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Information, Direct Access to Farmers, and Rural Market Performance in Central India

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Information, Direct Access to Farmers, and Rural Market Performance in Central India†

By Aparajita Goyal*

This paper estimates the impact of a change in procurement strategy of a private buyer in the central Indian state of Madhya Pradesh. Beginning in October 2000, Internet kiosks and warehouses were established that provide wholesale price information and an alternative marketing channel to soy farmers in the state. Using a new market-level dataset, the estimates suggest a significant increase in soy price after the introduction of kiosks, supporting the predictions of the theoretical model. Moreover, there is a robust increase in area under soy cultivation. The results point toward an improvement in the functioning of rural agricultural markets. (*JEL* O13, O18, Q12, Q13)

In developing countries, due to high transport costs, the lack of reliable price information, and the inability to verify the quality of produce, farmers who produce cash crops are often exploited by intermediaries. There is growing recognition among economists and policymakers that this lowers farmer's profitability and reduces incentives to produce and control quality thereby leading to an adverse effect on both equity and efficiency (Pranab Bardhan 1989; Jason Clay 2004).

In the case of soybeans, a major cash crop in the central Indian state of Madhya Pradesh, farmers sell their produce to traders operating in government regulated wholesale agricultural markets, called *mandis*. The traders, in turn, sell to processing companies. There are approximately 230 main *mandis* in the state where farmers periodically sell their produce through an open outcry ascending bid auction. The auction begins when a government employee visually inspects the quality and sets the initial bid. From here, the traders bid upward until the crop is sold. Government regulated *mandis* were explicitly established to protect farmers, and open auctions were considered the best safeguard against excessive trader's influence. However, the ability to collude among a relatively small number of traders in each *mandi* led to the extraction of a significant share of profits leaving little for the farmer who had no alternative method of selling (David Upton and Virginia A. Fuller 2003).

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Although the traders make up for a lack of infrastructure, such as transport and storage facilities in rural areas, they are also well informed about prices prevailing in different markets and the price offered by processors (Abhijit Banerji and J. V. Meenakshi 2004). Farmers often do not have information about market conditions prior to the sale. Moreover, processors are unable to perfectly monitor the traders. Access to information as well as direct interactions between farmers and processors can therefore have a potentially important effect on the price received by rural producers and on their behavior. Knowledge of prevailing prices allow farmers to reap the gains from broader market search. An increase in return can induce farmers to re-optimize their decisions regarding land allocation toward alternative crops.

Beginning in October 2000, ITC Limited, a large buyer of soybeans, decided to eliminate intermediaries to gain control over the quality as well as lower its transaction costs though the implementation of a unique *e-Choupal* intervention in the state of Madhya Pradesh.[1] The intervention had two dimensions. Internet kiosks were set up in villages that enabled farmers to access daily wholesale prices of soybeans, both in the local *mandis* as well as the price offered by ITC (a processor of soybeans). In addition, warehouses (called hubs) were established that enabled scientific testing of quality and facilitated the sale of soybeans by the farmers directly to the private company. After comparing the price in nearby *mandis* and the price offered by ITC at the hubs, farmers can decide where to sell their produce, thereby providing farmers with both an outside option as well as relevant price information. Furthermore, ITC is able to judge the quality of soybeans that it purchases directly from the farmers at different prices. By the end of 2004, in districts that had ITC hubs and kiosks, 4.08 percent of the annual soy production was sold directly to ITC, making the intervention sustainable because it is profitable for the private company to implement it, and profitable for the farmers to use it. This is an important reason why many of the efforts undertaken by governments and NGOs to remove intermediaries or provide information services to rural producers in developing countries have not met with the same success (Daniele Giovannucci 2005).

This paper examines the impact of this innovative initiative on the price received by soybean farmers in the *mandis* and on their subsequent planting decisions. A simple model is developed that explains how the provision of information and the presence of scientific testing together affect the price of soy in local markets. Improvement in price information to farmers, due to the presence of kiosks, is likely to reduce the trader's monopsony power leading to an increase in the offer price of the good in the *mandis*. The presence of a hub, however, is likely to exert two opposing forces. On the one hand, direct buying by ITC is expected to divert a part of the sales away from the *mandis*, leading to an upward pressure on price, the competition effect. On the other hand, scientific testing of quality performed at the ITC hubs might induce farmers to self-select, putting a downward pressure on the price offered in the *mandis*, the composition effect. If farmers with good quality soybean have a greater tendency to sell directly to the private company, the effect of the hub on the *mandi* price is a priori ambiguous, and is ultimately an empirical question.

[1] The ITC group is one of India's largest private sector companies with a market capitalization of approximately US$11 billion and annual sales of US$2.6 billion (Ravi Anupindi and S. Sivakumar 2006).

The location and installation date of each Internet kiosk and hub, available from the private company, provide the spatial and time patterns of the implementation of the intervention in the state of Madhya Pradesh. The outcomes, monthly wholesale price and volume of crops sold in government regulated *mandis* in the state from April 2000 to September 2005, are available from the Madhya Pradesh State Agricultural Marketing Board. Measuring output response to this intervention is crucial for understanding the effect of this intervention on farmers' behavior. Annual district level data on area cultivated, production and yield of crops from 1998 to 2004 is available from the Commissioner of Land Records, Madhya Pradesh.

This is the first attempt to collect *mandi* level data on the price and volume of crops to examine the impact of a change in the procurement strategy of a private buyer on the functioning of rural markets in India. Using differential timing in the introduction of kiosks and hubs across the districts of the state, the paper finds an immediate and significant increase in the average price of soybeans after the introduction of kiosks, lending support to the predictions of the theoretical model. The presence of kiosks in a district is associated with an increase in the monthly *mandi* price of soybean by 1–3 percent, taking into account *mandi* and month fixed effects and district-specific time trends. The presence of hubs appear to have no effect on average price, implying that the composition effect, perhaps, offsets the competition effect, pushing the estimate of the impact of the hub on *mandi* price toward zero. In addition, the dispersion of soybean prices across the affected *mandis* in Madhya Pradesh decreased after the intervention. The increase in price and the reduction in dispersion appears to influence farmers' planting decisions. There is a significant increase in the area under soy cultivation due to this intervention.

This paper makes two contributions. First, the results contribute to the substantial economic literature emphasizing that information is critical for the efficient functioning of markets. A series of theoretical papers including George J. Stigler (1961), Steven Salop and Joseph E. Stiglitz (1977), Dale O. Stahl II (1989), and R. Preston McAfee (1995) describe models where the presence of costly search lowers competition and creates an inefficient allocation of goods across markets. There is also a growing empirical literature assessing the effects of improvements in information on both the level and dispersion of prices. For instance, Jeffrey R. Brown and Austan Goolsbee (2002) show that the growth of online price comparison sites reduced term life insurance premia by 12 percent in the United States. In a recent study, Robert Jensen (2007) shows, using micro-level survey data, that the adoption of mobile phones by fishermen and wholesalers in South India is associated with a dramatic reduction in price dispersion, the complete elimination of waste, and an increase in both consumer and producer welfare. This paper presents robust empirical evidence that information improves the functioning of rural markets by increasing the competitiveness of buyers.

Second, direct interactions between producers and processors are gaining considerable interest in the developing world. While intermediaries deliver critical services to rural producers, they are also often exploitative and there can be large efficiency gains from their removal (Ammar Siamwalla 1978; Timothy Besley and Robin Burgess 2000). This intervention shows that it requires serious investment to bypass intermediaries, but it is possible, and can be beneficial for both farmers and final buyers. The immediate benefit to ITC Limited of this intervention was the improvement in quality of soybeans procured, from the creation of a direct marketing channel, and a reduction in its transaction costs. The results in this paper suggest that there can be net welfare gains to farmers resulting from a redistribution of surplus away from traders to the farmers and the overall gain of deadweight loss under monopsony.

The rest of the paper is organized as follows. Section I provides background on the marketing of soybean in the state and the details of the intervention. Section II outlines a conceptual framework for understanding the gains from the change. The data are described in Section III. The empirical strategy and results are discussed in Section IV. Section V addresses alternative explanations and Section VI concludes.

I. Background

A. *Agricultural Marketing in Madhya Pradesh*

Madhya Pradesh (MP) is the second largest Indian state in terms of area and ranks seventh in population.[2] More than 11 million people are directly engaged in agriculture, contributing 30 percent to the state gross domestic product (GDP) (Government of Madhya Pradesh 2005). With most development indicators below the national average, it is among the lower income states of the country.[3] The State Agricultural Marketing Board facilitated the development of 233 main *mandis* (government regulated wholesale agricultural markets), with well built storage and display areas, where farmers periodically sell their produce. According to the MP Agricultural Marketing Act of 1972, every farmer is required by law to sell his or her produce in these regulated markets. According to Upton and Fuller (2003), "transactions outside the *mandis* were officially prohibited by the government to protect farmers from exploitation by unscrupulous buyers. Open auctions were considered the best safeguard against this." Nevertheless, an estimated 12 percent of the produce is sold by farmers to cooperative societies and village merchants outside these spot markets.

The *mandis* in the state are classified into four categories (A–D) based on the annual revenue collected through the payment of *mandi* tax by buyers.[4] The procurement process in the *mandis* of different sizes is identical. The buyers in the *mandi* are all licensed traders, i.e., each buyer needs to obtain a license to operate inside a *mandi*. These traders are mostly intermediaries and eventually sell the produce to millers, processors, and plant owners (involved in crushing or refining of the produce). A trader who buys on behalf of a private company is sometimes called a commission agent because the private company pays him a commission to build a relationship that ensures timely delivery of produce in the future.

[2] The state has a total area of 308,144 square kilometers and approximately 60 million people (Census of India 2001). It is closest in area to the state of Arizona in the United States.

[3] In the year 2000, MP had a per capita GDP of Rs 7947 and a rural headcount ratio of 37 percent, which was almost 30 percent lower than the national average (Government of Madhya Pradesh 2005).

[4] Every buyer operating inside a *mandi* pays 2.2 percent of the purchased value as tax to the *mandi* committee. There are 30 A grade, 25 B grade, 84 C grade, and 94 D grade main *mandis* located in the towns of MP.

According to B. B. Singh (2005), soybean cultivation in India was negligible until 1970, but it grew rapidly thereafter in response to the domestic deficit of edible oil supply. India is now the fifth largest producer of soybean in the world, and MP produces more than 60 percent of India's soybean crop.[5] Soybean is usually sown in June because it requires sufficient moisture for its germination, and the monsoon rains are very important for the subsequent growth of the crop.[6] The crop is ready to be harvested in September and, being a cash crop, almost the entire crop is marketed. Approximately 65 percent of the total soybean crop produced in a year is sold in the *mandis* from October–December, immediately after the harvest. There also appears to be considerable seasonal fluctuation in price. For instance, the average price in the fourth quarter, over the years 2000–2005, is 8.5 percent lower than in the second quarter.

Farmers transport their produce by animal-drawn carts and tractors to a nearby *mandi* where it is sold through an open outcry ascending bid auction. Field studies reveal that farmers travel 30–40 km on average to reach a *mandi,* and they usually make this trip a couple of times each month (Upton and Fuller 2003; Anupindi and Sivakumar 2006). The farmer displays his produce in a heap in the *mandi* yard or simply stands beside his tractor. The auction begins when the auctioneer (a government employee) visually inspects the quality and sets the initial bid. From here the traders bid upward until the produce is sold. This is a very rapid process and in a matter of seconds the final price is decided. The government employee and the traders move from heap to heap picking up samples of the produce and making a price estimate. In principle, edible oilseeds are traded on the basis of fair average quality (FAQ) determined by the presence of dirt, damaged seeds, and moisture content in each lot of produce offered for sale. For instance, the highest or the FAQ price is offered to a sample of soybean that is on a 2-2-10 quality scale (sample contains not more than 2 percent dirt, 2 percent damaged seeds, and 10 percent moisture in the seed).[7] Traders start to discount the price of beans when the proportion of dirt, moisture, and damaged seeds exceed that level.

Once the final price is set, the farmer's produce is bagged and weighed on a manually operated balance scale. After weighing, the full value of the farmers produce is calculated and the farmer is paid in cash. Oilseed grading is undertaken in an unscientific manner in nearly all *mandis*. Formal testing of the oil content to discern quality is not performed (World Bank 1997). It is important to clarify the various dimensions of soybean quality in this context. The transactions between farmers and buyers are based on observable features of quality, such as the amount of moisture, dirt, and damaged seeds in each lot of produce offered for sale. This is mostly dependent on the storage technology used by farmers, which is likely to be highly correlated with the farmers' income. However, there is an unobservable dimension

[5] The largest producer of soybean in the world is the United States, followed by Brazil, Argentina, and China as of 2005. India produces about 6 million tons of soybean annually. The state of MP is the largest producer of soybean in India, followed by Maharashtra and Rajasthan.

[6] There are two major cropping seasons in India: *Kharif* and *Rabi*. The *Kharif* season falls during the southwest monsoon (July–October) when crops are grown both in rain-fed and irrigated areas. Soy is a *Kharif* crop. The *Rabi* season falls during the winter months (November–March) when crops are grown mostly in irrigated areas. From November to March, most soy farmers grow wheat (Government of Madhya Pradesh 2000).

[7] If a farmer had soybean with say, 1-1-5 quality parameters, he would still receive the FAQ price.

of quality that refers to the amount of oil and protein content of the seed. This aspect of quality is dependent on the variety of seeds planted by the farmers, the timely application of pesticides and fertilizers and use of farming techniques. Discussion of the impact of the intervention on overall improvement in both observable and unobservable aspects of quality is presented in a later section.

Soybean prices in India are determined to an extent by conditions prevalent in the international market. Soybean is processed to extract edible oil and a high protein residue called de-oiled cake (DOC) commonly used as animal feed.[8] The *mandi* price of soybean in MP tracks the Chicago Board of Trade (CBOT) prices of soybean, DOC, and oil reasonably closely. The correlation coefficients of the monthly *mandi* price of soybean in MP with the CBOT price of soybean, soy-oil, and soy-meal are 0.84 (0.06 standard error (SE)), 0.42 (0.03 SE), and 0.87 (0.09 SE) respectively.[9]

B. *Description of the e-Choupal Intervention*

ITC Limited implemented an *e-Choupal* program that enabled it to buy soybean directly from the farmers starting in October 2000.[10] Prior to this intervention, ITC purchased soybean from traders (operating in the *mandis*) and processed the beans to produce edible oil and DOC for sale in the domestic and international market. Since ITC did not have any direct contact with the farmers, it commissioned certain traders (called commission agents) to buy soybean from the *mandis* on its behalf. The company was dependent on its agents' knowledge about local farmers and their produce.

Interviews with ITC officials revealed that the distortion of quality undertaken by the agents meant that the company paid a high price for a lower overall quality of soybean, which upon processing yielded less oil and more contaminated DOC.[11] ITC believed that by bypassing the intermediaries, it would be able to better control the quality of the produce and also lower its transaction costs. Moreover, the company had dual roles for the infrastructure that it was creating as it planned to sell its own consumer products in rural areas in the future. According to Richa Kumar (2004), "ITC calculated that it saved Rs 12.9 million in the first year of operation through better quality oil and DOC obtained from processing soybeans procured through the *e-Choupal* intervention."

This intervention provided an alternative to ITC for procuring soybean and to soy farmers for selling their produce. Beginning in the year 2000, ITC established a total of 1,700 Internet kiosks and 45 hubs over the course of 4.25 years in the major soy growing districts of the state.[12] The intervention has two dimensions.

[8] The processing of soybean is done by solvent-extraction process. In India, soybean is composed of 82 percent DOC and 18 percent oil (World Bank 1997).

[9] The CBOT price is listed in US Dollars/Ton. The monthly *mandi* mode price listed in Rupees/Quintal was converted to US dollars/Ton using monthly exchange rates. CBOT prices of crops and currency exchange rates are available from the *International Financial Statistics* of the International Monetary Fund.

[10] The word *choupal* stands for a village gathering place in Hindi.

[11] Agents buy soybean of varying quality throughout the day. They mix different grades of quality and sell the lot to the company at a high price. Moreover, agents often ask ITC to increase its price saying that the price is too low for them to buy any soybean in the *mandi*s.

[12] The full cost for setting up the infrastructure was borne by ITC and farmers could use these services free of charge.

Internet kiosks were set up in villages that provide information about *mandi* prices to soy farmers in the state. Each Internet kiosk was designed to cater to its host village and four other neighboring villages within a five kilometer radius (Coimbatore Prahalad 2003). The Internet kiosks are managed and operated by farmers trained in basic computer usage, who are selected from within the village and provide free services to other soy farmers.[13] Each day the (minimum and maximum) prices of soybean in approximately 60 local *mandis* are posted on a Web site. Along with this information, ITC's own offer price at its 45 hubs is also posted. Specifically, each evening, ITC posts the prevailing *mandi* prices and its offer price for high (FAQ) quality soybean at the hubs that is guaranteed for the next day.[14] In addition, farming techniques and weather updates are also available in the local language to farmers through the kiosks.

Hubs are mostly warehouses that are established in towns. The 45 hubs include the 9 processing plants leased by ITC. Hubs represent a point of contact between farmers and the ITC. A farmer can sell directly to ITC by going to the nearest hub. ITC's goal is to have a hub within a 30–40 km radius of its target farmer (Prahalad 2003). Once the farmer arrives at one of the hubs, his produce is carefully tested to discern quality. ITC can offer a price below the posted FAQ price if quality is below the FAQ level. However, the minimum support price (MSP), declared annually by the government of India, is the lowest price that ITC can offer for a certain poor quality threshold.[15] ITC is not allowed to buy below MSP (a condition imposed by the government on ITC). Transactions below minimum support price can only take place in *mandis*. After the price is set and accepted by the farmer, his beans are weighed on an electronic weighbridge, and the weight is multiplied by the offered price. The farmer then receives cash instantly.[16]

As mentioned earlier, the state Marketing Act prohibited transactions outside the *mandis*. However, ITC used a provision in the by laws of the Act to procure soybean from farmers at its hubs from October 2000.[17] The state Marketing Act was subsequently amended in April 2003 allowing farmers to explicitly sell outside the *mandis* provided that the buyers obtain a "Purchase Center License" (Government of Madhya Pradesh 2008).[18] The amendment to the Act represents an important step toward greater flexibility in the marketing of agricultural produce in the state.

[13] A host village is typically a middle rung village with a population of 1,000–3,000, according to the 1991 census. The computer equipment is typically placed in a farmer's house who receives 0.5 percent of the value of each transaction that is made through the kiosk at the ITC hub, thereby giving him the incentive to spread price information widely to other farmers.

[14] The offer price of ITC posted in the evening on the Web site is honored the next day. The next morning, ITC offer prices may be revised according to the *mandi* movements. The ITC price can go up from the posted price (if the *mandi* rates are higher), but can never fall, thus offering a guarantee.

[15] The government of India declares MSP for agricultural produce every year at the national level. "The aim is to ensure remunerative prices to the growers of the produce with a view to encourage higher investment and production" (Government of Madhya Pradesh 2000).

[16] The hubs are managed in part by ITC's former commission agents, some of whom have been integrated into this intervention because they provide important storage and transport services and have knowledge about local village conditions.

[17] This provision permitted farmers with small landholdings and annual output to sell their produce outside the regulated markets.

[18] According to Upton and Fuller (2003), "the government amended the act to legalize purchases of beans outside the *mandis*. Since the Web site was accessible to anyone, including the government, to cross-check posted prices—it facilitated the government's acceptance of the initiative."

Table 1—Share in Total Volume of Crop Production

State		Western region		Eastern region	
Crops	Share (%)	Crops	Share (%)	Crops	Share (%)
Soybean	49.44	Soybean	68.57	Rice	39.61
Rice	14.82	Maize	11.36	Maize	12.40
Maize	11.71	Sorghum	6.61	Soybean	10.94
Sorghum	7.62	Cottonseed	3.78	Sorghum	9.66
Cottonseed	4.59	Red Gram	2.83	Cottonseed	6.21
Red Gram	3.13	Rice	2.51	Millet	5.29
Groundnut	2.51	Groundnut	2.30	Red Gram	3.74

Notes: Sample includes district level production in the year 1998–1999 obtained from the Commissioner of Land Records, Government of Madhya Pradesh. Total production includes production of all 18 crops (6 cereals, 5 pulses, 7 oilseeds) grown during the monsoon season of Madhya Pradesh.

The 45 districts can be divided into two main regions: the high soy producing region in the west central part of the state and the low soy producing region in the east. The abundance of deep and medium black soil in the western region of the state makes it very conducive to soy production, while the eastern and northern regions are primarily a rice growing belt. Soy constitutes more than 65 percent of total volume of agricultural production in the monsoon season in this group of districts as opposed to approximately 11 percent in the east (see Table 1). The kiosks and hubs were built in the 23 high soy producing districts in the west central region of the state.[19] An average of 74 kiosks and 2 hubs per district were built and the majority of the hubs were established in the same town as a main *mandi*.

The next section outlines a model that captures some of the key features of the rural marketing environment. In particular, the presence of physical transport costs and information frictions, which tend to limit farmers' choices of where to sell their produce are considered. An important motive for ITC to start buying directly from the farmers was to be able to control the quality of soybeans that it purchases. The endogeneity of supply in a simultaneous game gives us predictions about the determination of prices of differentiated products. There are other significant features of the intervention, such as the offer of a guaranteed price by ITC Limited and the repeated interactions between the traders and farmers, that are not explicitly modeled. However, even this simple and tractable model provides an understanding of the types of effects that can be expected from the intervention and the underlying mechanisms of change.

II. Conceptual Framework

Consider a variant of the Harold Hotelling (1929) model in which farmers are uniformly distributed along the interval [0,1]. The good has two quality levels—high (H) and low (L). Farmers observe the quality of their good. A proportion λ of the

[19] According to 2001 census, there were 45 districts in MP. Three new districts were created in 2003 making a total of 48 districts in 2005. The total number of districts in the 2001 census are considered to avoid complications.

farmers have low quality and are distributed uniformly along the unit interval. The farmers have unit supply, i.e., each farmer sells one or zero units of the good.

There are two market towns located at the extremes. For simplicity, assume that only one trader operates in each market.[20] Trader 1 is located at $x = 0$ and trader 2 at $x = 1$. The unit cost for each trader operating in each market is c, and is independent of quality. For ease of exposition, c is normalized to 0.[21] Farmers incur a transportation cost t per unit of distance.[22] Traders do not possess the technology to verify quality. Furthermore, both traders sell the good to processors at a competitive price p_i', where $p_i' = \gamma_i p^* + (1 - \gamma_i)p^{**}$, such that $p^{**} > p^*$ and γ_i is the proportion of trader i's goods that are of low quality.[23]

The timing of the game is as follows. Traders simultaneously choose prices. Farmers then choose to sell to either trader 1 or trader 2.[24] Let the price offered by trader 1 be p_1 and the price offered by trader 2 be p_2. Suppose, first, that farmers are not perfectly informed about the price offered by traders prior to sale. A farmer can sell the good to a trader if and only if he knows the price offered by that trader. I adopt the model developed by Jean Tirole (1988), which builds on Gerard R. Butters (1977) and Gene M. Grossman and Carl Shapiro (1984), to analyze spatial competition with imperfect information. Let $\Theta_i (i = 1,2)$ denote the fraction of farmers who know the price offered by trader i. Farmers located anywhere along the segment have equal chance of knowing this price information. The potential supply to trader 1 is a proportion Θ_1 of all farmers. A fraction $1 - \Theta_2$ of this potential supply do not know the price offered by trader 2. The remaining fraction Θ_2 also know the price offered by trader 2 and therefore constitute a more elastic or competitive segment of supply.

When the two traders choose prices simultaneously, trader 1's choice is described by

$$max_{p_1}\left\{(p_i' - p_1)\left[\Theta_1\left((1 - \Theta_2) + \Theta_2\left(\frac{p_1 - p_2 + t}{2t}\right)\right)\right]\right\}$$

and trader 2's choice is described similarly. The symmetric equilibrium ($\Theta_1 = \Theta_2 = \Theta$) prices offered by both traders are

$$p_1^{pre} = p_2^{pre} = \lambda p^* + (1 - \lambda)p^{**} - \frac{t(2 - \Theta)}{\Theta}. \tag{1}$$

[20] As discussed in the previous section, there are multiple traders operating in each *mandi* who participate in the procurement auction. In this paper, I do not explicitly model the auction process or the strategic interaction between traders within a given *mandi*, but rather focus on the interaction between traders across *mandis*.

[21] This represents the miscellaneous transaction costs incurred by the traders, such as the cost of storing, weighing, loading, and bagging per unit of soybean.

[22] The results of this model will hold for quadratic transportation costs, where marginal transportation cost increase with distance, as well.

[23] This captures the idea that a processor samples the quality of the produce and pays a price based on the proportion of low quality. γ_i is determined in equilibrium. $(0 \leq \gamma_i \leq 1)$.

[24] It is implicitly assumed that transport costs are below the price offered by the processor for low quality $(t < p^*)$ such that farmers always prefer to sell.

When kiosks that post prices are introduced, Θ increases. It is straightforward to see that equilibrium prices will be higher $((\partial p^{pre}/\partial\Theta) = (2t/\Theta^2) > 0)$. The provision of price information to farmers increases the proportion of the market where traders compete. The magnitude of the increase will depend on the parameter Θ. If Θ is high to begin with, then the increase in the price caused by the introduction of kiosks is unlikely to be very large.[25]

Now, suppose that a third trader, who I call trader 3, enters and locates itself next to trader 2 at $x = 1$. This is consistent with how ITC Limited introduced its hubs. Forty out of the 45 hubs were located in the same town as the main market.[26] I assume that the price offered by all traders is known to all farmers prior to sale $(\Theta_i = 1)$. Trader 3 has access to superior technology that allows it to verify quality. Farmers know that trader 3 can distinguish between quality levels. I continue to assume that traders 1 and 2 do not possess the technology to verify quality. Each of the three traders set prices. The strategy profile of all traders is given by $\mathbf{p} = (p_1, p_2, p_3^L, p_3^H)$. The proportion of low quality goods received by each trader, γ_i, is determined endogeneously.

Since trader 2 and trader 3 are located in the same market town, the outcome of their price competition is similar to a Bertrand outcome. The introduction of a third trader who is able to verify quality, drives down the price of a low-quality good to the marginal value of low quality, given by p^*. The price offered by trader 2 is then too low for it to attract any high-quality goods. In equilibrium, the three traders receive different proportions of low- and high-quality goods. The proof is in the Appendix. With heterogeneous quality, there are two opposing forces on the prices offered by traders 1 and 2. On the one hand, entry by trader 3 puts upward pressure on the price offered by traders 1 and 2, the competition effect. On the other hand, sorting of farmers based on their quality puts a downward pressure on price offered by traders 1 and 2, the composition effect. It will ultimately be an empirical question to determine which of the two effects dominates.

III. Data

The data used in this paper comes from four different sources. First, information on monthly prices and volume of crops sold in the main *mandis* of the state from April 2000 to September 2005 is available from the MP State Agricultural Marketing Board. Second, annual district level production, yield and net area under cultivation of crops from 1998–2004 is taken from the Commissioner of Land Records, MP.[27] Third, dates of installation and location of all Internet kiosks and hubs is obtained from the

[25] A plausible concern is that interlinked transactions between farmers and traders, such as the provision of credit by traders that binds the sale of the final product by the farmers to them, will imply that better information will not lead to more arbitrage opportunities (as discussed by Bardhan 1989). However, interviews with farmers did not reveal any evidence in support of significant interlinkages in the production of soy. Farmers reported that they obtain credit from nationalized banks and cooperative societies rather than from the traders. The rapid expansion of the rural bank network is noted by Robin Burgess and Rohini Pande (2005).

[26] Theoretically, it is optimal for trader 3 to locate himself in the middle of trader 1 and 2 and capture all the supply. In reality hubs must be established in towns and not on farm land. The towns are located at the extremes of farm land, which is where trader 3 can set up hubs.

[27] Net area cultivated refers to area under crops grown only during the monsoon season of MP.

Table 2—Installation Dates across Districts of Madhya Pradesh

District	Date of first kiosk	Date of first hub
Betul	Mar–03	Apr–03
Bhopal	Nov–00	Oct–03
Chhindwara	Mar–03	Oct–03
Damoh	Apr–03	Nov–03
Dewas	Dec–00	Apr–03
Dhar	Dec–00	Oct–02
Guna	Mar–01	Nov–01
Harda	Oct–00	Oct–02
Hoshangabad	Nov–00	Oct–02
Indore	Dec–00	Sep–01
Khandwa	Sep–01	Oct–01
Mandsaur	Mar–02	Nov–03
Narsinghpur	Apr–03	Nov–03
Neemuch	Jun–02	Oct–02
Raisen	Oct–00	Oct–00
Rajgarh	May–01	Nov–03
Ratlam	Dec–00	Oct–03
Sagar	Apr–03	Nov–03
Sehore	Oct–00	Apr–02
Shajapur	Dec–00	May–02
Shivpuri	Nov–01	None
Ujjain	Oct–00	Oct–03
Vidisha	Apr–01	Apr–02

Notes: Data obtained from the Business Records of ITC Limited. The installation date of an Internet kiosk is defined as the day the computer equipment was installed in the village by ITC. The hub installation date is defined as the day the first direct sale was made by a farmer at the ITC warehouse.

company's business records. Monthly procurement of soybean by ITC Limited at each of its hubs is also obtained from the company and lastly, annual administrative and demographic information at the district level is taken from the census of India 2001.

A total of 1,704 Web kiosks and 45 hubs were established in 23 (out of a total of 45) districts of MP during the time period from October 2000 to January 2005. The installation date of an Internet kiosk is defined as the day the computer equipment was installed in the village by ITC. On the other hand, the hub installation date is defined as the day the first direct sale was made by a farmer at the hub. In this way, I measure effective installation of hubs. Table 2 provides the dates at which the first kiosk and the first hub were set up in each district.[28] The installation of the first hub always postdates the installation of the first kiosk in a district. Thus, at most, two effects can be identified—the effect of kiosks without hubs and the effect of kiosks with hubs.

The state marketing board collects monthly data on prices and quantities crops sold in the *mandis* of the state. In a particular *mandi*, different crops of varying quality are sold each day at varying rates. *Mandi* officials record the price and quantity sold of every transaction. At the end of the day, a daily minimum price, maximum price, and mode price, as well as total quantity sold for every crop are recorded by

[28] Kiosks were built really rapidly in each district. Thus, the date of the first kiosk is to be interpreted as essentially the date that all kiosks were built in a district.

mandi officials.[29] From all the daily entries for a given month, a monthly minimum, maximum, and mode price, as well as total monthly sales are calculated.[30] The monthly price and sales data is provided by each *mandi* to the central state marketing board, from where I obtained the data for a period of 66 months (from April 2000 to September 2005). With no measures of average price in a month, the mode price can be considered the best available proxy for mean price. Additional price data in a subsample of *mandis* is available from April 1998. Data on individual transactions and on daily prices and sales is not available.[31]

It is important to point out that I observe the price of crops sold in government regulated wholesale *mandis*. This data does not include the price posted or offered by ITC. Moreover, these are raw monthly prices without any quality grading, which is a major drawback since quality may have changed in response to the intervention. An overall increase in the quality of soybean produced will tend to bias the results toward finding a positive price effect of the intervention. This concern will be discussed at length in the subsequent sections.

The monthly sales volume of a crop in a *mandi* measures the total quantity that was sold in a month. This volume consists of two key components. The first component is the total amount of the crop sold inside the *mandi* yard, which is recorded and calculated as described above. The second component is the quantity sold by farmers directly to private buyers outside the *mandi* yard, but for which *mandi* tax has been paid to the concerned *mandi*.[32] Thus, the quantity of soybean sold at the ITC hubs is included in the *mandi* sales volume data. Since I observe monthly procurement of soybean by ITC at its hubs, I deduct this amount from the relevant quantity sold in the *mandi* where it paid tax to obtain my preferred measure of the total sales volume of a *mandi*, which excludes the amount sold at the ITC hubs.

To my knowledge, this is the first attempt to collect and compile detailed data on price and volume of crops sold in government regulated wholesale agricultural markets to examine the impact of a change in the procurement strategy of a private buyer on the functioning of rural markets in India.

Table 3 provides summary statistics. Throughout the empirical analysis, I use data from 23 high soy producing districts that received the intervention. Out of a potential 66 months of data for each crop in each of the 144 *mandis* in 23 districts of the state, any observation where the outcome is recorded as 0 or missing is excluded. From a panel of potential 9,504 *mandi* $\times$ month (144×66) observations for soybean, I am left with 8,276 (8,639) positive observed values of mode price (sales).[33]

[29] The daily minimum price is the lowest price that prevailed that day. The daily maximum price is the highest price that prevailed that day. The daily mode price is the price at which the highest quantity of a crop is sold in a day.

[30] The monthly minimum price is the lowest prevailing price in a given month (minimum of daily minimums). The monthly maximum price is the highest prevailing price in a given month (maximum of daily maximums). The monthly mode price is the price that is associated with the highest quantity of a crop sold in a month (mode of daily modes associated with highest quantity sold).

[31] Daily price and sales recorded in individual *mandis* are not compiled by the state marketing board. Moreover, individual *mandis* do not typically keep records of historical daily price and sales information.

[32] A buyer operating outside the *mandi* yard is required by the law to provide complete documentation (recording the quantity bought) to the *mandi* officials. This amount is added to the sales volume of a particular *mandi*.

[33] The 9,504 potential number of observations contain 12 (43) instances where the mode price (sales) is recorded as zero, and there are 1,216 (822) missing observations. This leaves a total of 8,276 (8,639) positive observed values of mode price (sales) for soybean.

Table 3—Summary Statistics

	N	Mean	SD
Any kiosk in a district	9,504	0.76	0.43
Any hub in a district	9,504	0.48	0.50
Mode price of soy	8,276	1,187.54	228.96
Maximum price of soy	8,284	1,257.05	253.06
Minimum price of soy	8,284	1,053.37	231.51
Sales volume of soy	8,639	1,691.71	3,740.70
Mode price of soy below minimum support price	464	834.63	51.48
Mode price of soy in the fourth quarter	1,966	1,126.02	177.21
Coefficient of variation in price of soy across *mandis*	9,504	0.19	0.03
Total area cultivated	161	265.92	113.47
Area under soybean	161	178.73	87.48
Area under maize	156	22.89	24.37
Area under groundnut	161	5.40	13.35
Area under rice	161	7.82	12.91
Total production	161	243.74	121.49
Soy production	161	161.22	102.77
Maize production	156	40.96	49.54
Groundnut production	161	5.98	16.11
Rice production	161	6.14	9.97
Total yield	161	929.74	268.51
Soy yield	161	890.42	296.17
Maize yield	156	1,748.85	463.19
Groundnut yield	161	1,101.91	454.14
Rice yield	161	800.83	268.88

Notes: Prices and sales volume are recorded monthly from April 2000–September 2005 for 144 markets. Output is recorded annually for a period of 7 years from 1998–2004 in 23 districts. Production is measured in thousand tons, area in thousand hectares, price in rupees/quintal.

IV. Empirical Strategy

The goal of the empirical analysis is to examine the impact of a change in the procurement strategy undertaken by ITC on the functioning of government regulated wholesale agricultural markets over time. To do this, I utilize panel data on monthly crop prices and volume of sales to rely on plausibly exogenous variation driven by the intervention. Since different districts received kiosks and hubs at different times, this differential timing is used to isolate the impact of the intervention on the price and output of soybean in agricultural *mandis* located in a district.

As discussed in Section IB, kiosks and hubs are built in 23 high soy growing districts in the west central part of the state. The identification strategy exploits inter-district variation in the timing of the introduction of kiosks and hubs across these 23 districts to identify the effect. The identifying assumption is that, in the absence of the intervention, there would have been no differential change in the price of soy across the districts over this period. To the extent that the timing of the intervention in different areas was chosen in response to actual and forecastable changes in the local price of soybean, the results would be biased. However, since the date of the introduction varied substantially across districts, and was chosen far in advance by ITC officials, this type of endogeneity seems unlikely to have been present.[34] Figure 1 shows the

[34] The districts of Raisen, Sehore, Ujjain, and Harda were selected to receive the kiosks first because these districts contained ITC's processing plants, which could serve as a hub. Subsequently additional warehouses were

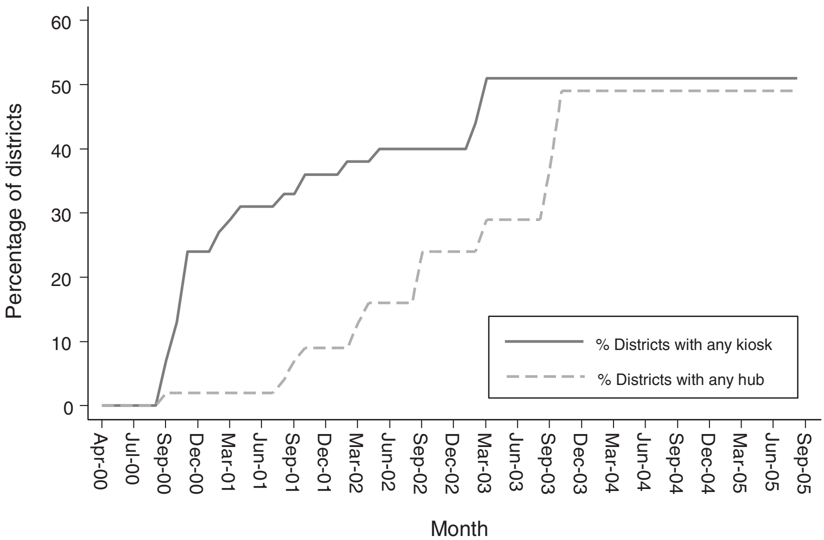

Figure 1. Percentage of Districts with Kiosks and Hubs

percentage of districts with at least one kiosk and hub in each year. By the end of 2000, 11 out of 45 districts (24 percent) had received at least 1 Internet kiosk, while only 2 percent of the districts had at least 1 hub. By 2004, all 23 districts (51 percent of total) had received at least 1 kiosk and hub.[35] It is difficult to imagine another factor with a sharp and discrete change that drives both the introduction of kiosks and changes in soybean price. Conditional on *mandi* and month fixed effects as well as district-specific time trends, the timing of the introduction of kiosks and hubs across districts is plausibly orthogonal to future movements in price.

A. *Basic Results*

I start by estimating

$$P_{ijt} = \beta_1 + \beta_2 K_{jt} + \beta_3 H_{jt} + \gamma_i + \mu_t + t\phi_j + \epsilon_{ijt}, \tag{2}$$

where the outcome variable, P_{ijt} is the log mode price of soybean in *mandi* i located in district j at month t. Since prices are likely to change proportionally rather than

leased (to serve the role of hubs) and kiosks were set up around each one of them. The chief executive of the Agri-Business Division of ITC Limited stated the following: "We started setting up kiosks around our pre-existing processing units (to maximize on logistics savings). The actual location of a processing unit is a function of which unit is available for toll operations, as we depend on hired units. Thereafter, we expanded in radius into all the key soy growing areas. Even here sequence started with such locations that result in the lowest landed cost of soybeans at each of the processing units."

[35] Shivpuri is the only district that has Internet kiosks and no hub. Thus, only 49 percent of total districts in the state received a hub.

Table 4—Effect on Monthly Wholesale Market Price and Quantity of Soybeans

	Log(mode price)			Log(min. price)		Log(max. price)		Log(sales volume)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Kiosk	0.017	0.017		0.018		0.001		0.055
	[0.005]**	[0.005]**		[0.007]*		[0.004]		[0.149]
Hub		−0.001		0.007		0.001		−0.13
		[0.007]		[0.011]		[0.006]		[0.131]
Kiosk pre 1–6 months			0.001		0.014		−0.004	
			[0.007]		[0.012]		[0.006]	
Kiosk post 0–5 months			0.019		0.031		0.001	
			[0.007]*		[0.010]**		[0.006]	
Kiosk post 6+ months			0.016		0.028		−0.006	
			[0.009]		[0.013]*		[0.008]	
N	8,276	8,276	8,276	8,284	8,284	8,284	8,284	8,639
R^2	0.88	0.88	0.88	0.75	0.75	0.88	0.88	0.74

Notes: Kiosk is an indicator variable for whether there is a kiosk in a district. Hub is an indicator variable for whether there is a hub in a district. Kiosk pre-1–6 months is an indicator variable for six months leading up to kiosk introduction in a district. Kiosk 0–5 months is an indicator variable for the month the kiosk is introduced and the first five months thereafter. Kiosk 6+ is an indicator variable for the sixth month and beyond kiosk introduction in a district. All regressions include *mandi* and month fixed effects as well as district time trends. Robust standard errors in brackets are clustered by district.

**Significant at the 1 percent level.

*Significant at the 5 percent level.

by a fixed rupee amount, it is sensible to transform the variable using logs.[36] The γ_i's represent a full set of *mandi* fixed effects that control for unobserved time invariant heterogeneity in *mandi* characteristics arising from differences in infrastructure, soil quality, and market size.[37] The μ_t's represent a full set of month fixed effects (there are 65 indicator variables for the sample going from April 2000 to September 2005) that control for any time varying aggregate factors affecting the price of soybean across all the *mandis* in the state, such as world prices, common demand shocks, or common climate shocks.

To control for differential price trends across districts during the period of interest, district-specific time trends are also included represented by $t\phi_j$. The standard errors are clustered at the district level. ϵ_{ijt} is a *mandi*-district-month specific error term. K_{jt} is an indicator variable for whether there is a kiosk in district j in month t. Similarly, H_{jt} is an indicator variable for whether there is a hub in district j at month t. Since hubs were set up after kiosks, β_3 measures the marginal effect of adding a hub to a kiosk.

Using the sample of 144 *mandis* in 23 districts of the state, the results indicate a positive and significant effect of kiosks on the average price of soybean as presented in Table 4. The presence of kiosks in a district is associated with an increase in the

[36] Moreover, the mode price appears to be positively skewed, whereas the log mode price is much more symmetrically distributed. Results are qualitatively similar when estimated in levels.

[37] District fixed effects are essentially incorporated by including *mandi* fixed effects.

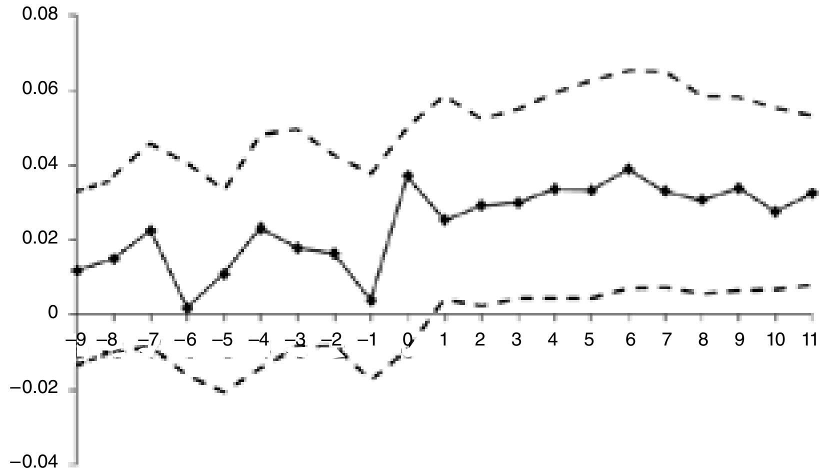

Figure 2. Month Effect of Kiosks on Price

average monthly mode price of soy in the *mandis* located in that district by 1.7 percent (columns 1–2). This result lends support to the theoretical prediction that the availability of price information to farmers increases the competitiveness of traders in local output markets, leading to an increase in the price of soybean in the *mandis*. The effect of a hub on the *mandi* price of soybean is very small and insignificant. Since quality is scientifically tested at the ITC hubs, there might be sorting of farmers based on the quality of their produce. If farmers with good quality soybean have a greater incentive to sell directly to the private company, I would expect a modest decline in the price of soybean in the *mandis* over time. The result implies that the additional competition effect of the hub is being offset by the composition change effect, leading to a small and statistically insignificant net effect of the hub.

The results in columns 1–2 assume that the effect of the intervention is instantaneous. On the one hand, awareness about the presence of kiosks and learning over time is likely to accentuate the effect of the intervention. On the other hand, supply might respond to this sudden increase in price leading to a downward pressure on the market price of soybean over time. To examine whether and how the effect of kiosks varies over time, I include additional pre-and post-binary variables that indicate time periods immediately preceding or following kiosk introduction. This allows me to differentiate between a level and a trend effect of the intervention. In column 3, I find that the significant increase in soy price tends to persist after kiosk introduction. The coefficients on post 0–5 months and post 6+ months are significant and not statistically different from each other. In addition, I add an indicator variable for the months leading up to kiosk introduction (placebo test), and find that the difference between the post and pre coefficients is significantly positive.

Figure 2 plots the month effect of the intervention (a 95 percent confidence interval is plotted in a broken line). There appears to be no significant changes in price before the introduction of kiosks, with a sharp acceleration in price occurring at the point of introduction that persists. All coefficients are statistically insignificant pre-intervention, but significantly different from zero post-intervention. This suggests that the timing of kiosk introduction is not being driven by pre-existing differential trends in price. The evidence directly lends support to the identification strategy and the consequent validity of the effect.

Columns 4–7 of Table 4 present the results for the average monthly minimum and maximum prices of soybean in the local markets. One might expect different effects on minimum and maximum prices, though the theoretical model does not investigate this possibility as it simplifies by assuming a single price. Intuitively, if the minimum price represents the price received by the least informed farmers, then the presence of kiosks is expected to have a positive and significant effect on the average minimum price in the *mandis*. Similarly, if the maximum price represents the price already received by most informed farmers, I should then expect no additional effect of the kiosks on the maximum price. In columns 4–5, the presence of kiosks in a district increases the monthly average minimum price by 1.9 percent. Moreover, the effect of kiosks in the first 6 months is a robust 3 percent that persists. The presence of kiosks and hubs have no apparent significant effect on the average monthly maximum price of soybean in the *mandis* of MP (columns 6–7). This result strengthens the argument that improvements in information are responsible for the impact of kiosks on the average price received by farmers in local markets.[38]

An empirical test of whether direct buying by ITC caused volume of sales to be diverted from the *mandis* is imperative to understanding the effect of the intervention. Column 8 of Table 4, shows that the presence of hubs is associated with a slight reduction in the quantity of soybean sold in the *mandis* (excluding quantity of soy sold to ITC). The coefficient is negative, but insignificant. Aggregating treatment at the district level is likely to underestimate the impact if *mandis* located close to hubs are affected more than others located farther away. Measuring heterogeneous effects by distance is beyond the scope of the current paper, but a likely extension for future work.

B. *Price Dispersion*

Information about prices in different markets is likely to reduce dispersion in the price of soybean within the group of *mandis* that were "treated." The magnitude of price dispersion faced by soybean farmers is substantial. For instance, the tenth and ninetieth percentile of the mode price of soybean across *mandis* in May 1998 is Rs775/Qtl. and Rs1002/Qtl., respectively. I examine the amount of price dispersion by computing the standard deviation and the coefficient of variation of mode price across *mandis* located in a district within a given month.[39] These two complementary measures are

[38] A regression of the residuals from estimating equation (2) on its lag produces a coefficient of −0.004 (0.011 s.e.), suggesting that the residuals appear to be much less serially correlated than expected. I also use two commonly used unit root tests for panel data: Levin-Lin-Chu (LLC) and Im-Pesaran-Shin (IPS). Under the null hypothesis, both tests assume that all series in the panel are nonstationary. LLC test assumes that all series are stationary under the alternative hypothesis, whereas IPS test assumes that only a fraction of the series in the panel is stationary. Using both tests (on a subsample of *mandis* with no missing data), I reject the null hypothesis of nonstationarity of the price variables.

[39] It is important to point out that inter-district spillovers, would result in underestimation of the impact. Nevertheless, within district comparison remains a useful starting point to estimate the baseline effect of the intervention on price dispersion.

Table 5—Effect on Price Dispersion

	Coefficient of variation		Standard deviation	
	(1)	(2)	(3)	(4)
Kiosk	−0.009	−0.009	−11.09	−10.341
	[0.004]*	[0.004]*	[5.293]*	[5.100]*
Hub		−0.003		−3.454
		[0.004]		[4.703]
N	1,474	1,474	1,474	1,474
R^2	0.31	0.31	0.36	0.36

Notes: The dependent variable is the coefficient of variation, or the standard deviation in the monthly mode price of soybean across *mandis* located in a district within a given month. The unit of observation is a district-month. All regressions include district and month fixed effects as well as district linear trends. Robust standard errors in brackets are clustered by district.

**Significant at the 1 percent level.

*Significant at the 5 percent level.

commonly used in the literature (Alan T. Sorensen 2000). The coefficient of variation, defined as (sd/mean), is a unit free measure of relative price dispersion. With an average of six *mandis* located in each district, the sample is collapsed to observations at the district-month level. Table 5 shows that the mean coefficient of variation of price across *mandis* in a district declines on average after Internet kiosks are introduced. The coefficients in columns 1–2 are negative and significant but very small. Similarly, the standard deviation in the price of soy across *mandis* is also decreasing post intervention, suggesting a reduction in spatial price variability.

C. *Output Response*

If the average price of soybean in the *mandis* increased after the introduction of the kiosks, it is important to examine the output response on the part of farmers. The presence of kiosks and hubs may create entry and exit in response to an increase in the price. To the extent that farmers have an incentive to expand area and production of soy, we might expect a change in the mix of crops grown by farmers. This can be directly tested by using annual district level production data to estimate the following equation:

$$y_{jt} = \beta_1 + \beta_2 K_{jt} + \beta_3 H_{jt} + \delta_j + \nu_t + t\omega_j + \epsilon_{jt}, \quad (3)$$

where y_{jt} is the outcome of interest for district j in year t. δ_j's are a full set of district fixed effects that control for time invariant district characteristics. ν_t's represent a full set of year fixed effects controlling for climate shocks and other secular changes in outcome variables that are common across districts of the state. District-specific linear time trends $(t\omega_j)$ controlling for the possibility of a spurious correlation between the introduction of kiosks (and hubs) and outcomes across districts are also included in the above specification. ϵ_{jt} is a district-year specific error term. Standard errors are are clustered at the district level. K_{jt} and H_{jt} are indicator variables denoting whether kiosks and hubs exist in district j in year t.

Table 6—Effect on Crop Output

	Total	Soybean	Rice	Maize	Groundnut
	(1)	(2)	(3)	(4)	(5)
Panel A. Area					
Kiosk	0.026	0.190	−0.121	0.048	0.085
	[0.017]	[0.060]**	[0.055]*	[0.044]	[0.115]
Hub	−0.048	−0.009	−0.027	−0.054	−0.107
	[0.042]	[0.068]	[0.099]	[0.069]	[0.112]
Panel B. Production					
Kiosk	0.082	0.186	−0.097	0.075	−0.027
	[0.093]	[0.082]*	[0.105]	[0.107]	[0.111]
Hub	0.05	0.048	−0.063	−0.003	−0.01
	[0.121]	[0.144]	[0.141]	[0.148]	[0.201]
Panel C. Yield					
Kiosk	0.056	−0.004	0.023	0.026	−0.112
	[0.091]	[0.080]	[0.104]	[0.108]	[0.150]
Hub	0.098	0.057	−0.036	0.051	0.098
	[0.100]	[0.110]	[0.107]	[0.101]	[0.161]
N	161	161	161	156	161
R^2	0.7	0.62	0.74	0.66	0.59

Notes: All regressions include district and year fixed effects as well as district linear trends. Robust standard errors in brackets are clustered by district. All dependent variables are in logs.

**Significant at the 1 percent level.

*Significant at the 5 percent level.

Panel A in Table 6 presents the results from estimating equation (3) to examine the effect of the intervention on net area cultivated.[40] The total (net) area cultivated under all crops grown in the same season as soy is not significantly affected by the intervention (column 1). However, there appears to be a positive and significant impact of the intervention on the area cultivated under soy (column 2). The presence of kiosks in a district is associated with a 19 percent increase in area under soy. Since the overall area cultivated is not affected by the intervention, this suggests that farmers are substituting away from an alternative crop and into soy. In column 3, I find a negative association between the presence of kiosks and the area cultivated under rice in a district. I do not find a significant effect of the intervention on any of the other 16 crops grown in this season in the state.[41] Specifically, the area under maize (the second largest crop in terms of its share in total production in the western region of the state) and groundnut (the second largest edible oilseed after soy as shown in Table 1) is not significantly affected by the presence of kiosks and hubs as presented in columns 4–5. In Panel B (column 2), the intervention is also associated with approximately 19 percent effect on the production of soy. This important effect on output strengthens the argument that improvements in information are indeed

[40] The net measure accounts for relevant area at a single point in the year, while gross area accounts for each separate use of the same area during a year. Soybean, maize, and groundnut are cultivated only during the monsoon season, hence the relevant measure in this paper is net.

[41] For brevity, results for all the other crops are not included (available from the author).

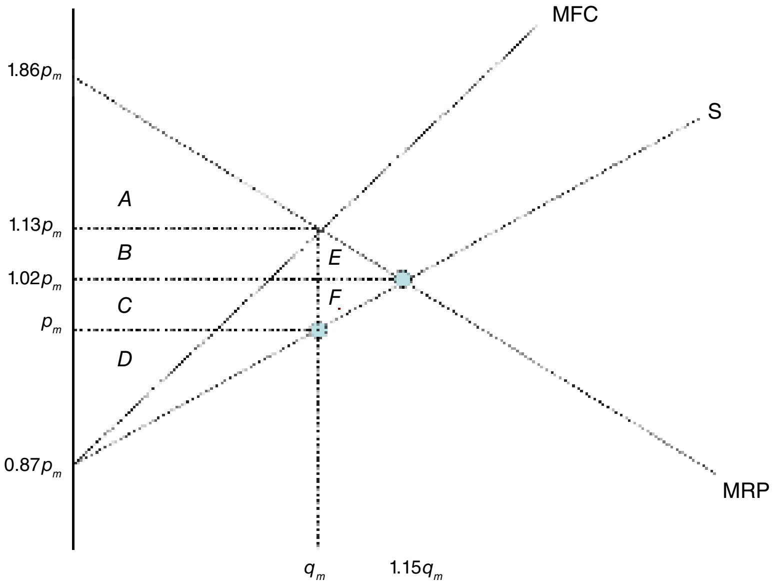

Figure 3. Welfare Changes in Local Markets

translating into higher return for farmers. Otherwise, I would not expect to find a change in their planting behavior.

D. *Welfare Effects*

Figure 3 shows the basic analytics of the welfare change as a result of this intervention. The pre-intervention monopsony equilibrium in the *mandis* of the state is given by (p_m, q_m).[42] The traders purchase soybeans up to the quantity at which the marginal factor cost is equal to the marginal revenue product, q_m in Figure 3. Since the traders want to pay the lowest price at which the farmers are willing to provide q_m, the equilibrium price is given by the height of the supply curve at this quantity p_m. The intervention results, on average, in a 2 percent increase in the *mandi* price and a 19 percent increase in soy production as estimated above. Of the 19 percent increase, approximately 3.6 percent is bought by ITC annually, which leads to a 15 percent increase in soy production being transacted in the *mandis*. Hence, the post-intervention competitive equilibrium in the *mandis* is characterized by $(1.02p_m, 1.15q_m)$.[43] Under the assumption of a linear supply curve, the pre-intervention profits of the farmers, given by D, can be calculated to be $0.065p_m q_m$. After the intervention, there is a 33 percent $(C + F)$ net gain in profits of the farmers of which 31 percent (C) represents the

[42] Since the supply curve facing the monopsonist slopes upward, the marginal factor cost curve lies above the supply curve.

[43] With a linear supply curve, $P = a + bQ$, b is calculated to be equal to $0.13p_m/q_m$ and $a = 0.87p_m$. The marginal factor cost $(a + 2bQ)$ at q_m is calculated to be equal to $1.13p_m$. For the traders, the demand for soybeans is a derived demand determined by its marginal revenue product. Under the assumption of linearity, $P = r - sQ$, s is calculated to be equal to $0.73p_m/q_m$ and $r = 1.86p_m$.

redistribution of surplus away from traders to farmers and an additional 2 percent (F) is the the welfare gain of deadweight loss under monopsony.[44]

The profits of the traders before the intervention, given by $A + B + C$, can be calculated to be equal to $0.5p_m q_m$. After the intervention, the traders lose 4 percent of their profits (C) to the farmers and gain 2 percent (E) of the deadweight loss. This results in a 2 percent net loss in traders profits. The analysis characterizes an important innovation that improvements in information result in a relatively larger net gain for the farmers, but not a huge net loss for the traders. However, a caveat is in order when interpreting these results for soybeans since a general equilibrium approach of monopsony would require an examination of its effects within the context of the entire market economy comprising of all crops transacted in the *mandis*.

This intervention, implemented by a profit maximizing private company, provided an alternative both to ITC for procuring soybean and to soy farmers for selling their produce. By targeting soy farmers, the immediate benefit to the private company of this intervention was the improvement in procurement efficiency of soybeans resulting from the creation of a direct marketing channel. According to Kumar (2004), "ITC calculated that it saved Rs 13.3 million in transaction costs or almost 2 percent of the total value of the produce in the first season of procurement through this intervention." This feature makes the intervention self-sustaining because it is profitable for both the private company and farmers to implement and use it respectively.

V. Alternative Explanations

A legitimate concern is that the increase in price observed post-intervention may actually reflect an increase in the overall quality of soybean over time. As mentioned earlier, there is an unobservable aspect to soybean quality that refers to the oil and protein content of the seed, and there is an observable aspect of quality that refers to the presence of moisture, dirt, and damaged seeds in the sample of produce offered for sale. An increase in either one or both aspects of quality will tend to bias the results. Unfortunately, I do not observe quality contingent prices of crops. The MP marketing board does not publish monthly prices with quality grading. Given this shortcoming, I provide two pieces of suggestive evidence that an overall improvement in quality is not what is driving the results.

Kiosks provide information on farming techniques and weather forecasts which could lead to an improvement in unobservable aspects of quality. Panel C in Table 6 provides estimates of the effect of the intervention on the annual yield of crops. While this is circumstantial evidence, it seems plausible that improvements in technique that led to increased quality would also improve yield. I find no evidence of a significant increase in annual district level yield of soy.

A related concern is that, perhaps, farmers clean up their produce more after the introduction of kiosks, which would increase the observable aspects of quality leading to an increase in price. This is a valid concern, because daily buying of soybean

[44] The new profits of the farmers are characterized by $D + C + F$. This can be calculated to be equal to $0.0865p_m q_m$, where $C = 0.02p_m q_m$ and $F = 0.0015p_m q_m$.

in local markets and hubs is based on observable features of quality. The Government of India announces the MSP of soybean for a certain quality threshold each year. It is required by law that only soybean of quality below the MSP quality be sold at a price below MSP. To examine the impact of the intervention on observable quality, I restrict the sample to *mandi*-month cells where the observed monthly mode price of soybean is below the MSP. This subsample has 464 observations. If improvement in observable aspects of quality creates an increase in price that is spuriously attributed to the key explanatory variables, then the impact of the intervention on the price of soybean in this subsample should also be positive. The coefficients on K_{jt} and H_{jt} are negative, very small, and not significantly different from zero.[45] Furthermore, I find an instantaneous effect of kiosks on price of soy in local markets (as estimated previously), and it is hard to imagine that the response on quality of soybean could be that immediate. Anecdotally, farmers were not aware of any new varieties of soy growing seed being introduced in this period and considerable overall improvement in quality appears to be a longer term change. These pieces of evidence lend support to the assertion that the increase in price was due primarily to the increase in information to farmers and the resulting increase in competitiveness of buyers in *mandis*.

It is plausible that traders would exit *mandis* located near a hub and move into *mandis* that are not located near hubs, but still located near kiosks. This increase in demand could be an alternative mechanism leading to an upward pressure on *mandi* prices. Similarly, the offer of a guaranteed price by ITC could potentially increase *mandi* prices by reducing farmer's risk. However, the potential exit of traders away from the *mandis* is likely to take place only after hubs have been established. Similarly, the guaranteed price can only be realized once the farmer decides to sell at the hub. Given that I do not find any significant effects of the hub on the average price and price dispersion, this type of exit behavior or risk reduction seems unlikely to be driving the kiosk result.

VI. Conclusion

The intervention implemented by a private company in the central Indian state of Madhya Pradesh is associated with a significant increase in the monthly price of soybeans in government regulated wholesale agricultural markets. On average, the *mandi* price of soy increased by 1–3 percent after the introduction of kiosks, lending support to the predictions of the theoretical model. The dispersion in price across affected *mandis* in Madhya Pradesh also appears to decrease post-intervention. Moreover, there is a significant increase in the area under soy cultivation due to the intervention.

I use inter-district variation in the timing of the introduction of kiosks and warehouses to isolate the causal effect. The findings of this paper show that information provision is crucial for increasing the efficiency of rural markets. The analysis also contributes to an understanding of the potential benefits from direct interaction between

[45] The results (available from the author) are similar if the sample is restricted instead to those *mandi*-month cells where the monthly minimum or maximum price is below the MSP. These subsamples contain 2,225 and 233 observations, respectively.

producers and processors in the context of agricultural marketing in India. The results suggest that there are net welfare gains to soy farmers as a result of this intervention. The immediate benefit of this intervention to ITC Limited was the improvement in procurement efficiency of soybeans resulting from the creation of a direct marketing channel and a reduction in its transaction costs. It appears that the traders are losing some of their traditional monopsony power and facing a shrinking market. The ITC initiative is part of an overall institutional change in the marketing environment, although traders might well be able to maneuver themselves to a more advantageous position in rural central India in the long run. I conclude that a change in the procurement strategy of a private buyer of soybean in Madhya Pradesh has had significant spillover effects on the movement of prices across agricultural *mandis* in the state.

Although this study sheds light on the implications of this intervention for the functioning of *mandis*, the impact on total income of the farmers is an open question. If panel data were available measuring farmer characteristics, such as landholdings, quantity and quality of all the crops grown and harvested, transportation costs incurred, number of traders and daily prices, one could measure accurately the individual response to this intervention. Future research could then determine the general equilibrium effects of improved information on wages, poverty, and investment incentives faced by farmers.

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