(0.01)	(0.01)	(0.00)
	Market	0.02	0.07	0.05
		(0.01)	(0.01)	(0.00)
Fraction of sold potatoes sold to (2008)				
	phoria/ML/OT	0.96	0.88	0.92
		(0.01)	(0.01)	(0.01)
	Market	0.03	0.12	0.08
		(0.01)	(0.01)	(0.01)

Notes: Numbers in parentheses are standard errors. ML = moneylender. OT=outside trader.

Table 2: Descriptive Statistics, by District

Table 2: Descriptive Statistics, by intervention group

	Village	Mobile	Control	Village v. Control	Mobile v. Control	Village v. Mobile
Distance to mandi (km)	8.07	8.56	8.93	0.86	0.37	0.49
	(1.01)	(1.65)	(0.88)	(1.34)	(1.87)	(1.94)
Village has a PCO box (2007)	0.46	0.42	0.67	0.21	0.25 *	-0.04
	(0.10)	(0.10)	(0.09)	(0.14)	(0.14)	(0.15)
Owned land (2008) (acres)	1.19	1.09	1.09	-0.09	0.00	-0.10
	(0.05)	(0.05)	(0.05)	(0.07)	(0.07)	(0.07)
Cultivated land (2008) (acres)	1.29	1.25	1.21	-0.08	-0.04	-0.04
	(0.05)	(0.05)	(0.05)	(0.07)	(0.07)	(0.07)
Fraction of area planted with potatoes (2008)	0.51	0.51	0.53	0.02	0.03 *	-0.02
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Households with landline phones (2007)	0.24	0.23	0.25	0.01	0.01	-0.01
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
Households with cell phones (2007)	0.34	0.31	0.34	-0.01	0.02	-0.03
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
Source of information (2007) (asked in production survey: Jan-March 2007)						
Phoria	0.63	0.65	0.74	0.11 ***	0.09 ***	0.02
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
Market	0.35	0.34	0.38	0.02	0.04	-0.02
	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
Friends	0.13	0.16	0.16	0.03	0.00	0.03
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)

Table 3: Descriptive Statistics, by Intervention Group: Panel A

Table 2: Descriptive Statistics, by intervention group (contd.)
Note: the rows below are for data post-intervention so shouldn't be used to infer balance

	Village	Mobile	Control	Village v. Control	Mobile v. Control	Village v. Mobile
Sold atleast once to phoria/ML/OT (2007)	0.95	0.95	0.99	0.04 ***	0.04 ***	0.01
	(0.01)	(0.01)	(0.05)	(0.01)	(0.01)	(0.01)
Sold atleast once to market (2007)	0.09	0.07	0.03	-0.07 ***	-0.05 ***	-0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Sold to both (2007)	0.04	0.03	0.01	-0.03 ***	-0.01	-0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Sold atleast once to phoria/ML/OT (2008)	0.93	0.96	0.93	0.01	-0.02	0.03 **
	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
Sold atleast once to market (2008)	0.13	0.13	0.14	0.01	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
Sold to both (2008)	0.06	0.09	0.08	0.02	-0.01	0.03 *
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Fraction of sold potatoes sold to (2007)						
phoria/ML/OT	0.93	0.94	0.98	0.05 ***	0.04 ***	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Market	0.07	0.06	0.02	-0.05 ***	-0.04 ***	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)

Notes: Numbers in parentheses are standard errors. ML = moneylender. OT = outside trader.

Table 4: Descriptive Statistics, by Intervention Group: Panel B

Table 3: Price data, by district

	Hugli	Medinipur West	Overall
Big mandi prices 2008 (prices received by phoria)	4.23	6.00	4.77
	(0.04)	(0.06)	(0.04)
Gross Prices received by farmer 2008 (control group)	2.26	2.09	2.15
	(0.07)	(0.03)	(0.03)
when sold to phoria	2.25	2.07	2.14
	(0.07)	(0.04)	(0.04)
when sold in market	2.46	2.15	2.19
	(0.50)	(0.07)	(0.08)
Net prices received by farmer 2008 (control group)	2.16	2.01	2.06
	(0.07)	(0.03)	(0.03)
when sold to phoria	2.17	2.01	2.07
	(0.07)	(0.04)	(0.04)
when sold in market	2.43	1.94	1.99
	(0.51)	(0.07)	(0.09)
Tracked prices 2008 (control group)	2.72	2.11	2.30
	(0.10)	(0.05)	(0.05)

Notes: All prices reported are Rupees/kilogram for two varieties: jyoti and chandramukhi.

Table 5: Potato Prices: Mandi Prices, Prices Received by Farmers, and Prices Tracked by Farmers

Table: Sources of Price Information for Sample Farmers

	Control	Mobile	Village	Village v. Control	Mobile v. Control	Village v. Mobile
Trader	0.74	0.59	0.42	0.32 ***	0.16 ***	0.16 ***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Friends & neighbors	0.16	0.22	0.14	0.02 ***	-0.06 ***	0.08 ***
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
Others	0.01	0.09	0.37	-0.36 ***	-0.08 ***	-0.28 ***
	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)

Note: Farmers were asked to choose from the following list of possible sources: friends, relatives, neighbors, caste members, traders, members of local government, NGO employees, cooperative members, government officials and other.

Table 6: Sources of Price Information, by Intervention Group, 2008

Table: Effect of interventions on price tracking behavior

	Probability that farmer tracks wholesale prices		How long ago did you last track prices? (minimum) (days)		Tracked price (Rupees/kg)	
Private info	0.85	0.78	0.68 ***	0.71 ***	0.04	0.02
	(-.33)	(-0.54)	-(3.29)	-(3.00)	*0.35*	*0.20*
Phone recipient		1.77 **		0.83 ***		0.08
		(1.93)		-(3.08)		*1.12*
Public info	3.53 ***	3.54 ***	0.75 **	0.75 **	0.26 **	0.26 **
	(1.90)	(1.91)	-(2.56)	-(2.56)	*2.42*	*2.42*
Land	1.61 ***	1.60 ***	0.99	0.99	0.01	0.01
	(3.75)	(3.78)	-(0.71)	-(0.70)	*0.37*	*0.36*
Observations	*11731*	*11731*	*11731*	*11731*	*1282*	*1282*
Pseudo R-squared/R-squared	*0.11*	*0.12*			*0.53*	*0.54*

Notes: During the fortnightly trading surveys (March -- Dec 2008) a randomly selected 50% sample (stratified by village) was asked "Do you keep track of retail (potato) prices? Do you keep track of wholesale (potato) prices?" and if they answered yes to either question, were asked to list up to 3 markets (2 varieties per market) where they tracked prices, how long ago they last tracked the price, the price when they last tracked it and the source of their information. Each observation is a household-variety-market combination. Dummies for fortnight are included.

Table 7: Effect of Intervention on Farmers' Price Information, 2008

Table: Effect of Intervention on Total Quantity Sold

	Quantity sold (kg)							
Private info	564.01	1.03	484.65	0.88	-140.93	-0.23	-93.44	-0.15
Phone			524.55	1.18			-308.62	-0.66
Public info	230.38	0.44	229.40	0.44	-501.18	-0.85	-502.20	-0.85
Land	2250.36	12.80 ***	2252.24	12.89 ***	2220.25	12.45 ***	2219.42	12.41 ***
Medinipur dummy	254.90	0.61	251.28	0.60				
Constant	2846.29	5.16 ***	2844.90	5.16 ***	3606.06	6.33 ***	3608.72	6.33 ***
Mandi fixed effects	No		No		Yes		Yes	
R-squared	0.35		0.35		0.39		0.39	
Observations	*2318*		*2318*		*1606*		*1606*	

Notes: The unit of observation is a farmer-variety-quality. Dummies for variety and quality are included. Standard errors are clustered at the village level. A mandi is defined as a market-variety combination.

Table 8: Effect of Intervention on Total Quantity Sold by Farmers, 2008

Table: Effect of Intervention on Average Net Price Received

	Net price received (Rs/kg)							
Private info	-0.06	-0.44	-0.07	-0.55	0.01	0.09	0.01	0.12
Phone			0.10	1.05	0.03	0.40		
Public info	-0.10	-0.82	-0.10	-0.82	-0.01	-0.06	-0.01	-0.06
Land	-0.09	-5.05 ***	-0.09	-5.03 ***	-0.07	-4.53 ***	-0.07	-4.54 ***
Medinipur dummy	0.23	2.45 **	0.22	2.44 **				
Constant	2.21	18.26 ***	2.20	18.26 ***	2.31	23.56 ***	2.31	23.57 ***
Mandi fixed effects	No		No		Yes		Yes	
R-squared	0.37		0.37		0.46		0.46	
Observations	*2318*		*2318*		*1606*		*1606*	

Notes: The unit of observation is a farmer-variety-quality. Dummies for variety and quality are included. Standard errors are clustered at the village level. A mandi is defined as a market-variety combination.

Table 9: Effect of Intervention on Average Price Received (Net of Transactions Costs) by Farmers, 2008

Table: Effect of Intervention on Tracked Price

	Tracked price (Rs/kg)							
Private info	-0.02	-0.10	-0.06	-0.32	-0.23	-1.37	-0.28	-1.54
Phone			0.23	1.53			0.30	1.72 *
Public info	0.45	2.98 ***	0.45	2.98 ***	0.29	2.12 **	0.29	2.12 **
Land	0.02	0.76	0.02	0.79	0.03	0.99	0.04	1.04
Medinipur dummy	-0.30	-2.14 **	-0.30	-2.14 **				
Constant	2.40	16.11 ***	2.40	16.11 ***	2.54	23.58 ***	2.53	23.58 ***
Mandi fixed effects	No		No		Yes		Yes	
R-squared		0.35	0.35		0.46		0.47	
Observations		*940*	*940*		*605*		*605*	

Notes: The unit of observation is a farmer-variety-quality. Dummies for variety and quality are included. Standard errors are clustered at the village level. A mandi is defined as a market-variety combination.

Table 10: Effect of Intervention on Average Price Tracked by Farmers, 2008

Table: Panel A: Effect of Intervention on Comovement of Total Quantity Sold with Mandi Price

	Quantity sold (kg)							
Average mandi price	-517.40	-2.92 ***	-517.08	-2.91 ***				
Private info	-2904.11	-1.59	-3083.74	-1.68 *	-3624.81	-2.36 **	-3831.19	-2.36 **
Private info x Avg mandi price	772.40	1.82 *	796.05	1.85 *	820.20	2.12 **	885.49	2.13 **
Phone			1334.19	1.03			1448.78	0.80
Phone x Avg mandi price			-186.52	-0.58			-446.39	-0.95
Public info	-2077.82	-1.31	-2075.32	-1.30	-3390.20	-2.46 **	-3390.88	-2.46 **
Public info x Avg mandi price	499.89	1.34	499.16	1.34	676.43	2.19 **	675.88	2.18 **
Land	2246.51	12.69 ***	353.64	0.72	2195.72	12.14 ***	2195.13	12.08 ***
Medinipur dummy	355.33	0.72	2248.98	12.73 ***				
Constant	5200.73	5.37 ***	5195.77	5.36 ***	3732.16	6.76 ***	3736.45	6.75 ***
Mandi fixed effects	No		No		Yes		Yes	
R-squared	0.36		0.36		0.39		0.39	
Observations	*2299*		*2299*		*1592*		*1592*	

Panel B: Total Effects of the Intervention at Different Levels of the Mandi Price

Private Info								
at 10% mandi price	-687.49	-0.94			-1271.01	-1.95 *		
at 90% mandi price	1866.36	1.87 *			1440.88	1.29		
Private Info, no phone								
at 10% mandi price			-799.23	-1.09			-1290.02	-1.97 *
at 90% mandi price			1832.83	1.80 *			1637.76	1.38
Private Info, with phone								
at 10% mandi price			-0.31	0.00			-1122.28	-1.34
at 90% mandi price			2015.05	1.71 *			329.55	0.26
Public info								
at 10% mandi price	-643.26	-1.00	-642.83	-1.00	-1448.99	-2.17 **	-1451.24	-2.17 **
at 90% mandi price	1009.56	1.11	1007.59	1.11	787.56	0.92	783.50	0.92

Notes: The unit of observation is a farmer-variety-quality. Dummies for variety and quality are included. Standard errors are clustered at the village level. A mandi is defined as a market-variety combination. Mandi prices are not reported separately by quality.

Table 11: Effect of Intervention on Co-movement of Total Quantity Sold by Farmers with Mandi Price, 2008

Table: Panel A: Effect of Intervention on Comovement of Net Price Received with Mandi Price

	Net price received (Rs/kg)							
Average mandi price	0.18	2.38 **	0.18	2.38 **				
Private info	-0.74	-2.11 **	-0.76	-2.16 **	-0.84	-3.54 ***	-0.87	-3.69 ***
Private info x Avg mandi price	0.15	2.01 **	0.15	2.02 **	0.20	3.69 ***	0.21	3.76 ***
Phone			0.09	0.29			0.20	0.71
Phone x Avg mandi price			0.00	-0.01			-0.04	-0.58
Public info	-0.21	-0.63	-0.21	-0.63	-0.39	-1.65	-0.39	-1.64
Public info x Avg mandi price	0.02	0.29	0.02	0.29	0.09	1.53	0.09	1.53
Land	-0.09	-5.08 ***	-0.26	-1.93 *	-0.07	-4.98 ***	-0.07	-4.95 ***
Medinipur dummy	-0.26	-1.93 *	-0.09	-5.07 ***				
Constant	1.73	5.66 ***	1.73	5.66 ***	2.32	26.26 ***	2.32	26.23 ***
Mandi fixed effects	No		No		Yes		Yes	
R-squared	0.41		0.41		0.47		0.47	
Observations	*2299*		*2299*		*1592*		*1592*	

Panel B: Total Effects of the Intervention at Different Levels of the Mandi Price

Private Info								
at 10% mandi price	-0.32	-1.93 *			-0.26	-2.21 **		
at 90% mandi price	0.18	1.08			0.41	2.56 **		
Private Info, no phone								
at 10% mandi price			-0.33	-2.00 **			-0.27	-2.34 **
at 90% mandi price			0.17	1.00			0.42	2.55 **
Private Info, with phone								
at 10% mandi price			-0.24	-1.25			-0.18	-1.16
at 90% mandi price			0.25	1.07			0.38	1.82 *
Public info								
at 10% mandi price	-0.15	-0.98	-0.15	-0.98	-0.13	-1.13	-0.13	-1.13
at 90% mandi price	-0.08	-0.41	-0.08	-0.42	0.17	0.91	0.17	0.91

Notes: The unit of observation is a farmer-variety-quality. Dummies for variety and quality are included. Standard errors are clustered at the village level. A mandi is defined as a market-variety combination. Mandi prices are not reported separately by quality.

Table 12: Effect of Intervention on Co-movement of Price Received (Net of Transactions Costs) by Farmers with Mandi Price, 2008

Table: Panel A: Effect of Intervention on Comovement of Tracked Price with Mandi Price

	Tracked price (Rs/kg)							
Average mandi price	0.15	1.93 *	0.15	1.93 *				
Private info	-0.69	-1.34	-0.74	-1.39	-1.27	-2.90 ***	-1.29	-2.76 ***
Private info x Avg mandi price	0.15	1.39	0.15	1.35	0.24	2.88 ***	0.23	2.62 **
Phone			0.28	0.72			0.07	0.13
Phone x Avg mandi price			0.00	-0.01			0.06	0.49
Public info	-0.13	-0.26	-0.12	-0.24	-0.58	-1.37	-0.58	-1.36
Public info x Avg mandi price	0.12	1.14	0.12	1.12	0.20	2.15 **	0.20	2.16 **
Land	0.01	0.49	-0.78	-3.77 ***	0.03	0.86	0.03	0.89
Medinipur dummy	-0.78	-3.75 ***	0.01	0.52				
Constant	2.07	6.14 ***	2.07	6.16 ***	2.56	24.17 ***	2.56	24.11 ***
Mandi fixed effects	No		No		Yes		Yes	
R-squared	0.38		0.39		0.48		0.49	
Observations	*936*		*936*		*604*		*604*	

Panel B: Total Effects of the Intervention at Different Levels of the Mandi Price

Private Info								
at 10% mandi price	-0.27	-1.07			-0.57	-2.49 **		
at 90% mandi price	0.22	0.92			0.24	1.23		
Private Info, no phone								
at 10% mandi price			-0.31	-1.21			-0.61	-2.47 **
at 90% mandi price			0.18	0.70			0.16	0.77
Private Info, with phone								
at 10% mandi price			-0.03	-0.13			-0.37	-1.65
at 90% mandi price			0.45	2.02 **			0.60	2.29 **
Public info								
at 10% mandi price	0.23	1.02	0.23	1.04	-0.01	-0.03	0.00	-0.02
at 90% mandi price	0.64	2.66 ***	0.64	2.65 **	0.66	2.98 ***	0.66	3.00 ***

Notes: The unit of observation is a farmer-variety-quality. Dummies for variety and quality are included. Standard errors are clustered at the village level. A mandi is defined as a market-variety combination. Mandi prices are not reported separately by quality.

Table 13: Effect of Intervention on Co-movement of Price Tracked by Farmers with Mandi Price, 2008

Table: Effect of Intervention on Farmers' Cropping and Production of Potatoes

	Total area planted (acres)				Total quantity harvested (kg)				Yield (kg/acre)			
	(1)		(2)		(3)		(4)		(5)		(6)	
Private info	0.02	0.63	0.01	0.44	447.77	1.19	404.79	1.06	1313.16	2.96 ***	1180.54	2.93 ***
Phone			0.04	1.31			267.89	0.85			826.51	1.22
Public info	0.03	0.73	0.03	0.73	201.56	0.51	201.53	0.51	-86.90	-0.23	-86.96	-0.23
Land	0.17	13.38 ***	0.17	13.42 ***	1672.17	11.89 ***	1673.09	11.92 ***	94.11	1.19	96.95	1.25
Medinipur dummy	0.01	0.32	0.01	0.31	79.46	0.27	77.50	0.26	-331.87	-0.98	-337.89	-0.99
Constant	0.39	10.44 ***	0.39	10.45 ***	3739.78	9.07 ***	3740.42	9.07 ***	9570.63	26.97 ***	9572.59	26.92 ***
R-squared	0.44		0.44		0.42		0.42		0.04		0.04	
Observations	*3386*		*3386*		*3386*		*3386*		*3386*		*3386*	

Notes: The unit of observation is farmer-variety-quality. Variety and quality dummies are included. Standard errors are clustered at the village level. Numbers in the second column are t-statistics. *** p <0.01, ** p<0.05, * p<0.1.

Table 14: Effect of Intervention on Farmers' Cropping and Production of Potatoes, 2008

Table: Effect of Intervention on Quantity and Timing of Sale of Potato Harvest

	Percent of harvest sold		Percent sold at harvest		Percent sold middle		Percent sold late	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Private info	-0.01	-0.01	-0.05	-0.05	0.02	0.01	0.04	0.03
	(0.32)	(0.15)	(0.85)	(0.69)	(0.22)	(0.16)	(1.09)	(0.91)
Phone		-0.04 *		-0.06		0.03		0.03
		(1.95)		(1.60)		0.53		0.82
Public info	0.00	0.00	-0.05	-0.05	-0.05	-0.05	0.11 ***	0.11 ***
	(0.03)	(0.03)	(0.75)	(0.75)	(0.80)	(0.81)	2.92	2.92
Land	0.03 ***	0.03 ***	-0.03 ***	-0.03 ***	-0.03 ***	-0.03 ***	0.06 ***	0.06 ***
	4.34	4.35	(2.71)	(2.74)	(2.95)	(2.93)	6.55	6.60
Medinipur dummy	-0.08 **	-0.08 **	0.15 **	0.15 **	0.02	0.02	-0.16 ***	-0.16 ***
	(2.55)	(2.54)	2.51	2.52	0.29	0.29	(5.28)	(5.30)
Constant	0.96 ***	0.96 ***	0.53 ***	0.53 ***	0.24 ***	0.24 ***	0.23 ***	0.23 ***
	31.46	31.51	8.42	8.42	3.72	3.72	6.80	6.80
R-squared	0.53	0.53	0.07	0.07	0.03	0.03	0.12	0.12
Observations	*3386*	*3386*	*2318*	*2318*	*2318*	*2318*	*2318*	*2318*

Notes: "At harvest" is defined as weeks 1-12 of the year. "Middle" is weeks 13 to 26, and "Late" is weeks 26 to 52. The unit of observation is farmer-variety-quality. Variety and quality dummies are included. Standard errors are clustered at the village level. Numbers in the second row are t-statistics. *** p <0.01, ** p<0.05, * p<0.1.

Table 15: Effect of Intervention on the Timing of Farmers' Potato Sales, 2008

Table: Total price received by farmer as a function of whether he sold at the market

	Overall		Hugli		Medinipur	
Sold to market	0.36	2.78 ***	0.56	2.99 ***	0.36	1.99 *
Mandi price	0.23	5.07 ***	0.47	6.92 ***	0.19	4.65 ***
Land	-0.06	-4.01 ***	-0.07	-2.21 **	-0.05	-3.53 ***
Medinipur dummy	-0.29	-2.25 **				
Constant	1.44	9.06 ***	0.73	3.11 ***	1.30	5.78 ***
R-squared	0.37		0.48		0.29	
Observations	*3919*		*2002*		*1917*	

Notes: The unit of observation is a farmer-quality-variety-week when a transaction occurred. Variety and quality dummies are included. Standard errors are clustered at the village level.

Table 16: Effect of Intervention on the Timing of Farmers' Potato Sales, 2008

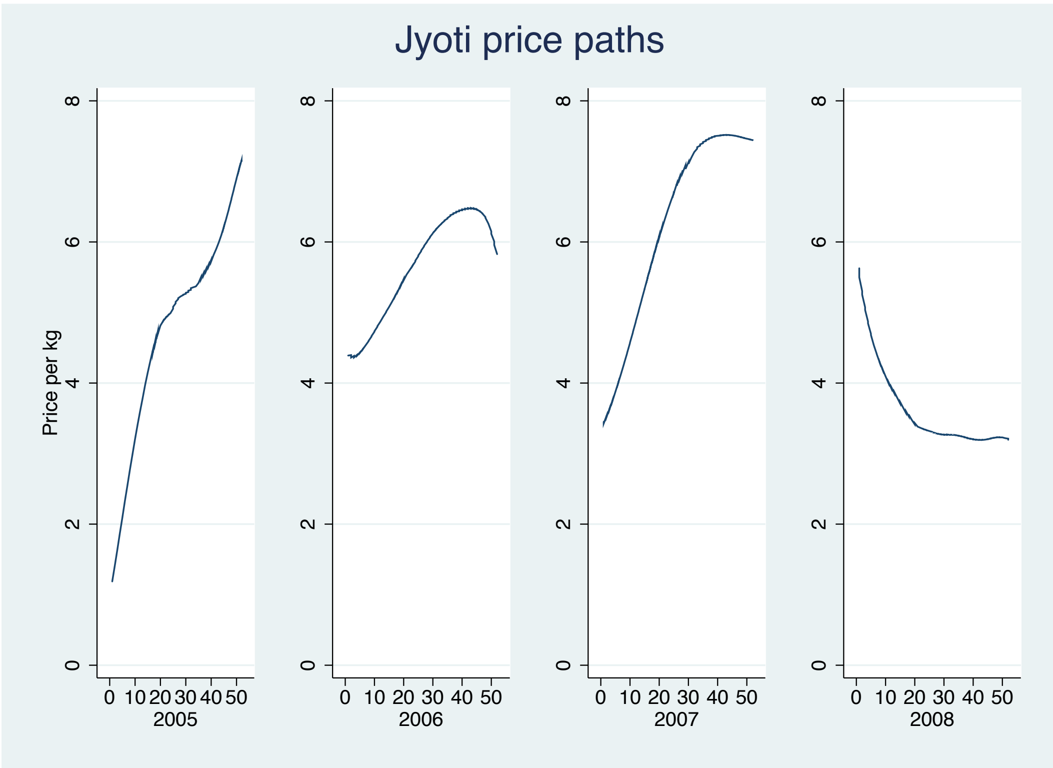

Figure 1: Mandi Prices by variety, 2008

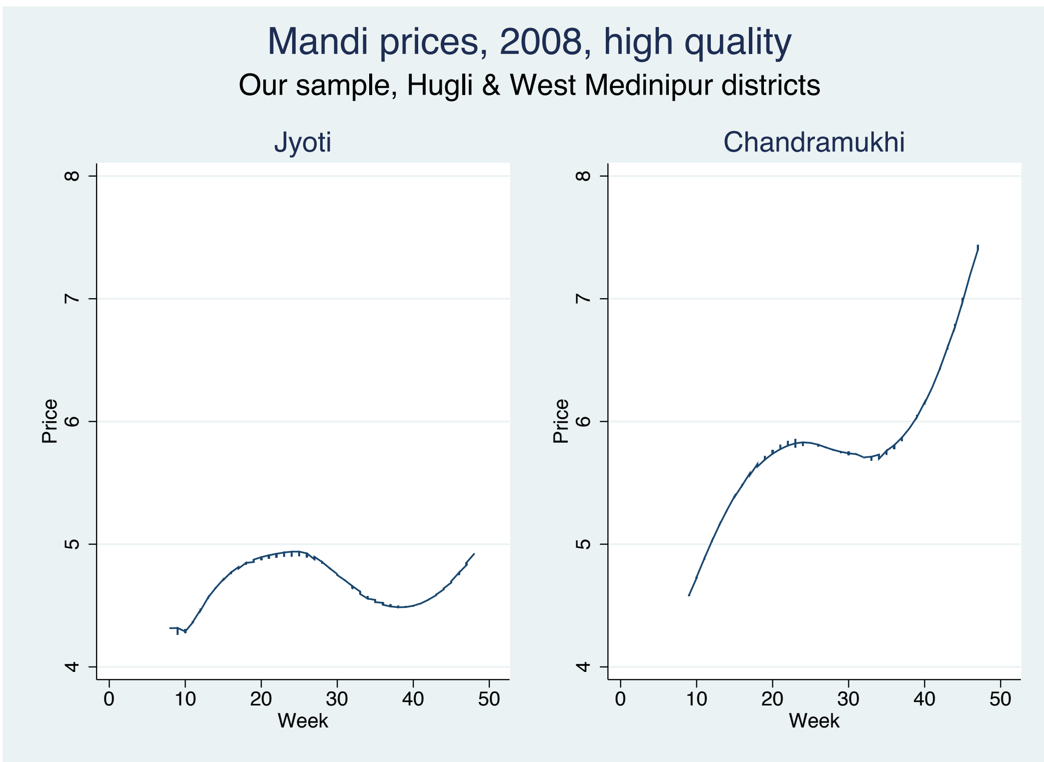

Figure 2: Mandi Prices by variety, 2008

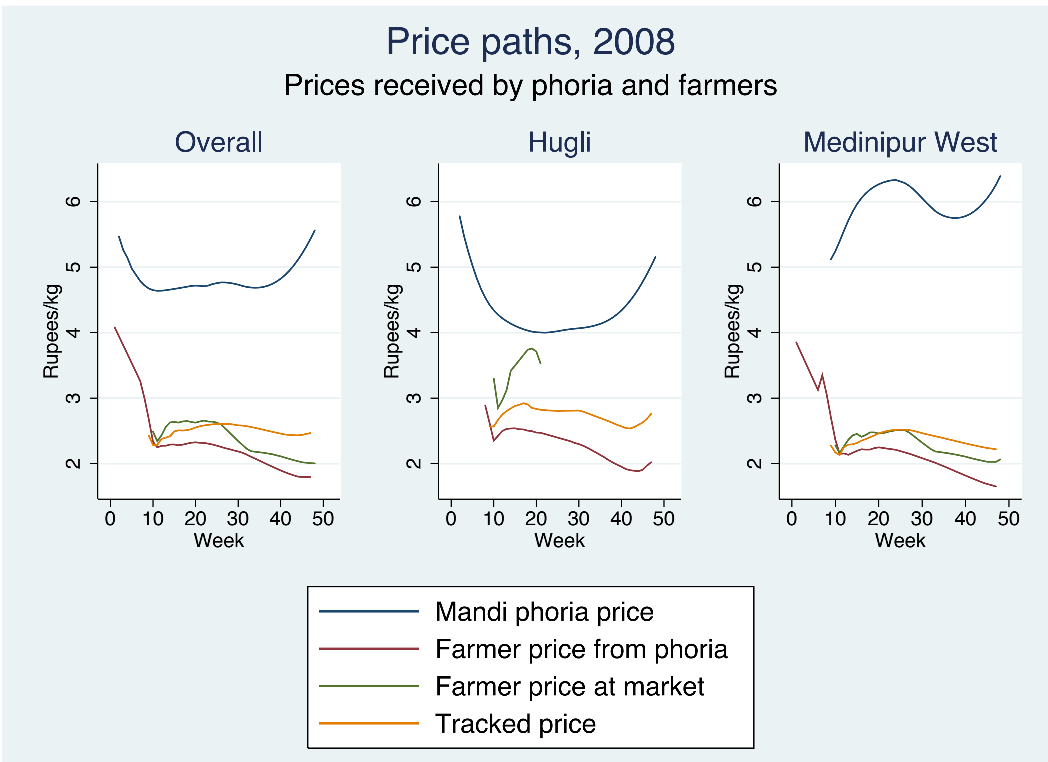

Figure 3: Mandi prices, farmer prices and tracked prices, by district, 2008

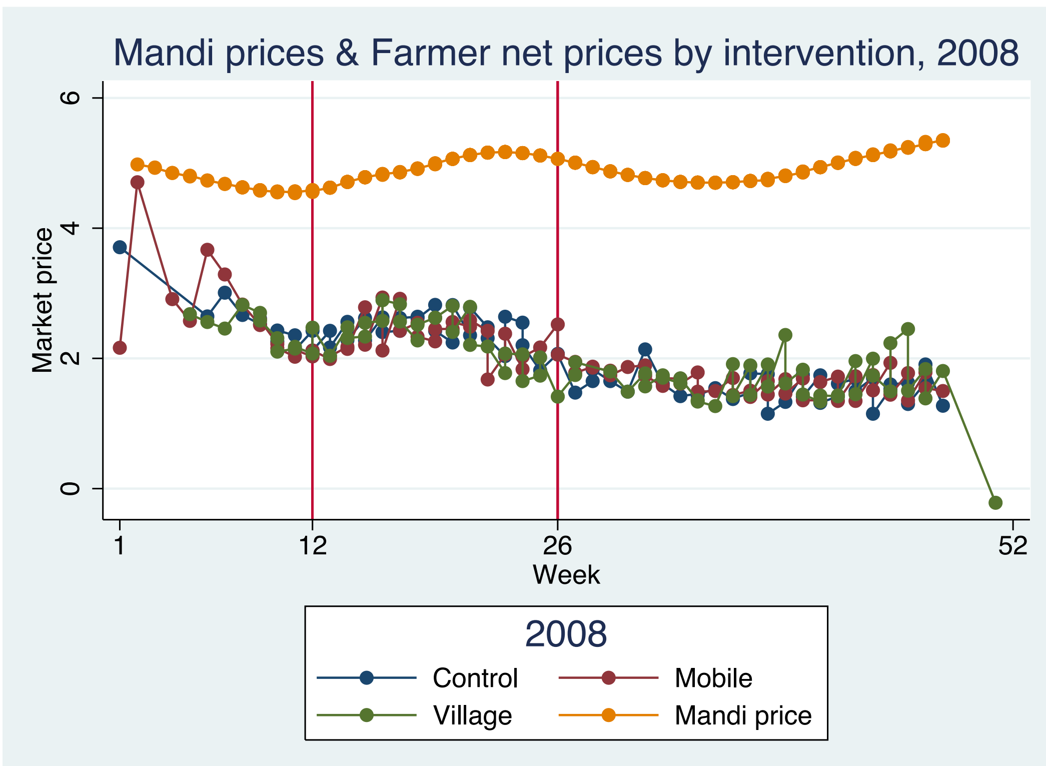

Figure 4: Middlemen Margins and Average Intervention Impacts, Jyoti and Chandramukhi potatoes, 2008

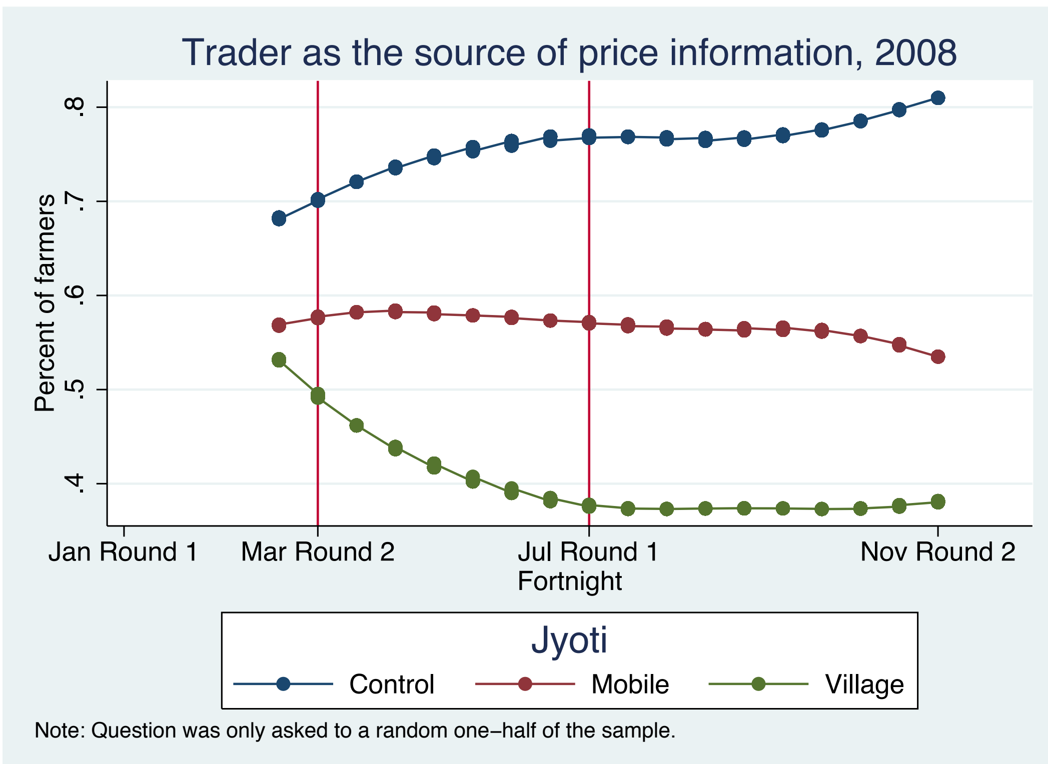

Figure 5: Changes to Information Source Over Time, by Intervention Group, 2008

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