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Where to Sell?

Market Facilities and Agricultural Marketing

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Abstract

This paper analyzes the effect of facilities and infrastructure available at the market place on a farmer's decision to sell at the market using a comprehensive survey of farmers, markets and villages conducted in Tamil Nadu, India in 2005. The econometric estimation shows that the likelihood of sales at the market increases significantly with an improvement in market facilities and a decrease in travel time from the village to the market. The results suggest that wealth reduces a farmer's cost of accessing market facilities more than it increases her/his opportunity cost of leisure. The wealthy farmers are able to capture a disproportionate share of the benefits of facilities available at congested markets. The policy simulation, however, shows that the marginal benefits from an improvement in market facilities will favor poorer farmers in the context of India.

This paper—a product of the Sustainable Rural and Urban Development Team, Development Research Group—is part of a larger effort in the department to understand the impact of investment in infrastructure and facilities on agricultural commercialization and development. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at fshilpi@worldbank.org.

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1 Introduction

The rural areas are home to the vast majority of the world's poor. As most of the rural poor are engaged in agriculture, diversification and commercialization of agriculture are often regarded as essential pre-conditions for rural income growth and poverty reduction (Johnson, 2000). The importance of access to well functioning markets for agricultural specialization has been highlighted in both traditional and recent development literature. Not surprisingly, investment in rural infrastructure including market facilities has featured as an important development priority in most developing countries. While the issue of investment in market facilities has been discussed frequently in various policy fora, there is, to our knowledge, no empirical evidence on the importance of market facilities for agricultural commercialization. Similarly, little is known about the distribution of benefits from such investments. This paper utilizes a unique dataset on agricultural markets in India to examine how facilities available at the market influence farmers' choice of place of sales. By relating farmers' place of sales to their level of sales, this paper also estimates the distributional consequence of an improvement in the facilities at the market.

The issue of agricultural commercialization and specialization has long been a staple of development literature (Bardhan, 1989; de Janvry, Fafchamps and Sadoulet, 1991; Goetz, 1992; Key, Sadoulet and de Janvry, 2000; Bellemare and Barrett, 2005; and Holloway, Barrett and Ehui, 2005). A common theme of this literature is that the presence of 'transaction costs' affects farmers' production and sales decisions. The empirical literature, however, focuses almost exclusively on one component of the transaction costs, namely transportation cost. Taking distance to nearest market as an indicator of transportation cost, a number of recent studies have shown that access to market influences a farmer's decision to sell (Jacoby, 2000; Fafchamps and Shilpi, 2003), and to sell at the market (Fafchamps and Hill, 2005). A

different but related body of empirical literature, focusing mainly on traders, underscores the significance of transport costs in determining the transaction costs faced by the traders (Minten and Kyle, 1999; Fafchamps, Gabre-Medhin, and Minten, 2005). The importance of the rural transportation network for agricultural trading has been highlighted also in a separate strand of literature which examines the spatial integration of agricultural markets (e.g. Badiane and Shively, 1998). A major conclusion of all these different strands of empirical literature is that the condition of the rural transportation network exerts strong influence on the efficiency of agricultural marketing system.

Along with transportation costs to the nearest market, the characteristics of the nearest market can also influence the transaction costs of taking products to markets. For instance, a highly congested market with few facilities can add substantially to waiting time, product deterioration and losses, and costs to farmers and traders. These concerns about marketing costs have, indeed, underpinned the renewed emphasis on investment in market facilities in a number of developing countries including our focus country, India (e.g. Acharya, 2004). The arguments for such investments, however, remain intuitive in the absence of any quantitative evidence. This paper attempts to fill this gap in the literature by providing some first-hand evidence on the importance of market facilities for a farmer's decision to sell at the market.

The starting point of our empirical analysis is a simple transaction cost model of a farmer's choice of location of sales, similar in principle to the model presented in Fafchamps and Hill (2005). The theoretical model formalizes the idea that along with distance, facilities available at the market are relevant factors in determining the transaction costs. The interaction of market facilities and distance to market from a farmer's village is captured by defining a market access index similar to the widely used "gravity" measure. The market access index is simply the number of facilities available at a market normalized by the square of the distance

from village to that market, where the distance is measured by the travel time.[1] Market access, according to the theoretical model, would positively influence a farmer's propensity to sell at the market. The theoretical model also shows that in addition to a direct impact, wealth level can moderate or accentuate the impact of the market access index on a farmer's place of sale decision.

The empirical specification derived from the theoretical model is estimated using data from a unique survey of farmers, traders, markets and villages in Tamil Nadu, India conducted during 2005.[2] The survey utilizes a design which allows us to map farmers to the nearest wholesale market. The survey collected detailed information on infrastructure and facilities available at this market, which are then utilized to define an index of market facilities. This index of market facilities is then combined with distance from the market to the villages where farmers reside to derive the market access index. The regression results confirm that an improvement in market facilities implied by an increase in the market access index leads to an increase in the farmer's propensity to sell at the market. The impact of the market access index also depends on the wealth of the farmers. The estimated coefficient of the interaction of wealth and market access index suggests that wealth reduces a farmer's costs of accessing market facilities more than it increases his/her opportunity cost of leisure. This means that wealthy farmers are perhaps able to avail of cheaper modes of transportation and to reduce waiting time and costs in utilizing the market facilities.

We also combine the farmers' place of sale choice with their total sales revenue and simulate the impact of a 20 percent improvement in the market facilities. The simulation

[1] As will be evident from the analysis presented in the following sections, the empirical results are robust to alternative definition of the market facility index.

[2] Tamil Nadu, located in southern India, is the fifth largest state in the country, with a population of about 62 million people and gross domestic product per capita of $588 in 2003/04 (World Bank, 2005a). Although agriculture accounted for 15.3% of total state gross domestic product in 2001, the sector employed 49.5% of the labor force (World Bank, 2005b).

results show that the additional investments in market facilities are pro-poor as sales of the poorer farmers increase more than proportionately than that of the wealthy farmers. The results thus suggest that while the relatively wealthy farmers are able to capture the benefits of existing facilities better than the poorer small holders, the marginal benefit from an improvement of the market facilities will be much higher for the poorer farmers.

The rest of the paper is organized as follows. Section 2 outlines the conceptual framework. Section 3 describes the data used in the study. Section 4 presents the main empirical results. Section 5 discusses the results from the policy simulation. Section 6 concludes the paper.

2 Conceptual Framework

In order to identify the ways through which physical infrastructure and facilities in a market can influence agricultural marketing, we start by considering the sales decision of the farmers. The model presented in this section is an extension of the theoretical model in Fafchamps and Hill (2005) which focuses on the impact of distance to market and wealth on farmers' choice of place of sales.

In order to highlight the channels through which market facilities may exert influence on a farmer's choice of place of sales, we start with a simple model where a farmer can either sell at the farmgate or take the produce to a market.[3] In the former case, the farmer receives the price at farmgate, p^f, whereas s/he receives a higher market price p^m but incurs a transaction cost C if s/he takes the produce to the market. Assuming a perfectly competitive market, a

[3] In this formulation, the choice of place of sale is modelled as a choice conditional being a seller. This is a reasonable assumption in the context of our empirical analysis which focuses mainly on cash crops (tomato, maize and mango). Maize is used as animal feed in Tamil Nadu, with farmers reporting virtually no home consumption. For all crops in our sample, only 2 percent of the farmers reported making no sales.

price-taker farmer i thus chooses to sell at the farm-gate if:

$$p^f \geqslant p^m - C_i$$

Note that the transaction cost C is assumed to be farmer-specific as has been emphasized in a large literature on farm household's choices [de Janvry, Fafchamps and Sadoulet, 1991, Goetz, 1992, Key, Sadoulet and de Janvry, 2000]. Let the difference between the payoffs from selling at the market and selling at the farmgate be D_i=$p^m - C_i - p^f$. Factors that raises D_i will increase sales at the market as opposed to the farmgate and vice versa.

Following Fafchamps and Hill (2005), we assume that villages are also served by itinerant traders who incur transaction costs T to transport and sell the produce at the market. Free entry into itinerant trading implies that in equilibrium:

$$p^f = p^m - T$$

The difference between the payoffs from selling at the market and at the farm-gate can be re-defined as:

$$D_i = T - C_i \tag{1}$$

A farmer would choose to sell at market if $D_i \geqq 0$ and vice versa. For the empirical modelling, a farmer's choice of market as a place of sale is represented by a binary variable (S) such that

$$\begin{aligned} S_i &= 1 \text{ if } D_i^* = D_i + u_i = T - C_i + u_i \geqq 0 \\ &= 0 \text{ otherwise} \end{aligned} \tag{2}$$

where D_i^* is a latent variable determined by the difference in payoffs from selling at different locations and an error term u_i. Equation (2) provides an econometric specification which can be applied to the data as soon as one identifies the possible determinants of the transaction costs of both farmers and itinerant traders. As already mentioned, most of the empirical studies focuses on distance to nearest market as an important component of transaction costs. Fafchamps and Hill (2005), for instance, have shown that if the farmer's cost of transportation increases at a faster rate than the trader's cost, then farmers located closer to market will take their product to market, whereas farmers located farther away will sell to the itinerant traders. This insight can be incorporated formally in the regression by specifying equation determining the latent variable as the following:

$$D_i^* = g(d_i) + \beta Z_i + u_i \tag{3}$$

where d_i is the distance to market for farmer i, $g(.)$ is a flexible function of distance, and Z_i is a vector of other explanatory variables to be discussed shortly. While the role of distance as a component of transaction cost is indisputable, the above formulation implicitly assumes that all destination markets for the farmers are identical in terms of their characteristics. This is a strong assumption in the context of developing countries where the physical infrastructure and facilities available in the market itself vary considerably across market locations. In the context of India, Acharya (2004) noted that congestion and delays in the markets due to lack of proper market infrastructure resulted in long waiting periods for the farmers. Similarly lack of market infrastructure and facilities added substantially to marketing costs of the traders. The World Bank (2007) report also noted wide variation in the market facilities and infrastructure across Indian States. In order to accommodate the possible effect of market

infrastructure and facilities on farmer's place of sales, equation (3) can be modified as:

$$D_i^* = f(d_i, F_i) + \beta Z_i + u_i \tag{4}$$

where F_i is an index of market infrastructure and facilities at the location nearest to farmer i. We assume that an increase in F_i indicates an improvement in market infrastructure and facilities. From equation (1), we can derive the following condition:

$$\frac{\partial D_i}{\partial F_i} = \frac{\partial T}{\partial F_i} - \frac{\partial C_i}{\partial F_i}$$

An improvement in F_i will reduce transaction costs of both traders and farmers. The expression $\frac{\partial D_i}{\partial F_i}$ is positive if the farmer's transaction cost decreases at a faster rate than that of the traders ($|\ \frac{\partial T}{\partial F_i}\ | < |\ \frac{\partial C_i}{\partial F_i}\ |$). In that case, a farmer's probability of selling at the market will increase with an improvement in market facilities ceteris paribus. The assumption that an improvement in market facilities reduces farmer's transaction costs at a faster rate than that of traders is not unrealistic as traders may have better access to facilities even in congested markets and an improvement would translate into lesser reduction in costs for them.

Estimation of equation (4) requires further specification of the function $f(d_i, F_i)$. Existing studies, which ignored the possible impact of market facilities, used the logarithm of distance as an explanatory variable to linearize the function $g(.)$ in equation (2). A more plausible formulation in our context is one where distance and market facilities interact with each other as facilities of a market and its location jointly influence a farmer's decision. The effects of distance and market facility on a farmer's decision to sell at the market tend to go in opposite directions. In order to ensure consistency, we utilized the widely used "gravity equation" to

linearize $f(.)$ as:[4]

$$f(d_i, F_i) = \gamma \frac{F_i}{d_i^2} \equiv \gamma M_i$$

where M_i is an index of market access and γ is a parameter to be estimated. Given our assumption that a farmer's transaction cost increases at a faster rate with an increase in distance, and decreases at a faster rate with improvements in market facilities compared with that of the itinerant traders, an increase in M_i will increase the probability of sales at the market implying a positive sign for γ in equation (4).

As to other determinants of transaction costs, a farmer may be more inclined to sell at the market if her/his quantity sold is large provided that unit cost of transportation decreases with an increase in quantity sold, as shown by Fafchamps and Hill (2005). If unit cost is independent of quantity sold, then quantity sold may be irrelevant for the place of sale decision.

Since taking produce to the market involves own and perhaps family labor for supervision and actual sales, a farmer's (and family member's) opportunity cost of time is also relevant in explaining her/his place of sale. As shown by Fafchamps and Hill (2005), other things being equal, the wealthy farmers have a higher shadow cost of labor. This is because wealthy farmers tend to have more productive capital. Moreover, having more income, they tend to prefer leisure. Because of higher opportunity costs of labor, the wealthy farmers are more likely to sell at the farmgate.

The farmer's wealth level, however, has an opposing effect on farmer's choice of place of sale. Congested markets may lead to rationing of access to facilities and wealthier farmers may fare better in accessing those facilities. As Acharya (2004) noted in the context of

[4]The gravity equation has been widely utilized in the international trade literature to identify barriers to trade (see for instance, McCallum, 1995; Baldwin and Taglioni, 2006).

Indian markets, this may happen either because wealthy farmers are able to take advantage of relatively low cost transport facility (e.g. trucks instead of carts) or because their wider social network ensures lesser waiting time in accessing the market facilities. To illustrate how these two opposing forces affect farmer's responsiveness to market access, consider the following parameterization of the transaction cost C_i (per unit of sales):

$$\begin{aligned} C_i &= \tau(M_i, y_i) w(y_i) q_i^{-\delta}, \ \delta \geqq 0 \\ \tau &= M_i^{-\theta_1} y_i^{-\theta_2}, \ \theta_1, \theta_2 > 0 \\ w &= y_i^{\lambda}, \ \lambda > 1 \end{aligned}$$

where τ is the time required to take the produce to the market and make the sale, and $w()$ is the opportunity cost of time, and q_i is the total quantity sold. Following Fafchamps and Hill (2005), we assume that transaction cost does not increase more than proportionately with an increase in quantity sold, so that $\delta \leq 1$. The opportunity cost of labor $w()$ is assumed to increase with an increase in wealth y.[5] The time required to transport and sell, τ , varies inversely with M, the market access index. The market access index, on the other hand, is influenced positively by market facilities and inversely by distance to market. The time τ is

[5] The opportunity cost of labor may also vary inversely with wealth. Barrett and Clay (2003) showed that if wealthier households are also much larger, their shadow cost of leisure may be lower than that of poorer and smaller households. We controlled for household size and composition.

also influenced inversely by wealth of the farmer. Using equation (1), we have:

$$\begin{aligned}
\frac{\partial D_i}{\partial M_i} &= \frac{\partial T}{\partial M_i} + \theta_1 M_i^{-\theta_1 - 1} y_i^{\lambda - \theta_2} q_i^{-\delta} > 0 \\
\frac{\partial D_i}{\partial y_i} &= -(\lambda - \theta_2) M_i^{-\theta_1} y_i^{\lambda - \theta_2 - 1} q_i^{-\delta} \lesseqgtr 0 \\
\frac{\partial^2 D_i}{\partial M_i \partial y_i} &= \theta_1 (\lambda - \theta_2) M_i^{\theta_1 - 1} y_i^{\lambda - \theta_2 - 1} q_i^{-\delta} \lesseqgtr 0 \\
\frac{\partial^2 D_i}{\partial M_i \partial q_i} &= -\delta \theta_1 M_i^{-\theta_1 - 1} y_i^{\lambda - \theta_2} q_i^{-\delta - 1} < 0
\end{aligned}$$

Under the assumption that the farmer's benefit from an improvement in market access index increases at a rate faster than that of the itinerant traders, the first term ($\frac{\partial D_i}{\partial M_i}$) is positive. The effect of wealth on D_i depends on the relative magnitude of θ_2 and λ. If the effect of the opportunity cost of time dominates ($\lambda > \theta_2$), then $(\lambda - \theta_2) > 0$, and we have the same result as in Fafchamps and Hill (2005) that wealthy farmers are less likely to sell at the market. If, on the other hand, wealth's effect on time spent in undertaking the market transaction is larger than that of the opportunity cost of labor, $\frac{\partial D_i}{\partial y_i}$ becomes positive implying that wealthy farmers are more likely to sell at the market. Which of these opposing effects dominate remains ultimately an empirical issue to be resolved by the data analysis.

The above parameterization of transaction cost shows that wealth level can also affect the strength of the farmer's response to the market access index. Again, the ultimate effect depends on the sign of $(\lambda - \theta_2)$. If wealthy farmers have a time advantage in accessing market facilities compared to their opportunity cost ($(\lambda - \theta_2) < 0$), then the cross effect of wealth and market access on D_i is negative ($\frac{\partial^2 D_i}{\partial M_i \partial y_i} < 0$). This implies that as market facilities improve, poorer farmers are more likely to sell at the market. In other words, the market access index has a smaller effect on wealthy farmers, because they already have better access to facilities to begin with than what the travel time and market facility index – common to

all farmers in the same location– would suggest.

The above formulation of transaction cost also indicates that the effect of market access on farmer's place of sale may depend on the quantity sold except for the case where the transaction cost is proportional to the quantity sold ($\delta = 0$). According to the parametric forms specified above, an increase in the quantity sold will dampen the effect of market access on choice of market as a place of sale implying a negative coefficient for the interaction term. Having more wealth can also influence a farmer's response to quantity sold. For instance, wealth farmers are more likely to sell at the market, if quantity sold is larger and opportunity cost of labor is higher than the time (and cost) saving in marketing due to higher wealth.[6]

3 The Data

The data for the study come from the India agricultural marketing survey which was conducted in four Indian states (Uttar Pradesh, Orissa, Maharashtra and Tamil Nadu) during 2005.[7] The survey collected information on traders, entrepreneurs and farmers involved in trading, processing and producing five crops– mango, tomato, potato, turmeric and maize. In each state, 20 wholesale markets and 40 villages were selected in order to construct a sample of 400 traders and 400 farmers. The survey utilized an innovative sampling design to link farmers and traders to the markets. First, a market was selected for a given crop and all the traders operating in the market were listed. During the listing process, traders of the crop in the selected market were asked to list five villages from which they sourced most of their supply, or which were known to produce a significant amount of the selected crops. From

[6] This effect may arise because poorer farmers may face cash constraint in transporting larger quantities to market, and hence would be forced to sell at farmgate. Wealthier and unconstrained farmers, on the other hand will sell at the market if quantity sold increases. This is particularly true in the presence of public transportation.

[7] The survey was conducted as a part of the Indian agricultural marketing study (World Bank, 2007).

this, a list of villages that supplied to the selected market was developed. The enumerators interviewed 10 farmers in each of the two villages selected randomly from this list.[8] Market and community questionnaires collected detailed information on characteristics of the market and villages, and on the availability of different facilities at those locations. This linking of the villages to the market allows us to map farmers to markets and to examine how market facilities influence farmer's decisions.

Trading in agricultural produce in India is governed by the State Agricultural Produce Marketing Committee (APMC) Acts. In Tamil Nadu, the Act was adopted in 1987. It prescribes the setting up of a network of state controlled "regulated markets". These markets are operated by a "Market Committee", which are federated into a parastatal entity called the Tamil Nadu Agricultural Produce Marketing Board. All State government notified agricultural commodities grown in the surrounding area of the market are required to be taken to these markets, thus restricting the channels through which farmers can dispose their produce (World Bank, 2007). Among the four surveyed states which had legislated these Acts, Tamil Nadu was the only state which had not completely enforced the Act with respect to the establishment of wholesale markets. Other entities, such as individual traders, traders associations, local governments, were permitted to operate wholesale markets. As a result, only 10 percent of the sampled wholesale markets in Tamil Nadu were regulated.[9] In areas where the non-regulated markets operate, farmers have free choice in their place of sale. Our empirical analysis is thus based on the place of sales decisions of farmers located near these

[8] For detailed sampling strategy and weight constructions, see Fafchamps, Minten and Vargas-Hill (2006).

[9] The APMC acts were more strictly enforced in Maharashtra, Uttar Pradesh and Orissa with regards to the establishment of the wholesale markets. Regulated markets in the survey sample comprised 95%, 90%, and 85% of the markets in Maharashtra, Orissa and Uttar Pradesh respectively. The rules are poorly enforced in Orissa, and to some extent in Uttar Pradesh, resulting in some observed farm-gate sales. Since these sales are made under different constraints, we focus only on Tamil Nadu where no such restrictions on farm-gate sales are present.

non-regulated markets in Tamil Nadu.

The survey collected detailed information from farmers on their household background, production, post harvest activities, sales, credit and assets. The information collected on sales was particularly detailed where farmers were asked about sales made through different market locations (including farm-gate) as well as characteristics of the products sold. The survey collected information from farmers on infrastructure in their area, including distance and modes of transportation to the nearest markets (wholesale and retail). The farmers for whom we have complete information on their land ownership and location of sales, reported about 623 sales transactions.[10] However, none of the farmers sell turmeric at the farmgate and percentage of farmers selling potato at farmgate is negligible (2%). We thus drop transactions reported for these two crops (about 104 observations). Dropping farmers located near regulated market leaves us a sample of 481 observations. As regressions include district level dummies to account for location specific heterogeneity, another 36 observations are dropped because of lack of within district variation in the place of sales. This leaves us with a final sample of 445 transactions for our empirical analysis. Among these transactions, 58 percent relates to mango, 33 percent to tomato and rest to maize.

Table 1 summarizes the sales pattern of the farmers. According to Table 1, about 45 percent of these sales were made at the farmgate, and another 53 percent at the wholesale markets outside the ambit of the APMC regulations, and the rest in the village markets (2 percent). We also checked if any of the sales are made under interlinked contracts. According to the survey data, none of the farmers were paid before the actual sales which is a common practice under interlinked contracts. The insignificance of sales made under interlinked contract and of sales made in markets other than wholesale markets help us to model a farmer's

[10] Another 69 farmers reported contract farming. As it is difficult to classify their location of sales in a classical sense, we dropped these observations.

choice of location as a choice between selling at the market and at the farmgate.

According to Table 1, the median annual quantity sold through all different marketing channels is about 1 metric tons (mt) and average is about 2.3 mt. The median and average annual sales at village markets are higher than that of other locations. Apart from village markets, there is little difference in the median quantity of sales across different locations. However, the estimates of standard deviation suggest very large variation in the quantity sold at the farmgate. Among different crops, about one-fifth of maize and 48 percent of mangoes are sold at the market. Most of the tomatoes are also sold at the market (79 percent). The average size of quantity sold (about 1 mt, except for tomatoes) shows that these commodities can not simply be carried by the farmers as head-load to the market. This ameliorates concerns that farmers may be making market trips for other personal reasons and carrying crops to the market on the side does not necessarily impose any transaction costs on them.

A critical piece of information for our econometric analysis is the state of infrastructure and facilities available at each market location. The India agricultural marketing survey 2005 collected detailed information on the characteristics of, and the different facilities available in, the markets. Figure 1 shows the commodities traded in the surveyed markets. Majority of the markets trade in fruits, vegetables and grains. Markets are not completely specialized either: only 6 market is found to be trading in one commodity (mostly fruits). Table 2 summarizes the basic characteristics and facilities in Tamil Nadu's wholesale markets. The wholesale markets in Tamil Nadu are smaller in size and heavily congested compared with the overall sample of all 4 states (World Bank, 2007). As Table 2 indicates, infrastructure and facilities in Tamil Nadu are limited. Apart from having bus stations, police stations, commercial banks, and post offices, most markets offer few facilities. For instance, only 21% of the markets offer parking facilities. Only a limited number of the markets possesses any equipment. Because

facilities and infrastructure across markets are likely to be highly correlated as a market with better infrastructure may also be offering better facilities and equipment, it is impractical to use a large number of variables indicating state of the market in the regression analysis. To avoid collinearity problems, we constructed a combined index of market facilities and infrastructure. To construct this index, we first defined a number of indicator variables of the facilities available in a given market. For instance, an indicator variable showing presence of parking facility takes a value of unity if parking is available in a market, and zero otherwise. The indicator variables we selected include those for parking space, bus station, police station, commercial banks, post office, factory/mills, weighing, drying, grading, fumigation, large-scale mechanized weighing equipment, cold storage, warehouse and guard. The facility index is then defined as:

$$F = \sum_{j=1}^{N} I(F_j)$$

where $I(F_j)$ is the indicator variable showing presence of a facility F_j.[11] Table 3 reports the summary statistics for market facility index along with travel time from surveyed villages to relevant markets. On average, a market in Tamil Nadu has 5 facilities available– the minimum is just one facility and maximum 8 facilities– out of the 15 facilities that we considered in defining the facility index. Average travel time from surveyed villages to relevant markets is about 41 minutes, and median is about half an hour. The closest market is only 10 minutes away and farthermost about 1.5 hours away. The market access index, which is defined as the ratio of the facility index and travel time squared, has a median of 14 and mean of 19. It also displays large variation as indicated by the standard deviation. Apart from the market access index and quantity sold, the regression includes a large number of control variables.

[11] It should be noted that we check robustness of our results using alternative index of market facility constructed using the principal components of the available facilities. For detail see, section 5.

Summary statistics for these control variables are reported in appendix Table A.1.

4 Empirical Results

We take a sequential approach to present our regression results. Our dependent variable takes a value of unity if farmer sold at the market, and zero otherwise. Because of the binary nature of our dependent variable, we utilized standard Probit approach for the estimation. Standard errors are estimated after accounting for within cluster(village) correlations and possible heteroskedasticity. All regressions are weighted by the population weights of the farm households. All regressions include a set dummies for months of sale in order to account for seasonality in sales. They also include dummies for different crops and dummies for different districts to account for crop-wise and location-wise unobserved heterogeneity. Inclusion of these dummies lead to a reduction of sample size, as regressions drop perfect fits resulting in the final sample of 445 observations. The coefficients reported in the tables are marginal effects from the Probit estimation.

We start by reporting the simplest regression. In column 1 of Table 4, we report the effect of travel time to market on farmer's decision to sell at the market. Consistent with existing literature, an increase in travel time reduces the probability of selling at the market, but the estimated coefficient is statistically significant at 5 percent significance level. In the next column, we report the results from the estimation with the market access index as an explanatory variable. The estimated coefficient has an expected positive sign and is statistically significant at the 1 percent level. The positive sign of the coefficient implies that an improvement in the market access index increases the likelihood of sale at the market, either because of a reduction in transportation cost or because of an improvement in market facilities. This result suggests a positive influence of market access on farmer's choice of

market as a place of sale.

This simple regression discussed in the preceding paragraph, however, has not controlled for effects of other determinants of transaction costs. In the next regression, we introduce two most widely discussed determinants of transaction cost. The wealth of a farmer is measured by the amount of land s/he owns, and the logarithm of land owned is introduced as a regressor. The quantity of the product sold (weight expressed in kg) is also thought to be another possible determinant of transportation costs. However, as shown by Fafchamps and Hill (2005), quantity sold is possibly endogenous to the place of sale. This is because farmers may choose to sell small quantity at the farmgate and sell larger quantity in the market. In order to remedy the endogeneity problem, we utilized the Conditional Maximum Likelihood Estimation (CMLE) approach suggested by Smith and Blundell (1986) and River and Voung (1988). In the CMLE approach, at the first stage, an instrumenting equation for the suspected endogenous variable (quantity sold in our case) is estimated using an identifying instrument. The identifying instrument in our case is total quantity sold during the course of the survey year. At the second stage, a standard Probit regression is fitted while including the residual from the first stage regression as an additional explanatory variable. The test of significance of the residual in the second stage regression also provides a test of endogeneity of quantity sold. The first stage regression result is shown in column 1 of appendix Table A.2. The instrument is highly significant in the regression for quantity sold (t=11.39) indicating absence of weak instrument problem.

Column 3 in Table 4 reports the results from the CMLE. The addition of wealth and quantity sold has led to a slight reduction in the marginal effect of the market access variable from 0.0172 to 0.0144. However, the coefficient is still positive and statistically significant at the 5 percent level. The regression results also indicate that an increase in quantity

sold improves the probability of selling at the market by the farmers. This is expected when transportation cost declines with an increase in quantity sold. The effect of wealth is negative and statistically significant at 1 percent level. The result with respect to wealth is thus consistent with the expectation that wealthy farmers face higher opportunity cost of labor, and are less likely to sell at the market. The results with respect to quantity sold and wealth level are consistent also with the findings of Fafchamps and Hill (2005). The endogeneity of the quantity sold does not pose a serious problem in this regression. The null hypothesis of exogeneity of quantity sold can not be rejected as the first stage residual has a t-value of 0.32. This result is not surprising given the fact that more than two-thirds of the farmers make only one sale during the year.

The regression in column 3 still ignored a number of explanatory variables that may be relevant for determining both opportunity cost of labor and transaction cost. In the next regression reported in column 4, we included a number of household specific variables (household size, and composition). Since availability of family labor reduces the need for hiring outside labor for the transportation, handling and supervision of sales, the propensity to sell at the market should increase with an increase in the number of adult family members. To control for the opportunity cost of labor, we included the number of adult males as an indicator for family labor available for taking the product to market.[12] In addition, we included a dummy to indicate if household head belongs to the Scheduled Caste/Scheduled Tribe (SCST).[13] The log of age of the household head, and his/her education level are also

[12] Women seldom take produce to wholesale market in India. Note also that district level dummies capture, in addition to unobserved heterogeneity, the effect of cost of hiring labor as labor market often clears at local level.

[13] Scheduled Castes and Scheduled Tribes are communities that are accorded special status by the Constitution of India. These communities were excluded from the caste system that was the social superstructure of Hindu society in the Indian subcontinent (Wikipedia 2006, http://en.wikipedia.org/wiki/Scheduled_Castes_and_Tribes)

introduced as regressors.

According to the results in column 4 of Table 4, introduction of these additional regressors resulted in a reduction of the marginal effect of market access, wealth and quantity sold. The reduction is only slight in the case of market access. Consistent with our earlier results, the market access variable is still statistically significant at the 1 percent level and has a positive sign. The inclusion of additional regressors, however, greatly diminished the effect of quantity sold, whose coefficient has become statistically insignificant (t=0.37). Among the additional regressors, household head's education is statistically significant at the 5 percent level. The estimated coefficients imply a positive influence of education on the propensity to sell at the market and age. The coefficient of number of adult males has the expected sign, but it is not estimated with statistical precision. The t-value of the first stage residual (=0.99) again points to the absence of serious endogeneity problem.

Finally to check the robustness of the results with respect to market access, we added travel time to the regression, but it is not statistically significant in any of the regressions. These results are omitted for the sake of brevity.

4.1 Interaction Effects

The results so far indicated a strong positive relationship between the market access index and the propensity to sell at the market. The conceptual framework presented in Section 2 raised the possibility that wealth and quantity sold may also affect the slope of the market access index in the regression. There may also be some interaction effects between wealth and quantity sold. In this subsection we explore these interaction effects. We start from the most general formulation where we include all interaction terms among market access, wealth and quantity sold to the regression specification estimated in column 4 of Table 4. The

inclusion of these interaction terms with quantity sold raises the possibility of endogeneity of the interaction terms. The instruments used to identify the instrumenting equation for the interaction terms include interaction of quantity sold with market access and with wealth. The first stage regressions are reported in appendix Table A.2. As before, the identifying instruments are highly statistically significant in the relevant regressions.

The results from the CMLE are reported in column 1 of Table 5. The inclusion of so many interaction terms, which are understandably collinear, now renders most of the estimated coefficient statistically insignificant. The coefficient of interaction of market access and land ownership has a negative sign and is statistically significant at 5 percent level. None of the residuals are individually statistically significant. The joint test of significance of first stage residuals shows that endogeneity is still not a problem. In order to deal with the collinearity problems, we dropped the interaction of quantity sold and market access index, which has the lowest t value in the regression. The precision of estimated coefficients in column 2 improves, but the results again highlight the over-parameterization of the regression equation with heavily collinear terms. We again drop the interaction term with the lowest t-value, that is, the interaction of quantity sold and wealth. Dropping this interaction term significantly improves the statistical precision of the estimated coefficients reported in column 3. The first stage residual has a t-value of 0.49 with a P-value equal to 0.62. This implies that endogeneity of quantity sold is not at all a major concern in the regression. Accordingly, we drop the residual term in our final specification and estimate it using the standard Probit technique.

The marginal effects from the Probit estimation along with respective t-values are reported in the final column in Table 5. Consistent with our results discussed so far, the market access variable is highly statistically significant (t-statistic=4.57). The positive sign of the marginal

effect implies that an improvement in market access leads to an increase in the propensity to sell at the market by the farmers. The magnitude of the marginal effect of market access variable is also large (=0.013). Overall, the regression analyses indicate that the positive effect of market access is robust to the inclusion of many different explanatory variables and to the use of alternative estimation techniques (probit vs. CMLE). According to the regression results, wealth also affects the slope of the market access variable significantly. The coefficient of interaction of the wealth and market access variables is negative and again highly statistically significant (t=3.71) at one percent significance level. The negative sign of the interaction term implies that wealth confers higher benefits in accessing market facilities compared with its negative influence on opportunity costs of leisure, in other words, $\lambda < \theta_2$. The coefficient of wealth in the regression is also positive, again confirming that $\lambda < \theta_2$. However, the estimated coefficient has little statistical significance with a t-value equal to 0.36 although its magnitude is not too small. The comparison of the coefficient of market access and that of its interaction with land shows that $\lambda \ncong \theta_2$. In other words, wealth's effect on the ease of accessing market facilities dominates its effect on opportunity costs of leisure. Consistent with theoretical expectation derived from the simple model in Section 2, the quantity sold has a positive coefficient, which is also highly statistically significant (t=3.99). The marginal effect of quantity sold implies that a one percent increase in quantity sold increases the probability of market sales by farmers by about 2.6 percent. This, in turn, implies that farmers face decreasing transaction costs with an increase in quantity sold so that $\delta < 0$.

The interaction of the market access and wealth variables provides a way to disentangle wealth's two opposing effects on the location of sales in the regression. When wealth's effect on gaining easier market access is ignored (as in column 4, Table 4), the regression results confirm

the importance of the opportunity cost of leisure in the decision to sell at the market. This result is similar to that reported in Fafchamps and Hill (2005). However, when the interaction term is included (for instance in column 3, Table 5), we find that wealth's effect on gaining market access dominates over its effect on shadow cost of labor. While the relative strength of the two opposing effects of wealth may vary from country to country, the regressions in the context of India underscores the need for separating the two out.

4.2 Robustness

The results on the impact of market facilities so far relate to one particular measure of market facilities. An alternative index of market facilities can be constructed using factor analysis. Specifically, we construct the principal component factors of the 14 different facilities that were utilized to construct F_i used in regressions so far.[14] The factor analysis indicates that the principal component factors account for almost all of the variations leaving small amount of unexplained variance ("uniqueness"). We used the predicted first principal component as an index of market facilities (F^{pc}).[15] Since by construction, the principal factor component has a mean of 0 and standard deviation of 1, there are some values of the facility index which are negative. We add an arbitrary constant to the principal factor component to make the facilities index (F^{pc}) a positive number for all observations. The regression results using this facility index (F^{pc}) is presented in column 1 of Table 6. The results again confirm the positive effect of market access index on probability of sales at the market. Similar to results presented in column 4 of Table 5, the interaction of market access with wealth has a negative coefficient which is highly statistically significant (t=3.71). Comparison of results in column

[14] This is done by using stata command *factor* with option *pcf*.

[15] The scoring coefficients suggest that variations in three market facilities (parking space, whether market has a bank or not, and whether it has weighing facilities or not) contributes most in the construction of the market facility index using factor analysis.

1 of Table 6 and column 4 of Table 5 indicates that both indicators of market access produce comparable and consistent results confirming the robustness of our main results.

The regressions presented in the preceeding subsections included crop dummies to account for the heterogeneity across crops in terms their marketing needs. Both tomato and mango are perishable and may need similar market facilities to handle them. Yet, marketing requirements for these crops may differ in a way that may not have been captured sufficiently by crop dummies. Thus, as a further check of robustness, we estimate the regressions separately for tomato and mango.[16] The results reported in column 2 and 3 of Table 6, show that the basic results regarding the impact of market access and its interaction with landownership remains unchanged particularly in the case of tomato. The results are confirmed in the case of mango too though coefficients are estimated with less precision (lower t-values).

As a part of robustness check, we included more regressors in the estimation. For instance, we added a dummy to show whether farmers were paid after the sale rather than at the time of sale. Payments received after sales may indicate some type of contract between the farmers and traders. This dummy indicating payment after sales is not statistically significant in any of the regressions and thus have negligible influence on the estimated coefficients of the market access variable and its interaction term with land ownership.[17]

5 Improvement in Market Access: Distribution of Benefits

The results from our econometric analysis suggest that market access has a significant positive effect on a farmer's decision to sell at the market. The wealth level also influences farmer's decision to sell at the market through its interaction with market access. The estimated

[16] In the case of maize, we do not have enough observations to conduct meaningful estimaiton.
[17] We omit these results for the sake of brevity.

coefficient of the interaction effect implies that wealth allows farmers to gain access to market facilities easily and the resulting benefits largely outweighs its effect on opportunity cost of leisure. The regression results thus indicate that the effect of market access is also dependent on the wealth level of the farmers, thus pointing to possible distributional consequence of an improvement in access to market. In this section, we simulate the effect of an improvement in the market access index by 20 percent. Given the average market access index of around 5 in our sample, a 20% increase translates into adding about an extra facility in each market. As our sample consists mainly of tomato and mango farmers, the benefit estimates are only relevant for these farmers. Because of lack of data, we also do not attempt to account for the general equilibrium effects that may arise due to change in the cropping pattern of all farmers. Moreover, the estimated benefits are one-time benefits which ignore the benefits that may accrue over the lifetime of a facility. Thus the estimated benefits can be construed as the lower bounds of benefits from an improvement in market facility and market access.

One difficulty in the estimation of the welfare consequences of an improvement in market facilities is that we need data that would represent household welfare of the farmers such as consumption expenditure. However, the India agricultural marketing survey did not attempt to collect these information due to cost and time consideration. In the absence of household expenditure, we took total sales revenue as an indicator of the farmers' benefit from crop production and sales. At the first stage of the simulation exercise, a median regression is run on the log of total value of sales using the following specification.

$$V_i = \phi S_i + \Psi X_i + \varepsilon_i \tag{5}$$

where S_i, the decision to sell at the market is determined by equation (2) reported in the

conceptual framework. X_i is a vector of explanatory variables including land owned, farmer's age, education, whether the farmer is a member of farmers' or other relevant association, and different characteristics of the crop sold, etc. ε_i is the error term. The results from the median regression are reported in the appendix Table A.3.[18] As expected, the regression results confirm the positive correlation between total sales and wealth. Similarly, the total value of sales is higher if the product is sold at the market. The signs of most of the other coefficients are also consistent with apriori expectation. We also included the market access variable and various interaction terms, but none of the specifications indicated any significant direct effects of the market access variable in the regression for total value of sales.[19] For this reason we opted to exclude it.

For the simulation, equation 5 is combined with equation (2). The estimation results for equation (2) is already reported in column 4 in Table 5. In the estimation of the benefits from an improvement in the market access index, we assume that the unobserved heterogeneity across farmers are summarized by the estimated $\widehat{u}_i$ and $\widehat{\varepsilon}_i$ and remain the same after the policy change. Given this assumption, we estimate the predicted probabilities of selling at the market and then total sales at the observed value of market access variable (and all other variables) The is defined as the base scenario. We then assume that the market access index increases by 20 percent for every farmer.[20] We re-estimate the predicted sales probabilities of selling at the market and associated total value of sales. This is defined as the reform scenario. The predicted values of total sales under base and reform scenarios are then used to compute the percentage increase in sales due to the policy change.

Figure 2 plots the percentage change in sales against land ownership (indicator of wealth)

[18] The median regression is used instead of simple OLS because of large outliers in the value of sales.
[19] Results from these experiments are omitted for the sake of brevity, and can be obtained from the authors.
[20] One can contemplate other types of policy interventions also.

due to 20 percent improvement in market access index.[21] According to Figure 2, the percentage increase in sales is much higher for the poorer farmers compared with the wealthier ones with more land. The curve showing the relationship between percentage increase in sales and landownership is downward sloping and convex. The shape of the curve implies that the percentage increase in sales becomes smaller and smaller with an increase in landownership. For instance, the largest percentage increase in sales (about 1 percent) is experienced by farmers with less than 2.5 acres of land.[22] In contrast, farmers with land more than 7 acres experience less than 0.5 percent increase in sales due to a 20 percent improvement in market facilities. Indeed, the benefits from an improvement in market facility becomes negligible for farmers with more than 20 acres of land. Figure 2 demonstrates that the proposed policy change is likely to be pro-poor. [23]

The regression results in the previous section indicated that a farmer's wealth level enables her/him to gain better access to market facilities because of her/his access to better modes transportation cutting waiting time in the congested market places. The policy simulation, on the other hand, indicates that an improvement in facilities will benefit the poorer farmers disproportionately. This may seem puzzling at first. However, this is indeed expected because wealthy farmers already have better access to markets, and an improvement in market access thus benefit them much less compared with poorer farmers who face much more stringent marketing constraints. This result is thus consistent with the early program capture by the wealthy discussed in Ravallion and Lanjouw (1999).

[21] Figure 1 plots the relationship between percentage change in total sales due to an improvement in market access index which was estimated using non-parametric LOWESS estimator.

[22] The median size of land owned is about 3 acres and mean is about 5.26 acres in our sample.

[23] Using the farmer's population weights we can also estimate the total benefit from such as an improvement. This, however, will provide only one year benefit, whereas benefits from installing any facility will likely to spillover to many years. Without knowing the depreciation rates, it is not possible to estimate the present value of the return. Because of this, we refrain from reporting total benefits from this generic policy simulation.

6 Conclusions

There has been a resurgence of interest in agricultural marketing issues in many developing countries in recent years. The uneven progress in agricultural commercialization following structural adjustments, market deregulation and trade liberalization in many African countries brought the need for the development of market infrastructure and institutions at the forefront of policy discussions (Fafchamps, 2004; Kherallah et al, 2000). The rising incomes, increasing urbanization and a growing middle class in a number of Asian countries- already past their green revolution in cereal crops- have exposed the weaknesses of the traditional marketing arrangements with overly congested market places and their rudimentary facilities (World Bank, 2007). Investments in market infrastructure and facilities and in rural road networks now form a core of rural development strategies in many countries. While the weaknesses of the existing marketing systems are discussed at length (Acharya, 2004), there is a lack of empirical evidence on how these investments, particularly those in market facilities, will benefit farmers. This is surprising in the context of the debate on the possible impact of commercialization of agriculture on the poor (von Braun and Kennedy, 1994). In this paper, we examine the impact of market facilities and infrastructure on the farmer's decision to sell at the market using Indian agricultural marketing survey data.

In order to pinpoint the channels through which facilities and infrastructure available at the market can influence a farmer's decision to sell at the market, we develop a simple model of farmers' choice of location of sales, extending on the work of Fafchamps and Hill (2005). The theoretical model formalizes the idea that market facilities interacting with distance to market influences transaction costs and hence a farmer's decision to sell at the market. The model predicts a positive relationship between propensity to sell at the market and the market access index, defined as a ratio of number of facilities available at market to the square of

the travel time from farmer's village to that market. The model also shows that the wealth level of the farmer influences her/his response to the market access index with the ultimate effect of wealth being determined by the relative strength of its impact on the shadow price of leisure and on the ease of accessing market facilities.

The econometric estimation using data from the Indian state of Tamil Nadu confirms the theoretical prediction that the probability of selling at the market increases with an increase in the market access index which in turn improves due to an improvement of market facilities or due to a decrease in distance to markets. The interaction of the market access index and wealth is also highly statistically significant. The negative sign of the interaction term implies that wealth confers benefits in accessing market facilities and these benefits outweigh the negative effect of wealth on opportunity costs of labor. The regression results, which are robust to alternative specifications and estimation techniques and alternative definitions of the market facility index, indicate that wealthy farmers are able to capture proportionately more benefits from the market facilities in a congested market place. The observed interaction effect also implies that poorer farmers may also be facing stringent credit constraint in accessing cheaper but bulkier modes of transportation.

We combine farmers' choice of place of sales to their value of sales over a year and then simulate a policy change consisting of a 20 percent improvement in the market access index. The results show that such policy change benefits all farmers with land up to 20 acres. Moreover, the policy intervention benefits disproportionately the poorer farmers especially those with less than 2.5 acres of land. Our results thus suggest that while wealthy farmers are able to capture disproportionately the benefits of existing, and in the context of India, heavily congested market facilities, the marginal benefit from an improvement in market facilities in particular, and market access index in general will be much higher for the poorer small-

holders. In other words, such investments in market facilities and infrastructure (including transportation) will be pro-poor.

While this paper can be regarded as a first step towards quantifying the benefits of facilities and infrastructure available at market place, the market access index is estimated by counting the total number of facilities at a given location and dividing it by square of distance from the village to the market. This formulation of a market access index does not take into account the quality and scale differences in facilities across markets. Accounting for such differences will be important for more practical policy simulations and remains as a major priority for future research.

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Table 1: Place of Sales of Crops in Tamil Nadu

	% of Sales Made at	Quantity Sold		
		Median	Mean	Standard Deviation
Location	(%)	kg	kg	kg
Farmgate	45.3	1000	2815	8623
Un-regulated wholesale market	52.5	1000	1900	2966
Village market	1.3	2000	1750	880
Other	0.9	1000	1500	1000
All	100	1000	2305	6191
Sales at market				
Maize	17	4300	4186	1573
Tomato	79	300	665	877
Mango	48	2000	2884	3644

Table 2: Market Facilities

Market characteristics		Tamil Nadu	All 4 States
Market Area	Acre	3	26
Number of Shops	Number	236	181
Shop area (average)	Sq. feet	637	1001
Storage Capacity	Sq. feet	14	93
Facilities			
Parking (all vehicles)	(%)	21	33
Parking (Trucks)	(%)	13	14
Bus Station	(%)	93	77
Commercial Banks	(%)	87	78
Post Office	(%)	87	75
Police Station	(%)	89	81
Factory/Mills	(%)	50	57
Guard	(%)	50	53
Equipments			
Large scale weighing machine	(%)	3	29
Grading machine	(%)	20	17
Drying machine	(%)	0	1
Area for drying available	(%)	5	15
Fumigation equipment	(%)	3	5
Mechanized crop handling machine	(%)	0	4
Cold Storage	(%)	0	6
Warehouse	(%)	6	44

Table 3: Market Facility and distance

	unit	Median	Mean	Standard Deviation	Minimum	Maximum
Travel time to Wholesale market	hour	0.5	0.68	0.035	0.17	1.5
Market facilities	number	5	5.24	2.33	1	8
Index of Market Access	index	14.22	19.19	19.55	2.67	80

Index of Market Access=(market facilities/(travel time)^2)

Market facilities is total number of following facilities present in a market

Parking, bus, bank, postoffice, police station, mill, weighting facility, grading facility, drying facility fumigating facility, mechanized weighing, cold storage, warehouse, and guard

Table 4: Market Access and Sale at the market

	(1)	(2)	(3)	(4)
Travel time to market	-0.82741			
	(2.01)**			
Market Access Index		0.01722	0.01440	0.01166
		(2.93)***	(2.24)**	(4.25)***
Land owned(log)			-0.08306	-0.06087
			(4.01)***	(3.68)***
Quantity sold (log)			0.04852	0.00746
			(2.77)***	(0.37)
Household size(log)				-0.02016
				(0.51)
share of adult female				0.18329
				(1.79)*
Share of kids (5yr & Older)				0.17663
				(1.69)*
Share of old (>65 yr)				-0.03716
				(0.45)
Dummy if member of Scheduled				0.03917
Caste/Scheduled tribe				(1.08)
Age of household head				-0.08291
				(1.05)
Education of Household Head				0.01167
				(2.10)**
Number of adult male				0.02703
				(1.70)*
Residual from 1st Stage Quantity sold			-0.00976	0.02942
			(0.32)	(0.99)
Pseudo R^2	0.35	0.4	0.34	0.5199
Log Likelihood	-144.77	-132.31	-145.99	-105.6724

Robust z statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Note: Coefficients are marginal effects from Probit estimation

All regressions include dummies for crop, month of sales and district

Table 5: Market Access and Sales at the market: Interaction effects

	(1)	(2)	(3)	(4)
Market Access Index	0.00799	0.01388	0.01276	0.01280
	(0.93)	(5.62)***	(5.02)***	(4.57)***
Land owned(log)	0.08776	0.21071	0.00824	0.00884
	(1.24)	(1.71)*	(0.35)	(0.36)
Quantity sold (log)	0.04422	0.06570	0.01811	0.02612
	(1.80)*	(2.06)**	(1.36)	(3.99)***
Market Access*Land	-0.00182	-0.00341	-0.00354	-0.00373
	(1.91)*	(3.65)***	(3.55)***	(3.71)***
Quantity sold*Land	-0.01282	-0.03058		
	(1.19)	(1.59)		
Market Access*Quantity sold	-0.00019			
	(0.15)			
Residual from 1st stage				
Quantity sold	0.02580	-0.04133	0.01048	
	(0.56)	(0.77)	(0.49)	
Quantity sold*Land	0.02045	0.03766		
	(1.17)	(1.24)		
Market Access*Quantity sold	-0.00382			
	(1.30)			
Test of joint significance of				
1st stage residuals (χ^2)	2.35	2.02	0.24	
P-value	0.5035	0.36	0.6263	
Pseudo R^2	0.5969	0.56	0.5454	0.5446
Log Likelihood	-88.72006	-97.78	-100.0594	-100.2337

Robust z statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Note: Coefficients are marginal effects from Probit estimation

All regressions include dummies for crop, month of sales and district, household size and composition, log(age) and education of household head, dummy for member of SC/ST, and number of adult male.

Table 6: Market Access and Sales at the market: Robustness Check

	Prin. Component	Sub-samples	
	Market Facilities	Tomato	Mango
	(1)	(2)	(3)
Market Access Index	0.02169	0.02038	0.02777
	(4.67)***	(4.23)***	(1.83)*
Land owned(log)	0.00900	0.12073	-0.02615
	(0.67)	(3.77)***	(0.20)
Quantity sold (log)	0.01205	0.03892	0.16726
	(3.71)***	(3.22)***	(2.34)**
Market Access*Land	-0.00237	-0.00819	-0.01237
	(3.77)***	(6.05)***	(1.85)*
Pseudo R^2	0.5603	0.5186	0.4802
Log Likelihood	-96.788715	-25.90149	-92.17213

Appendix Table A.1: Summary statistics

	unit	Median	Mean	Standard Deviation
Household size	number	5	5.03	2.14
share of adult female	ratio	0.33	0.35	0.14
Share of kids (5yr & Older)	ratio	0	0.06	0.12
Share of old (>65 yr)	ratio	0.07	0.15	0.19
Dummy if member of SC/ST		0	0.13	0.34
Age of household head	Year	51	50.6	10.94
Age of household head Squared	Year	2601	2677	1125
Education of Household Head	Year	4	3.58	1.69
Number of adult male	Number	2	2.06	1.12
Agricultural Wage	Rupee/day	70	72.9	11.87

Table A.2: First Stage Regressions

Dependent variable	(1) Log(quantity sold in kg)	(2) Market Access* Quantity sold	(3) Wealth* Quantity sold
Total quantity sold (log)	0.79357	-1.03973	-0.06482
	(14.55)***	(1.37)	(0.76)
Market Access* total quantity sold	-0.00038	0.83603	-0.00061
	(1.08)	(63.53)***	(0.93)
Land* total quantity sold	-0.01117	-0.37602	0.81089
	(2.01)*	(1.93)*	(46.69)***
Market Access*Land	0.00542	0.22452	0.00916
	(3.00)***	(2.67)**	(1.50)
Household size(log)	0.28469	6.43147	0.26293
	(1.65)	(2.25)**	(0.84)
share of adult female	0.17752	8.79632	-0.53469
	(0.68)	(1.01)	(1.43)
Share of kids (5yr & Older)	-0.21700	8.24562	-0.71575
	(0.55)	(0.93)	(0.87)
Share of old (>65 yr)	-0.15645	-7.88725	0.11643
	(0.69)	(1.09)	(0.37)
Dummy if member of Scheduled	0.20481	9.82536	0.08623
Caste/Scheduled tribe	(1.42)	(1.97)*	(0.27)
Age of household head	-0.02840	-1.19531	-0.05302
	(1.21)	(1.69)	(1.19)
Age of household head Squared	0.00034	0.01265	0.00060
	(1.54)	(1.89)*	(1.49)
Education of Household Head	0.00258	0.22652	-0.00662
	(0.12)	(0.41)	(0.14)
Number of adult male	-0.02978	-1.85371	0.00714
	(0.82)	(1.77)*	(0.10)
Agricultural Wage (log)	0.19128	20.38366	-0.17682
	(0.36)	(1.22)	(0.24)
Constant	2.73026	-5.96058	6.44325
	(1.14)	(0.10)	(2.11)**
R-squared	0.69	0.98	0.98

Robust t statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

All regressions include dummies for crop, month of sales and district.

Appendix Table A.3: Determinant of Total Value of Sales (Median Regression)

Dependent variable	Log(Value of Sales)
Sold at market (dummy)	0.17935
	(2.96)***
Land owned(log)	0.32827
	(13.04)***
Age of household head	0.00089
	(0.44)
Education of Household Head	0.02147
	(1.45)
Dummy=1 if participated in association	0.13506
	(2.47)**
Dummy=1 if dried before sale	0.07019
	(0.25)
Dummy=1 if miled/dehusked/ground before sale	0.76580
	(5.64)***
Dummy=1 if graded/sorted	-0.08187
	(1.44)
Dummy=1 if packaged/crated	-0.21775
	(3.17)***
Dummy=1 if fumigated/treated	-0.02673
	(0.15)
Dummy=1 if pre-cooled/washed	1.16370
	(6.85)***
Dummy =1 if buyer is trader	0.44136
	(3.11)***
Dummy =1 if buyer is commission agent	0.80253
	(5.40)***
Dummy =1 if buyer is other	1.43414
	(5.66)***
Dummy =1 if paid at sale	0.04977
	(0.17)
Dummy =1 if paid at after sale	0.43845
	(1.49)
Constant	10.20500
	(21.51)***
Pseudo R^2	0.30

Robust z statistics in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Note: Regression includes month of sales dummies, crop dummies and district dummies

Figure 1: Number of markets trading in different commodities

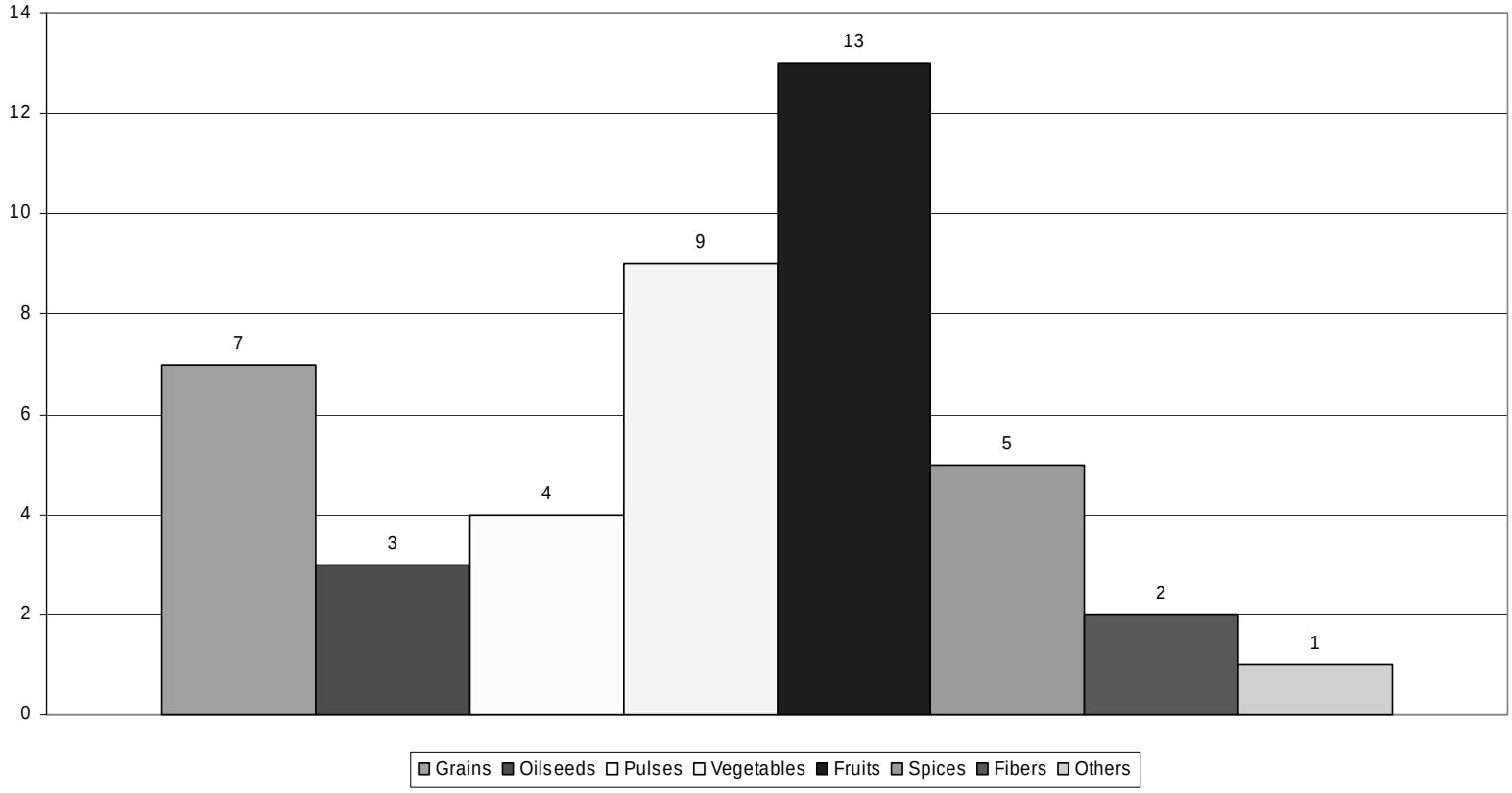


Figure 2: Distribution of Benefits

A 20% Improvement in Market Access Index in Tamil Nadu

