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Quality Control in Non-Staple Food Markets: Evidence from India*

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Abstract

Using original survey data collected on growers, traders, processors, markets, and village communities, we will compare the situation in four states – Tamil Nadu, Uttar Pradesh, Maharashtra and Orissa. We examine the way that information about crop attributes is conveyed (or not) along the value chain. We also document the infrastructures available at the level of the market. We find that little information circulates about unobservable crop characteristics. Growers receive a price premium when they dry, grade and pack their produce, but we find no evidence that information about crop salubrity or agricultural practices circulates through the value chain or that growers are encouraged to follow specific agricultural practices for quality purposes. Market infrastructure is deficient regarding sanitation, with few public toilets, inadequate drainage, and no coordinated pest control.

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1. Introduction

Product quality affects the value of a good to a buyer. Some product attributes are observable. Others can only be observed at a cost or not a all, but can have delayed health effects. Economists have long recognized the importance of product quality. The issue has received most attention in the industrial organization literature where it has been modeled primarily in terms of product differentiation. In that literature, the focus has been on firms' decisions to position their products in quality space, taking into account the response of other firms (e.g. Perloff and Salop 1985, Dixit and Stiglitz 1977). Limited observability is typically assumed to be solved through a reputation mechanism based on brand name and product recognition (e.g. Tadelis 1999, Horner 2002).

This approach does not easily apply to agricultural markets in poor countries. The large number of producers and market intermediaries makes it impossible for consumers to rely on brand names. This raises a number of empirical questions regarding agricultural markets in poor countries: Is information about product quality transmitted through the value chain? If yes, which dimensions of quality are transmitted and how?

We provide some elements of answer using original survey data that we collected on the marketing of non-staple food crops in India. We investigate the way information about quality is conveyed (or not) along the value chain. Non-staple crops such as fruits and vegetables are a good choice because quality (e.g., taste, perishability, safety) varies and matters more than for grain. Given its rapid economic growth and large middle class, India is a perfect country in which to study product quality in agricultural markets. Rising incomes translate into rapidly increasing demand for fruits and vegetables and an increased value put on quality.[1]

Results show that a large number of growers, traders and processors are involved in the pro-

[1] The rise in meat consumption also inflates the derived demand for chicken feed which, in India, is primarily maize. It is generally thought that half of all maize produced in India is devoted to animal production.

duction, marketing and processing of non-staple crops. There is very little evidence of horizontal or vertical integration and the use of modern forms of organization is negligible. Contract farming is rare. There is little involvement by supermarkets. Most of the economic agents involved in the value chain are quite small, except in wholesale where concentration is marked. Except for a handful of processors, brand names are not used to identify and differentiate products. The use of modern technology is also limited. The services and infrastructure provided by wholesale markets remain basic, with little cold storage and little or no organized pest control. The environment thus does not appear designed to identify, protect, and certify quality differences that are not observable.

Unsurprisingly, we indeed find that information about product quality does not circulate well. The data show that quality differences exist and that they are translated into price differences throughout the value chain. But quality is largely defined on the basis of observable attributes such as size and color. Quality differences are not translated into well defined grades and product attributes have to be assessed individually by each market participant.[2] Some quality information travels only partly through the chain, stopping at the level of wholesalers – perhaps because it is not relevant for retailers located downstream. Information about unobservable attributes is not conveyed at all. This is true, for instance, of information about pesticide and fertilizer application, post-harvest pesticide treatment, or the origin of irrigation water. As a result, sanitary risk is difficult to assess. Given that it is not assessed, it is not rewarded and growers do not even appear aware of sanitary risk. Finally, we find that most processors of the studied crops focus on the transformation of inferior quality products that they purchase at a discount, suggesting that the function of agro-processing is to reduce wastage.

[2] Grading is not facilitated by the fact that studied crops are produced using land races rather than standardized purchased seeds. This probably result in large multi-faceted variation in attributes across consignments, making grade standardization difficult.

Taken together, these findings indicate that the current value chain for non-staple crops in India provides a basic service, focusing on quantity rather than quality. This may be because many consumers are unwilling to pay a premium for attributes – such as food safety – that they do not perceive as relevant. As India further develops, however, urban consumers may put pressure on the chain to upgrade.

Agricultural markets in India have been studied extensively. The research has mainly focused on the effect of international trade liberalization (e.g. Sawhney 2005, Storm 1997, Parikh and et al. 1997, Athukorala and Jayasuriya 2003), the impact of public policy interventions (e.g. Umali-Deininger and Deininger 2001, Ramaswami and Balakrishnan 2002, Banerji and Meenakski 2004), and the existence of market integration (Palaskas and Harriss-White 1996). Little specific information is available about the value chain for non-staple crops.

More recent research has focused on the effect of contract farming and the emergence of new marketing arrangements for high-value food commodities (e.g. Singh 2002, Deshingkar, Kulharni, Rao and Rao 2003, Birthal, Joshi and Gulati 2005). This is in line with emerging research on changing food marketing systems and the rise of vertical integration in commodity chains in developing and transition economies (e.g. Reardon and Barrett 2000, Reardon, Timmer, Barrett and Berdegu 2003, Reardon and Swinnen 2004, Gulati, Minot, Delgado and Bora 2005). Our findings complement this literature, showing that Indian fruit and vegetable markets have yet to be affected by the supermarket revolution.

The paper is organized as follows. The conceptual framework is outlined in Section 2. The data collection process and the general characteristics of agents in the value chain are described in Section 3. The empirical analysis of the circulation of information about product quality is presented in Section 4. We finish with the conclusions in Section 5.

2. Conceptual framework

To clarify the issues surrounding quality control in the agricultural value chain, we begin by developing a simple model of the value and provision of quality. We then examine the conditions under which first best is achieved.

2.1. A model of quality

Let $q_i = \{q_i^0, q_i^1, ...q_i^N\}$ be a vector of attributes (e.g., size, color, taste) associated with a consignment i. Variable q_i^k denotes the quantity of attribute k associated with the consignment. Weight is treated the first attribute of a consignment, so that q_i^0 denote the weight of the consignment. We normalize attributes so that consumers derive positive utility from them, i.e.:[3]

$$\begin{aligned} U &= U(q_i^0, q_i^1, ...q_i^N) \\ &= \sum_{k=0}^{N} \alpha_k q_i^k \end{aligned}$$

with $\partial U / \partial q_i^k \geq 0$. For simplicity, we assume that U is measured in money equivalent.

Now consider two consignments i and j differing only in attribute k. For the consumer to be indifferent between the two, the price differential between the two must be equal to the difference in utility:

$$\begin{aligned} U(q_i^0, .., q_i^k, ...q_i^N) - p_i &= U(q_j^0, .., \tilde{q}_j^k, ...q_j^N) - p_j \\ p_i - p_j &\approx \frac{\partial U}{\partial q^k}(q_i^k - \tilde{q}_j^k) \end{aligned}$$

The price differential between the two consignments can thus be regarded as the implicit price

[3] If an attribute yields negative utility, e.g., the presence of bacteria, then we define q_i^k as the negative of that attribute.

of attribute k.[4]

We now turn to the production of attributes. Suppose for a moment that all attributes are perfectly observable. Growers have a joint production function for attributes denoted in implicit form as:

$$G(q_i^0, ...q_i^N; x_1, ...x_M x) \leq 0$$

where x is a vector of production inputs. Dropping the i subscript to improve readability, the efficient allocation is obtained from solving a social planner problem of the form:

$$\begin{aligned} \max_{\{x,q^k\}} U(q^0, q^1, ...q^N) - \sum_{n=1}^{M} p_n x_n \qquad & \text{subject to} \\ G(q^0, ...q^N; x_1, ...x_M) \quad = \quad & 0 \end{aligned}$$

which yields first order conditions of the form:

$$\begin{aligned} \frac{\partial U}{\partial q^k} - \lambda \frac{\partial G}{\partial q^k} &= 0 \\ -p_n - \lambda \frac{\partial G}{\partial x_n} &= 0 \end{aligned}$$

where λ is the Lagrange multiplier associated with the constraint. This yields the efficiency condition:

$$\lambda = \frac{\partial U / \partial q^k}{\partial G / \partial q^k} = -\frac{p_n}{\partial G / \partial x_n} \; \forall k, n \tag{2.1}$$

In equilibrium, λ is the price of the consignment. Combining the consumption and production

[4] If utility is additively separable, i.e., if $U = \sum_{k=0}^{N} \alpha_k q_i^k$, the formula holds exactly:

$$p_i - p_j = \alpha_k (q_i^k - \tilde{q}_j^k)$$

sides, it follows that:

$$\frac{dp}{dq^k} = \frac{\partial U}{\partial q^k} = p\frac{\partial G}{\partial q^k} \tag{2.2}$$

Equation (2.2) says that, in an efficient equilibrium, the price premium associated with attribute k is equal to the marginal utility of that attribute (expressed in money terms) and also equal to the marginal cost of producing the attribute. This is a standard result.

For an efficient equilibrium to arise, correct information about attributes must be conveyed across the value chain. To see this, imagine that correct information is only conveyed about a subset S of attributes with $S < N$. Since consumers only pay for attributes on which information is available, the price of consignment i can only vary with $\{q_i^0, ...q_i^S\}$. Consequently, growers receive no incentive for producing attributes q_i^k with $k > S$. As a result these attributes are set at the lowest level defined by the technology function $G(.)$. [5]

The marginal utility of certain product attributes is likely to be income sensitive. For instance, interest in organic foods and concerns over pesticides residues are higher among rich consumers. Accessing different markets thus requires variation in the mix of attributes. Poor Indian consumers, for instance, may be unwilling or unable to pay for the cost of reducing the health risks associated with food consumption. Foreign consumers in export markets, on the other hand, tend to be overly concerned with sanitary issues. Richer domestic consumers are also likely to be willing to pay more for certain attributes, such as freshness and taste. In order to serve these categories of consumers, the market must convey information about the

[5] In some cases, this implies that $q_i^k = 0$. This would be the case, for instance, for costly but unobservable post-harvest treatment. In many other cases, the quantity of unobserved attributes is not 0 simply because these attributes are produced at no extra cost in conjunction with observable attributes, e.g., tomatoes have a taste even if no special effort has been made to enhance it.

Some attributes, such as storability, may be valued by traders but not by consumers. Other attributes may even be valued negatively by consumer but positively by traders. Tomatoes and mangoes, for instance, bruise less during transport and handling if harvested early. But taste deteriorates when the fruit is harvested early because it does not mature in the sun. We abstract from these complications in the discussion here, but the same general principles apply.

attributes that more discriminating consumers value. If the necessary information does not circulate through the chain, it is impossible for these consumers to signal their willingness to pay more for high quality.

2.2. Information flows

So far we have discussed the cost of providing the attribute themselves, not the cost of transferring information about attributes. To this we now turn. Imagine a consumer considering whether to purchase a consignment. Not buying yields a normalized payoff of 0. There is one discrete attribute k that is either present or absent, i.e., $q^k = \{1, 0\}$. This attribute is revealed through consumption but is not immediately observable at buying time. There is no warranty. Let U_1 denote the consumer's utility when the attribute is present, and U_0 when it is absent. The buyer publicizes the attribute of the good by making an announcement $m^k = \{1, 0\}$, which may or may correspond to the true attribute q^k. A consignment claimed to possess the attribute (i.e., $m^k = 1$) is sold at price p_1; one that does not is sold at price p_0 with $p_0 < p_1$. Let the quality price premium be denoted α with $p_1 = p_0 + \alpha$.

There is no reason for the seller to report $m^k = 0$ when $q^k = 1$ since this would yield a lower price. But the seller has an incentive to report $m^k = 1$ when $q^k = 0$ since doing so raises the price. We assume that the buyer may either accept the seller's quoted price and quality, or incur cost c to inspect the good and assess its true attribute q^k. If the good is found of inferior quality, the buyer only pays p_0. If the buyer does not inspect, his expected payoff is $\pi^n = \tau U_1 + (1 - \tau)U_0 - p_1$ where τ is the probability that the seller is telling the truth. If he inspects, his payoff is $\pi^i = \tau(U_1 - p_1 - c) + (1 - \tau)(U_0 - p_0 - c)$. The gain from inspecting is:

$$G = \pi^i - \pi^n = \alpha(1 - \tau) - c \tag{2.3}$$

This shows that if the seller always tells the truth $G = -c$: in that case, inspecting is a waste of money. On the other hand, if the seller always lies, $G = \alpha - c$: if the price premium is larger than the cost of inspecting, the buyer chooses to inspect.

Let us now concentrate on the seller's incentives. We first note the buyer purchases the low quality good whenever $U_0 \geq p_0$. It is therefore in the seller's interest to set $p_0^* = U_0$. Turning to the high quality good, we first note that if the seller lies and the buyer inspects, lying yields nothing since the good is sold at price p_0 anyway. The seller gains from misreporting quality only if the buyer does not inspect. Solving equation (2.3) for τ tells us how much lying is feasible without inducing the buyer to inspect:[6]

$$\tau^* = \frac{\alpha - c}{\alpha} \tag{2.4}$$

To illustrate what is going on, let us first consider two special cases. First, suppose that the cost of verifying quality is 0. In this case the buyer inspects whenever there is a small probability that the seller may not be telling the truth. Lying thus yields no advantage for the seller: $\tau^* = 1$. To find the price at which the high quality good is sold, we note that the buyer purchases whenever $\pi^n \geq 0$. Since:

$$\begin{aligned} \pi^n &= \tau U_1 + (1-\tau) U_0 - p_1 \qquad (2.5) \\ &= U_1 - p_1 \end{aligned}$$

it follows that the maximum price the seller can set is $p_1^* = U_1$. In this case efficiency obtains because the equilibrium price differential $\alpha^* = p_1^* - p_0^*$ is equal to the utility gain from the

[6]Assuming that the buyer knows τ, for instance as a result of repeated buying over time.

attribute $U_1 - U_0$. Consequently, growers receive the correct incentive to produce the attribute valued by consumers.

Now suppose in contrast that the cost of verifying quality is very high so that the buyer never inspects. This is guaranteed whenever $c > U_1 - U_0$. In this case, the seller has no incentive to tell the truth: $\tau^* = 0$. Knowing this, the buyer buys the high quality good if $\pi^n \geq 0$:

$$\begin{aligned} \pi^n &= \tau U_1 + (1-\tau)U_0 - p_1 \\ &= U_0 - p_1 \end{aligned}$$

Since in equilibrium $U_0 = p_0$, it follows that the only price the seller can set for the high quality good is $p_1 = p_0$.

In the intermediate case, the equilibrium price premium is found by combining $\pi^n = 0$ with equation (2.4) and using $U_0 = p_0$. After some straightforward algebra we get:

$$\begin{aligned} \frac{\alpha - c}{\alpha}U_1 + (1 - \frac{\alpha - c}{\alpha})U_0 - p_1 &= 0 \\ \alpha^2 - \alpha(U_1 - U_0) + c(U_1 - U_0) &= 0 \\ \alpha^* &= \frac{1}{2}(b + \sqrt{b(b-4c)}) \end{aligned} \tag{2.6}$$

where $b \equiv U_1 - U_0$.[7] It is easy to verify that $\alpha^* < U_1 - U_0$, except when $c = 0$, in which case $\alpha^* = U_1 - U_0$. Consequently, growers do not receive the right price signal and there is under-provision of quality. Equation (2.6) further shows that the price charged for the high quality good $p_1 = p_0 + \alpha^*$ falls with inspection cost c. This is because as the inspection cost increases, the seller has more incentive to cheat, and this discourages the buyer. These results can be summarized as follows:

[7] The other root is smaller and hence is never optimal for the seller.

Proposition 1. *(1) When the inspection cost c is zero, the price differential between the high and low quality good is equal to the utility gain generated by the quality differential: $\alpha = U_1 - U_0$. As a result growers receive the right incentive to produce quality.*

(2) The price differential falls as the inspection cost rises.

(3) For a high enough inspection cost, the price differential vanishes. At that point both qualities are sold at the same price. The quality announcement made by the seller is irrelevant.

(4) For any $c > 0$, there is under-provision of quality.

Proposition 1 illustrates that the existence of inspection costs undermines the market for quality and results in under-provision. If quality is totally unobservable, the production of quality is not rewarded. This means, for instance, that sellers will not report any health risk associated with the good.

This unsatisfactory outcome could be corrected if the quality of the good is revealed upon consumption. In this case, sellers could promise to compensate the buyer if, upon consumption, the good turns out to be of inferior quality.[8] Given the small size of most transactions and the relative poverty of most parties, we do not expect the threat of court action to be credible and courts are probably unable to enforce warranty.(e.g. Bigsten, Collier, Dercon, Fafchamps, Gauthier, Gunning, Isaksson, Oduro, Oostendorp, Patillo, Soderbom, Teal and Zeufack 2000, Fafchamps & Minten 2001) Contract enforcement mechanisms based on repeated interaction[9] can, in principle, enforce warranty obligations and thus reward the production of quality. Warranty has to

[8] The optimal compensation is $b \equiv U_1 - U_0$. With warranty, the buyer no longer needs to inspect the good since his payoff without inspecting now is:

$$\begin{aligned} \pi^n &= \tau(U_1 - p_1) + (1-\tau)(U_0 - p_1 + b) \\ &= U_1 - p_1 \end{aligned}$$

irrespective of τ. It is therefore optimal for the seller to set $p_1^* = U_1$, which ensures first best. Finally if, as is reasonable, we assume that the seller incurs a cost when compensating a defrauded buyer, it follows that truth-telling is optimal: $\tau = 1$.

[9] These mechanisms are discussed in detail, for instance, in Fafchamps (1996) and Fafchamps (2004) and need not be debated here.

be provided each time the product changes hands. This is difficult to implement in an atomistic value chain with lots of intermediaries. Vertical integration can solve this problem by reducing the number of transactions between grower and consumer. Examples of vertical integration include contract farming and other out-grower schemes. Supermarkets also favor vertical integration by reducing the number of intermediaries between wholesaler and consumer (Reardon et al. 2003).

There are hidden attributes, such as health risk, that are not immediately or unambiguously revealed upon consumption. In principle, it may be possible to hold sellers responsible for the damage they have caused even if the damage is manifested with a lag. But providing the necessary evidence may be extremely difficult, and tracing the guilty party may be close to impossible in an atomistic market. In this case, external verification of the value chain is necessary. This can be accomplished by government through health and safety regulation. It can also be provided privately through franchising or independent certification. Recent years have witnessed an expansion of private and semi-private certification and labelling.[10] In developing countries, certification often involves non-governmental organizations that act as external guarantors.

To summarize, in the absence of regulation and certification, the theory predicts that, unless reputation effects enable economic agents to credibly offer warranty, attributes that are completely observable by the buyer do not carry a price premium. In contrast, attributes that are observable may carry a premium if the attribute is valued by the buyer. Attributes that are valued by certain intermediaries but not by final consumers carry a premium in the value chain only up to the level of those intermediaries.

The model also predicts that sellers announce the attributes of what they sell only if this attribute can be observed at a cost. If the attribute can be observed costlessly, making an

[10] Examples include organic, shade-grown, GM-free, and fair trade labels. Ethical labelling also applies to manufactured goods.

announcement is irrelevant; if the attribute cannot be observed at all, announcements are not believed so that there is no point making them. The objective of our empirical analysis is to investigate whether these predictions apply to Indian non-staple markets.

3. Data

Detailed data was collected from representative random samples of growers, traders, and processors of non-staple crops. To facilitate comparison, the surveys focus on five crops: mango, tomato, potato, turmeric, and maize. The first three are perishable fruit and vegetable crops.[11] Turmeric is partly destined to export markets, and maize is a feed crop. Information on individual agents is supplemented by data collected from market and village authorities.

We focus on four Indian states – Tamil Nadu, Uttar Pradesh, Maharashtra and Orissa. These states were chosen to capture the geographical and institutional diversity of India. Tamil Nadu and Maharashtra represent middle and southern states. The main difference between the two is institutional: in Maharashtra agricultural markets are tightly regulated while in Tamil Nadu they are not. Uttar Pradesh and Orissa represent northern states. The main difference between the two again is institutional. In Orissa government intervention in agricultural markets is generally regarded as ineffective. Uttar Pradesh is thought to be better in this respect.

Except in Tamil Nadu where the intervention of the state in agricultural markets is limited, the exchange of non-staple agricultural products falls in principle under the same rule as trade in major staples. In principle, all wholesale trade must take place within regulated markets and lots are to be sold via auction through the intermediation of commissioned agents. In practice, auctions are seldom used for non-staple crops and when they are they take the form of a silent auction. Commission agents play an important role in non-staple markets but their function

[11] In India potatoes are highly perishable because ambient heat favors germination.

and contractual responsibility is ambiguous. In practice, they seem to operate in a way that is not distinguishable from that of wholesalers. In the end, government intervention in non-staple markets boils down to providing market infrastructure and subsidized stalls to traders who in turn have to pay a market tax.

Detailed surveys of traders, growers, and processors were conducted in each of the four states covered by the study. In each state 20 wholesale markets and 40 villages were selected in order to construct a sample of 400 traders and 400 farmers. Community surveys were conducted at the market and village level. We also surveyed 600 processors and exporters. Given the difficulties encountered in constructing a reliable sampling frame and in getting selected enterprises to respond to the questionnaire, we make little use of those data here. Details of the sampling strategy can be found in Fafchamps, Vargas-Hill and Minten (2006).

Table 1 provides descriptive statistics for surveyed traders, weighted to ensure representativeness in each state. There is some diversity in the composition of the sample observed across states. Fewer commission agents are found in Orissa, and many wholesale traders also sell retail in Orissa and Maharashtra. There is greater separation of marketing functions in Uttar Pradesh with only 9% of sampled traders selling retail. Few traders in Tamil Nadu and Orissa sell in regulated markets. This confirms the characterization of Tamil Nadu as a state without regulated markets and Orissa as a state with regulated markets that function imperfectly. Most of the interviewed traders report buying from farmers. The mean working capital of a trader is around \$3000, but the median working capital is only \$476. Although there is some variation across states, trading in the five study crops is a low-tech enterprise. Aside from owning mechanical weighing scales and a telephone, trading enterprises do not own any physical capital. What this shows is that trade in non-staple crops is atomistic, with lots of intermediaries involved. Supermarkets are basically absent from the fruit and vegetable value chain. Contract farming is extremely rare and, in many states, still illegal. We found no public or private grading, certification, or labelling program in place for the five non-staple crops covered by the study.

Descriptive statistics for surveyed farmers are presented in Table 2. Figures are weighted to ensure representativeness in each state. Production of non-staple crops is even more atomistic than marketing, with tens of millions of small farmers involved. The characteristics of heads of farming households are similar across states. The distance to markets reported by farmers indicates that markets are located much further from producers in Tamil Nadu than in other states. This is true for both wholesale and retail markets. Maharashtra follows Tamil Nadu with average wholesale market distances of 17 and 30 kilometers. However the larger distances to wholesale markets in Tamil Nadu and Maharashtra do not deter farmers from selling there, as more farmers sell at wholesale markets in these states than in Uttar Pradesh and Orissa. In Orissa, in contrast to the other states, farmers are more likely to sell at retail than wholesale markets.

Contract farming could potentially solve some of the coordination and information problems between suppliers and buyers. Information on contract farming collected during the survey indicates very few farmers – only 5% of the farmers in our study – are engaged in contract farming. Nearly all the contracts observed in the survey are for mango. The only input provided by a large proportion of buyers is harvesting labor. Farming contracts thus boil down to forward sales of mangoes on the trees, which the buyer harvest himself in half of the contracts. The perceived advantages of contract farming in its current form are most related to price and client security; few farmers report provision of inputs or quality control. One fourth of respondents mention cash in advances as the reason for selling their crop forward. The major perceived disadvantage is getting a lower price. Taken together, the evidence thus indicates that contract farming, as it is currently practiced, is not used for quality control purposes.

4. Empirical results

We have briefly summarized the main characteristics of the population of growers, traders, processors and exporters of mango, tomato, potato, maize and turmeric. We have seen that production and marketing are atomistic, with little or no use of vertical integration or contracting to solve information problems. We now examine their trading practices, with a focus on quality control and the transfer of information about crop attributes.

Theory predicts that, in the absence of external certification, an atomistic value chain will only relay information about attributes that are observable by buyers. Information on attributes that are not observable by buyers – such as agricultural practices – will not be provided, whether these practices are valued by consumers or not. As a result, there will be no difference in unit price between agricultural practices. Theory also predicts that sellers need not explicitly provide information about characteristics that are costlessly observable by buyers, such as size and color.[12] Information should only be explicitly provided for attributes that are observable at a cost, such as taste or weight.

We examine the evidence in two ways. First we take advantage of the rich descriptive data we have collected to document quality control and information transfer practices. We also look for evidence that the government uses its involvement in agricultural marketing to promote quality and safety. We then turn to multivariate analysis to test whether unit prices paid to growers only vary with observable characteristics.

4.1. Information transfer and quality control

We begin by showing in Table 3 that a large majority of farmers use pesticides, irrigation, and fertilizer on the five studied crops. The only exception is mango, which is seldom irrigated.

[12] Costlessly, that is, if the buyer is physically present and the produce is packed in such a way that it can be observed.

The median number of pesticide applications is between two and three times over a crop cycle, depending on the state. The median time elapsed between harvest and the last pesticide application is large for maize, mango and turmeric (6 to 8 weeks) but is much smaller for tomato and potato (2 to 3 weeks). Few farmers have their land tested and when they do, it is primarily to determine what the soil is good for, not to find out about pesticide residues. While about 60% of the villages were visited by agricultural officers over the last year, only 8% was told that certain pesticides should not be used and that their post-harvesting practices should be changed. Only 1% of the village has been told that certain water sources should not be used for irrigating crops. Not all growers dry or clean their produce before selling it. Fumigation or any other type of post-harvest treatment is hardly ever undertaken by growers, except for turmeric. Only for turmeric do growers undertake any grading.

From this evidence, it appears that farmers are primarily concerned about the quantity and appearance of their produce, which are undoubtedly enhanced by the use of fertilizer, irrigation, and pesticides. But growers are less involved in post-harvest treatment and processing. Few of them seem aware of possible sanitary issues raised by pesticide usage or irrigation. This could be explained by the lack of concern for sanitary issues further down the value chain: if produce is likely to be soiled during handling at the market level, there is little reason for growers to worry about sanitary issues.

Table 4 indeed shows that market infrastructure is minimal in most cases. This is true in spite of the fact that our sample focuses on large wholesale and regulated markets which are probably better on average than rural retail markets. We note a lack of tarred surfaces and of public toilets in the market overall. There is a lack of piped water in individual stalls, which is crucial for hygiene. There is little cold storage and few if any grading/sanitary services are found in the studied markets. Drainage is poor. Whenever measures are taken against rats and pests, which does not happen frequently, they are undertaken by individual traders, not by market authorities. Given these conditions, it is likely that the studied crops are more sanitary when they leave the farm than when they reach the consumer.

Does this imply that there are no differences in quality? Quite the contrary. As shown in Table 5, almost all of growers and traders recognize different varieties for the five crops under study. Farmers associate quality differences with differences in size, shape, color, and moisture content – the latter being relevant only for maize and turmeric. These are easily observable attributes. Some growers reckon that quality depends on taste and smell, but these attributes appear less important. They are also less immediately observable.[13] Quality differences are associated with large price differences, especially for turmeric, tomato, and mango. From this it appears that growers perceive a strong price premium associated with observable quality.

A similar picture emerges from the answers provided by traders (second panel of Table 5). Except for maize where one fifth of growers and traders think that size does not matter, size is associated with quality by virtually all respondents. Shape matters somewhat less for traders than growers, except for potato. While nearly all growers think that color matters for quality, traders seem less concerned about it, except for tomato. Smell is also less important, especially for maize and potato. Similarly, traders seem less interested in taste than growers: a majority of traders states that quality does not depend on taste, compared to half of the growers claiming that it does. The difference is particularly striking in the case of turmeric where 54% of growers state that quality depends on taste while only 8% of traders say so. These results show that in their assessment of what affects product quality, traders grant less weight than growers to less observable attributes.

Traders and farmers report large price differentials associated with differences in quality.

[13] Tomato and mango could in principle be assessed on the spot but they often are not fully ripe when harvested. For maize and potato, taste and smell only become fully apparent once cooked.

This is particularly true for tomato and mango, the most perishable of the studied crops. Prices for these crops can increase or decrease by 50% for good and bad quality respectively. The differential is significantly lower for maize. Turmeric is an oddity: according to growers, price varies a lot with quality but according to traders it does not. More investigation is required to understand these features.

Next we turn to the information transmission process. Table 6 compares the information that growers claim buyers can tell by direct observation with the information they report transmitting to buyers. Growers vary a lot in the size of their production of non-staple crops. To capture the proportion of aggregate marketed surplus for which agronomic information is conveyed to the buyer, we weigh farmers' answers by the quantity they sell. So doing, we get a sense of the information available for the average produce in the value chain.

The first panel of Table 6 represents the percentage of marketed output for which the grower reports that the buyer can observe various crop attributes. We see that, with the possible exception of potato, buyers cannot tell whether growers have used fertilizer, pesticides or irrigation. Buyers can more easily tell which variety has been used. For those growers who undertake post-harvest operations such as drying, cleaning, or grading, the majority state that buyers can tell whether the activity has been undertaken. Fumigation stands as a strong exception, buyers being unable to tell whether it has been applied by growers.

The second panel of Table 6. presents the percentage of market output for which growers reported a given attribute. Percentages are computed only over those farmers who undertake the activity associated with the given attribute. We see that growers transmit very little information directly to buyers. The only apparent exception is packaging, but presumably buyers can tell whether the produce is packaged.

The explanation for this apparent lack of information transfer does not seem to lie with growers. Buyers indeed show little interest in – and require little information on – agronomic practices. For instance, a very low percentage of farmers said that, over the last five years, buyers have requested that farmers should not use certain agricultural inputs, or asked for changes in post-harvest practices. Virtually no farmer states that a buyer would pay more for produce complying with new specifications or requirements.

Statements by farmers are confirmed by the results of village focus groups interviews. While between 30% and 40% of village focus groups declare that buyers of maize, potato, tomato and turmeric pay attention to the type of seeds that are used, percentages quickly drop off for the buyers' interest in the type of pesticides that are used, the timing of the use of these pesticides and the kind of irrigation water used. Only about half of the villages state that buyers of agricultural produce in the village would refuse produce affected by fungus/pests.

Farmers were also asked where they obtain information on acceptable agricultural and post-harvest practices. The majority of farmers said that they obtained this information from other farmers (Table 7). Agricultural traders are seldom cited as a source of information on fertilizer and pesticide use (6%), irrigation practices (3%), sorting/grading of crops (7%), or post-harvest practices (5%). This confirms that very little information travels from traders to farmers regarding agricultural practices that could potentially affect the quality or safety of non-staple crops. This is consistent with earlier information indicating that traders care little about such crop attributes.

From this we conclude that the value chain does not reward specific agronomic practices, except to the extent that these practices affect directly observable characteristics. This finding is consistent with our model which indicates that conditioning the price on unobservable characteristics is only feasible if sufficient trust exists between seller and buyer. If sufficient trust is not present, such conditioning is not credible because it would result in misreporting. That misreporting is possible is indeed suggested by the observation that growers who fumigate fail to report this information to buyers.

Similar information was collected for market auctions that take place in regulated markets. Results are presented in Table 8. We see that surprisingly little information is explicitly conveyed to potential buyers. The quantity for sale is not reported in many cases, probably because individual buyers bid only for a portion of the consignment. We note that, consistent with our earlier findings, little or no information is provided regarding agronomic practices. Buyers also learn little about the humidity content, the place of origin, the grade or size, or the crop variety. Attributes that are least observable are the least likely to be explicitly mentioned at the auction. Buyers have to make up their own mind based on observable characteristics of lots offered for sale.

This interpretation is confirmed by Table 9, which shows quality control by individual traders. Respondents were asked to comment on quality control by themselves and by buyers during their last completed transaction. Responses indicate that the overwhelming majority of buyers and sellers check variety, quality and grade directly. In contrast, there is little interest in unobservables such as storage conditions, post-harvest treatments and use of pesticides. Very similar results were obtained for exporters and processors. While some traders refuse produce due to quality concerns, this is much less the case for food safety concerns. Food safety seems to be a relative minor concern of participants to the value chain.

To pursue this issue further, we report in Table 10 detailed answers to attitudes towards sanitary and phyto-sanitary issues by traders, processors and exporters. Traders are broken down into commission-agents, wholesalers, and retailers. A majority of respondents claim to purchase mostly from regular suppliers they trust. Most respondents also state that buyers buy from them because they trust the quality of the products they sell. Yet, most respondents appear unaware of possible sanitary issues related with their activity. This is particularly true among retailers, who deal directly with consumers, and for processors, who transform agricultural products for human consumption. The Table shows that few retailers and processors are willing to pay more for produce of better sanitary quality, and that few of them purchase from specific buyers because they trust the sanitary condition of what they buy. These results are consistent with the non-observable character of sanitary attributes.

Wholesalers are more aware of sanitary issues, however, and half of them respond incurring cost for sanitary purposes. However, those who purchase from them – retailers and processors – do not appear to care or to be willing to pay a sanitary quality premium. Consequently, the benefits from better sanitary care by wholesalers – assuming it exists – is likely to be lost further down in the value chain.

In marketing systems in developed countries, packaging is often used to convey information to buyers on the characteristics of the produce. Our survey shows that only one third of the retailers bought bagged or boxed produce. This figure is higher for commission agents and wholesalers. In most cases, packaging material is returned to the seller. All this suggests that bags and boxes are mostly used for transportation purposes. Information of unobservables does not appear to be transmitted through marked packaging.

We have already seen that regulated markets only offer basic infrastructure, with poor drainage and sanitation. The Table suggests that regulation is also deficient. Few processors and exporters obtain a health or phyto-sanitary certificate. Virtually no trader, processor or exporter of agricultural products has dealt with a government agency regarding sanitary or environmental regulation issues.

4.2. Prices

Now that we have a better sense of how information circulates in the value chain, we turn to prices. In the survey, traders, processors and exporters were asked whether prices depend on various crop attributes. Their answers are summarized in Table 11.[14] The most striking finding is the contrast between answers given by wholesalers and other participants to the value chain, mainly retailers, processors and exporters. A majority of wholesalers are of the opinion that prices paid for the five studied crops depend on various post-harvest practices. In contrast, the majority of retailers, processors and exporters do not think that post-harvest practices affect the price. A large proportion of processors and exporters even report that they do not know whether the price they pay depends on post-harvest practices. Commission agents occupy an intermediate position: they reckon prices depend on cleaning, packaging and grading, but not on any other post-harvest practice.

These results imply that these attributes are important for wholesalers but not for downstream retailers and processors. This may be because of handling and transport losses that affect wholesalers but not consumers. The price premium thus stops somewhere along the chain, as suggested in the conceptual section. The relative lack of interest in post-harvest practices expressed by processors is consistent with our earlier observation that, if anything, processors purchase mainly low quality fruits and vegetables and hence care little about attributes that determine quality.

To pursue this issue further, we test whether unit prices paid to producers vary signifi-

[14] Respondents were also asked whether the price paid depends on various agricultural practices such as planting date, irrigation, and the application of pesticides and fertilizer. Many respondents answered that it does, a surprising outcome since, as we have seen, that little information about agricultural practices travels through the value chain. We suspect that some respondents failed to draw the distinction between unit price and revenue. For instance, many traders answered that the price paid depends on the planting date. They may have understood the question as referring to the price paid for the entire crop, which depends on yield and thus on planting date. The same reasoning probably applies to questions about irrigation and the application of pesticide and fertilizer. For this reason we focus on questions regarding post-harvest treatment, which are less subject to this bias.

cantly with crop attributes. To this effect, we regress the unit price paid to growers on various agricultural and post-harvest practices. We estimate a regression of the form:

$$\log p_i = \alpha \log Q_i + \sum_k \beta_k q^k + \sum_t \delta_t D_t + \sum_j \gamma_j C_j + u_i \tag{4.1}$$

where p_i is the price per Kg, Q_i is quantity sold, q^k is a vector of crop attributes/practices, D_t a vector of month dummies, and C_j a vector of controls. We expect the unit price to be lower for large transactions, because transactions costs are lower.[15] Monthly dummies are included to capture seasonal effects. Control variables include dummies for whether the buyer is a consumer or another trader, crop dummies, location of sales dummies, type of payment dummies, and regional dummies. Because the unit price is computed as the total price divided by quantity sold, the price data exhibit signs of measurement error in the form of large outliers. To eliminate the role played by these outliers, equation (4.1) is estimated using a median (quantile) regression.

Results are in agreement with the qualitative information reported earlier. As anticipated, agricultural practices such as irrigation and fertilizer and pesticide application are never significant. Results presented in Table 12 therefore focus on post-harvest practices. They show a price premium for crops sold dried and graded. Not only are the coefficients strongly significant, the magnitude of the effect is also rather large. Results suggest that grading raises the price paid by 6% on average, while drying the crop raises it by 32%. Looking at individual crop results, we see that drying is a practice that is relevant only for maize and turmeric. For the latter, drying basically doubles the value of the crop. Of course, drying reduces moisture content and weight, so that part of the effect is mechanical. But drying also increases storability.

Pooled results also suggest a large positive premium for fumigated crops, but this result seems to be an artifact of pooling. Indeed, the significance of fumigation coefficient completely

[15] Measurement error in quantity sold may also affect the result.

disappears in the regressions at the product level. It is seemingly driven by the fact that turmeric fetches a much higher unit price than other crops and is also much more likely to be fumigated: 25% of turmeric is reported to be fumigated by farmers, compared to 3%-7% for other crops.

Other regressors are also of interest. When the product is harvested by the farmer himself, we observe on average a positive price premium, especially for mango. This is normal since the buyer has to incur the harvesting cost. In the case of maize, we get the opposite result: farmers who do not harvest the crop themselves get on average a higher price. This may correspond to situations in which the farmer is approached by a trader keen to secure maize quantities when the maize price is high. Crops sold under a contract farming contract receive a slightly lower price, but the difference is significant only for tomato and potato. We also note that farmers receive a significantly higher price when selling to a commission agent.

The price paid also depends on the place at which the crop was sold, a point studied in detail for Uganda by Fafchamps and Hill (2005). Selling at a village retail market seems to yield a large (10%) price premium, but the effect is only significant in the pooled regression, so it could be a compositional artifact. Looking at the un-pooled specific regressions we see that the premium by sales varies considerably depending on the crop: selling on wholesale markets (unregulated or regulated) fetches a significant higher premium for tomato. Prices for mango are higher at the farm gate, especially compared to unregulated wholesale markets.

5. Conclusion

Using original survey data that we collected in four Indian states, we have examined how quality control takes place in the value chain for five non-staple crops – mango, tomato, potato, maize and turmeric. We presented a model in which information about crop attributes influences unit price. We showed that, in the absence of external verification, theory predicts that information about unobservable attributes cannot be credibly transmitted if buyer and seller do not trust each other. As a result, information about these attributes does not circulate through the value chain and growers receive no incentive regarding unobservable crop attributes.

In agreement with model predictions, we find that information about the type of irrigation crops received or the application of pesticide and chemical fertilizer is not passed along the value chain. As a result, producers are only interested in agricultural practices that raise the quantity sold or improve observable characteristics of the crop, such as grading, packaging or drying. The same is true for post-harvest treatment such as fumigation, which is undertaken by few traders and seldom reported to buyers. Sellers in general only report observable attributes to potential buyers. This is consistent with the absence of trust: if the buyer does not trust the seller, there is not point making unverifiable claims about items for sale. Further confirmation of this interpretation is found in the finding that buyers always check observable attributes of what they purchase – they do not simply rely on seller's report.

Market infrastructures for non-staple crops are not very developed. The majority of markets are not paved, many do not have dedicated stalls for non-staple traders, and there are few grading or cold storage facilities. Sanitation facilities are largely deficient, with few public toilets, inadequate drainage, and little or no coordinated pest control. Auctions are conducted in an informal manner, with little information explicitly conveyed to buyers who have to inspect each consignment personally.

We find that agricultural practices have no effect on unit price. In contrast, a significant price premium is paid to growers for drying, grading and packaging the crops they sell – attributes that are immediately observable by buyers. The purpose of these attributes appears to be to reduce transactions costs to traders: they are only valued by traders and do not translate into unit price premia further down the value chain. This is consistent with the view that packaging only serves to facilitate the work of wholesalers, but carries no useful information further down the value chain.

By vertically integrating the value chain and by creating a long-term trust relationship between grower and buyer, contract farming can in principle provide a commitment mechanism capable of overcoming the information transfer problem. In our sample we find that few growers sell on contract. Those who do are predominantly mango growers who sell their crop forward. Contracts are of relatively short duration and the buyer only provides harvest labor, not inputs, seeds, or directions to improve quality. It is possible that more sophisticated contract farming practices exist in India, but they are probably quantitatively very small for the five non-staple crops that we studied.

These findings suggest that the value chain for non-staple crops in India remains fairly undeveloped. The findings reported here suggest that, because of credibility issues, the market cannot deliver sanitary food in a decentralized manner. There is therefore room for coordinated action to improve the infrastructure and pest control practices of existing markets. We are particularly concerned about the poor sanitation that characterize most non-staple markets. Although the Indian poor may not have the money to pay for more sanitary food, we are concerned about the potential health risk that results from this situation – particularly with respect to *e.coli* and other bacteria.

It is conceivable that, given the level of development of the country, many Indian consumers are unwilling to pay a large price premium for higher quality fruits and vegetables. We also suspect that few consumers would value organically grown produce. But rapid growth and the rapid rise in incomes are likely to result in a dramatic rise in the demand for safe high quality food. India's capacity to export non-staple produce, in raw or processed form, also depends on its ability to guarantee quality. The current value chain is unable to satisfy this demand.

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Table 1: Descriptive statistics of sampled traders

	Total	Tamil Nadu	Orissa	Maharashtra	Uttar Pradesh
Type of activity (% of traders)					
Commission agent	24	34	1	69	54
Sell wholesale	92	77	89	91	98
Sell retail	56	54	95	65	9
Buy directly from farmers	89	82	96	88	82
Sell/buy other than ag. products	11	8	23	9	1
Sell in regulated market	55	7	30	60	84
Socioeconomic background					
Age (years)	39	43	42	41	36
Proportion that are male (%)	99	98	97	100	100
Education, % of traders who have:					
No formal education	24	20	21	2	32
Primary	13	11	29	2	3
Middle	17	18	19	21	15
Secondary	26	29	23	30	26
High secondary	11	5	7	23	14
Undergraduate or more	8	16	1	22	9
Scale and structure of business					
Proportion that are sole owners (%)	92	93	93	93	91
Mean working capital of enterprise ($)	2778	2832	597	15607	1944
Mean annual purchases ($)	113722	531441	17811	68166	133658
Mean annual sales ($)	121521	561666	20459	72161	142849
Mean annual net revenue ($)	19557	41996	8040	4157	23864
Equipment (% of traders that own...)					
Mechanical scales	74	63	86	81	67
Processing equipment	1	1	0	2	2
Telephone	50	41	11	89	57
Computer	6	3	1	19	0
Non-motorized transportation	25	10	68	4	21
Motorized transportation	2	2	1	5	0

Table 2: Descriptive statistics of sampled farmers

	Total	Tamil Nadu	Orissa	Maharashtra	Uttar Pradesh
Characteristics of household head					
Age (years)	49	47	47	51	47
Gender (% male)	98	96	99	99	96
Education (mean years)	7	7	3	8	5
Religion (% Hindu)	90	96	98	96	76
Caste (% scheduled cast / scheduled tribe)	18	10	55	5	31
Welfare characteristics (% of households that...)					
Live in a *pucca* house (with tin roof)	75	81	35	95	55
Have a toilet in house	27	31	10	26	32
Own a television	61	71	26	91	25
Own a telephone	30	25	7	45	17
Have problems satisfying their food needs	27	56	43	1	46
Scale of farming enterprise					
Total value of output (mean, $)	1700	1200	500	2600	1100
Total value of sales (mean $)	1500	1100	400	2200	900
Market access (median distance to, Km)					
Closest wholesale market for grain	13	45	10	17	7
Closest wholesale market for fruit	15	35	10	30	7
Closest retail market for grain	6	13	6	8	3
Closest retail market for fruit	6	10	6	8	2
General selling practices (% of farmers)					
Sold at wholesale market in last year	80	79	39	96	71
Sold at retail market in last year	11	9	53	3	13
Sell with other farmers	4	9	2	1	5
Engage in contract farming	5	6	4	6	4
Sell with advance	9	37	3	3	7
Perform post-harvest activities	88	90	49	97	86
Store before sale	23	9	29	28	19

Table 3: Production, post-harvest, sanitary and phyto-sanitary practices of farmers

	Crop				
	Maize	Potato	Tomato	Mango	Turmeric
Proportion of farmers that undertakes one of the following practices to improve quality (%):					
choose particular seeds / variety	91	94	97	79	84
plant at a specific time	92	91	96	-	87
apply pesticides	68	93	92	87	73
apply fertilizer	93	88	96	87	82
irrigate	96	95	90	18	79
dry after harvest	66	-	-	-	91
clean after harvest	64	74	38	34	80
grade	28	84	69	81	69
fumigate / treat after harvest	9	4	9	13	64
package / crate	8	52	45	60	32
mill / grind	44	-	-	-	6
Phyto-sanitary practices					
Median number of times pesticide is used	2	3	3	3	3
Median number of weeks pre-harvest of last application	7	3	2	6	8
Proportion of crop grown by farmer who tested soil properties	27	27	26	6	10
Of those who tested, reason for testing soil (%):					
to determine what soil is good for	94	78	91	47	95
to find out about pesticide residue	5	8	2	53	5
Training of farmers on sanitary and phyto-sanitary practices	Overall				
% of villages visited by agricultural officers over last year	60				
% of farmers visited by agricultural officers at least once over last year	20				
% of villages where farmers have been told…					
… that certain pesticides should not be used	8				
… that certain water sources should not be used for irrigating crops	1				
… that their post-harvesting practices should be changed	8				

Table 4. Infrastructure, drainage and pest control in agricultural markets

Market infrastructure	Percentage
Type of road inside market yard (%)	
Kutcha road	42
Paved road	12
Pucca tar road	42
Other	3
% of markets that have public toilets	50
Proportion (%) of stalls that have...	
Electricity	61
Pipe water	25
Telephone (land line)	40
Grading equipment	3
Packing equipment	1
Fumigation machine	4
Availability on the market of (% of markets)	
… grading machine	16
… authorities that offer grading services to traders, f.ex visual inspection or certification	21
… drying machine	1
… area to dry crops	16
… crop fumigation equipment	5
% of markets with cold storage facilities	7
Drainage and pest control in markets	
Type of drainage (% of markets)	
covered sewer	22
concrete open sewer	27
both covered and concrete open sewer	4
earthen open sewer	15
no drainage	32
% of markets where drainage is adequate	56
If not adequate, why not? (% of markets)	
drains are too narrow	13
drains are clogged due to lack of planning	68
other	19
Measures taken against rats (% of markets)	
employees of market/association in charge	5
pest-control contracted to outside firm	3
individuals take care of rats in their store	32
no particular measure taken	59
Measures taken against insects damaging crops (% of markets)	
employees of market/association in charge	7
pest-control contracted to outside firm	3
individuals fumigate in their store	27
no particular measure taken	59
other	4

(unweighted average over the four states)

Table 5. Perceived quality and price difference by traders and farmers

	Product				
	Maize	Potato	Tomato	Mango	Turmeric
Farmers					
Proportion reporting different varieties for this crop	99	100	100	100	97
Proportion of crop grown by farmer who believes crop quality is determined by (%):					
size	81	100	99	100	100
shape	71	97	97	100	96
color	97	93	96	95	87
smell	46	14	34	51	58
taste	48	68	36	98	54
moisture content	93	-	-	-	73
Perceived price differences					
Mean per kilo premium for crop of high quality (Rs)	1.5	1.3	3.6	11.6	11.6
Mean per kilo discount for crop of low quality (Rs)	1.3	1.2	2.6	9.3	7.5
Traders					
Number of observations	353	543	568	476	185
% of traders that say different varieties exist	100	100	100	99	100
Perceived determinants of quality (%)					
Quality is determined by size?					
A lot	65	97	95	95	59
A little	13	3	4	3	39
Not at all	22	1	1	2	1
Quality is determined by shape?					
A lot	48	82	57	73	39
A little	23	15	39	13	59
Not at all	28	3	4	14	2
Quality is determined by color?					
A lot	56	55	87	58	41
A little	20	39	11	20	24
Not at all	23	6	2	21	34
Quality is determined by smell?					
A lot	2	4	29	38	21
A little	6	11	11	34	36
Not at all	91	84	59	28	43
Quality is determined by taste?					
A lot	9	37	12	57	1
A little	24	19	11	16	6
Not at all	67	44	77	27	92
Quality is determined by moisture content?					
A lot	79	-	-	-	16
A little	17	-	-	-	83
Not at all	4	-	-	-	1
Perceived price differences					
Mean per kilo premium for crop of high quality (Rs)	1.0	0.9	3.4	3.9	6.7
Mean per kilo discount for crop of low quality (Rs)	2.0	2.0	5.5	6.9	9.0

Table 6. Information transmission and requirements for buyers

	Crop				
	Maize	Potato	Tomato	Mango	Turmeric
Information available to buyers					
Proportion of crop grown by farmer who reports buyer can tell practice has been undertaken:					
(% of those that have undertaken practice)					
choose particular seeds / variety	62	85	58	81	78
plant at a specific time	23	65	48	-	44
apply pesticides	11	33	20	7	21
apply fertilizer	9	63	21	5	16
irrigate	23	56	32	7	11
dry after harvest	84	-	-	-	91
clean after harvest	75	77	54	62	77
grade	39	80	62	69	54
fumigate / treat after harvest	10	14	9	27	30
Proportion of crop grown by farmer who tells buyer practice has been undertaken:					
(% of those that have undertaken practice)					
choose particular seeds / variety	2	6	16	6	6
plant at a specific time	1	5	7	-	6
apply pesticides	1	10	10	6	7
apply fertilizer	1	6	9	2	5
irrigate	1	4	12	2	1
dry after harvest	1	-	-	-	0
clean after harvest	3	10	7	3	0
grade	1	6	13	3	0
fumigate / treat after harvest	0	25	8	2	4
package / crate	13	65	10	3	7
mill / grind	3	10	3	1	15
Requests on production, post-harvest and phyto-sanitary practices by buyers					
Proportion of crop sold for whom buyers have (in last five years, %):					
changed specifications regarding product quality	1	15	8	1	0
indicated they should not use certain chemicals / inputs	5	4	4	0	1
requested / required change of post-harvest practices	3	9	6	0	2
paid more if farmer complies with new spec.s/req.s	2	2	3	0	0
Proportion of crop grown by farmers who have changed practices t	2	0	2	0	1
Buyers of agricultural products in this village pay attention to…(% of villages)*					
… what type of seed has been used	32	40	38	13	33
… what kind of pesticides has been used	17	22	22	6	14
… to when pesticides have been applied	13	17	17	6	12
… to what kind of irrigation water has been used	10	8	14	2	12
Buyers of agricultural products in this village refuse produce affected by pests/fungus (% of villages) *	54	54	63	35	52

*: source is village survey; for other variables source is farmer survey

Table 7. Farmer access to information on agricultural and post-harvest practices

	State				
	Tamil Nadu	Orissa	Maharashtra	Uttar Pradesh	Total
Main source of information on fertilizer and pesticide use (%):					
other farmers	14	35	74	60	58
agricultural officers	21	34	11	8	13
agricultural campus students	0	0	0	0	0
agricultural traders	6	12	1	13	6
contractor of produce	1	0	0	0	0
input suppliers	27	7	10	14	13
radio/tv	0	2	1	2	1
newspaper/magazine	3	0	1	1	1
personal observation	27	8	2	0	5
other	1	3	1	1	1
Main source of information on irrigation practices (%):					
other farmers	26	50	81	86	73
agricultural officers	14	29	10	3	10
agricultural campus students	0	0	0	0	0
agricultural traders	1	6	0	6	3
contractor of produce	0	0	0	0	0
input suppliers	4	1	0	1	1
radio/tv	0	3	0	2	1
newspaper/magazine	2	0	0	0	0
personal observation	53	10	4	0	10
other	0	1	4	2	3
Main source of information on sorting/grading of crops (%):					
other farmers	30	54	79	76	69
agricultural officers	8	18	11	2	8
agricultural campus students	0	0	0	0	0
agricultural traders	4	17	1	13	7
contractor of produce	2	0	0	8	3
input suppliers	4	0	0	0	1
radio/tv	0	15	0	2	1
newspaper/magazine	2	0	0	0	0
personal observation	50	9	4	0	10
other	0	0	4	0	2
Main source of information on post-harvest practices (%):					
other farmers	31	56	77	77	69
agricultural officers	7	20	11	2	8
agricultural campus students	0	0	0	0	0
agricultural traders	1	9	0	13	5
contractor of produce	0	0	0	7	2
input suppliers	3	2	2	0	2
radio/tv	1	1	0	2	1
newspaper/magazine	5	0	0	0	1
personal observation	52	8	3	0	9
other	0	3	5	0	3
Number of observations	378	401	401	400	1580

Table 8. Reporting of produce characteristics at market auctions

	Yes for all crops	Yes for some crops	No
Explicit reporting of (%)			
… quantity offered for sale	61	17	22
… package/bag size	54	20	27
… reservation price	51	15	34
… place of origin	34	24	41
… name of farmer/seller	41	17	41
… name of broker/commission agent	44	10	46
… type of seed/variety	32	20	47
… grade/size	49	20	32
… percentage broken	44	10	46
… humidity content	17	12	71
… application of pesticides	7	5	88
… organic or non-organic farming	5	7	88

Source: Market survey

Table 9. Quality control by traders, processors and exporters

	Product					
	Maize	Potato	Tomato	Mango	Turmeric	Total
Trader						
Number of observations	292	365	366	316	134	1473
Type of transaction						
Quantity traded in kgs (median)	800	1500	475	800	800	1000
Value sale (amount received) in $ (median)	135	195	78	178	571	142
Quality checks (% of transactions)						
by the trader himself						
variety	81	72	86	92	84	83
quality and grade	85	83	87	92	84	86
moisture content	73	36	35	19	70	43
presence of stones and unwanted material	68	26	30	11	55	35
storage conditions (use of pest./treatment)	17	7	10	5	10	10
by the buyer						
variety	77	76	88	92	82	83
quality and grade	80	85	87	93	83	86
moisture content	69	40	40	17	69	43
presence of stones and unwanted material	63	30	34	11	51	36
storage conditions (use of pest./treatment)	16	9	10	4	5	9
Some buyer refused to buy some of the produce						
… due to quality concerns	13	21	21	17	7	17
… due to food safety concerns	10	9	12	7	4	9
Enterprises						
Type of transaction						
Quantity purchased in kgs (median)	1500	1000	300	300	450	500
Value purchase in $ (median)	36	21	52	26	60	38
Quality checks (% of transactions)						
by the enterprise itself						
variety	90	81	96	96	94	93
quality and grade	90	85	91	86	97	90
moisture content	87	37	60	46	81	62
presence of stones and unwanted material	42	33	30	16	37	28
storage conditions (use of pest./treatment)	10	26	21	14	17	16

(using data on their last completed transaction)

Table 10. Attitudes on sanitary and phyto-sanitary issues by traders, processors and exporters

	Percentage of …			
	Commission agents	Wholesalers	Retailers	Processors-Exporters
Buy from regular supplier form whom you trust the quality of the produce	55	89	72	73
Buyers buy from you because they trust the quality of the product you sell	74	95	84	89
There are sanitary issues for human health/pest/diseases	20	62	45	25
Incur costs for sanitary purposes	22	49	24	27
Bought bagged or boxed products on last sales transaction	76	43	37	51
If so, provided bags/boxes themselves on their last sales transaction	15	46	3	34
Do obtain a health certificate	-	-	-	33
Do obtain a phyto-sanitary certificate	-	-	-	15
Buyers pay more for crops with better sanitary quality	70	81	6	18
You only buy from regular suppliers from whom you trust the sanitary conditions	73	89	51	59
Buyers buy from you because they trust the sanitary conditions	77	88	61	70
Whether dealt with government agency over last 12 months on…				
… sanitation/epidemiology related issues	1	1	0	2
… environmental regulated related issues	0	0	0	2

Table 11. Perceived price premiums by traders, processors and exporters

		Percentage of…			
		Commission agents	Wholesalers	Retailers	Processors-Exporters
Price depends on …					
… planting date	yes	59	73	65	38
	no	37	26	26	35
	don't know	4	1	9	27
… application of pesticides	yes	46	77	71	39
	no	50	22	27	36
	don't know	3	1	2	25
… application of fertilizer	yes	62	78	76	45
	no	30	21	23	33
	don't know	7	1	1	22
… irrigation by farmer	yes	53	77	59	43
	no	44	22	31	34
	don't know	2	1	10	23
… drying	yes	12	66	30	46
	no	87	33	62	35
	don't know	1	2	8	19
… cleaning	yes	80	91	55	51
	no	20	8	44	31
	don't know	0	1	1	17
… packaging/crating	yes	78	84	5	30
	no	18	15	84	43
	don't know	4	1	11	26
… grading	yes	92	92	45	51
	no	8	7	45	28
	don't know	0	1	10	21
… fumigating	yes	10	48	28	12
	no	74	40	60	55
	don't know	16	12	11	33
… cold storage	yes	23	69	10	14
	no	71	29	79	53
	don't know	6	1	11	37
… certification	yes	17	55	3	15
	no	70	35	86	49
	don't know	12	10	11	35

Table 12. Determinants of producer prices

		Maize		Potato		Tomato		Mango		Turmeric		All products pooled	
	Unit	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
Quantity sold	log(kg)	-0.012	-1.170	-0.031	**-2.140**	-0.005	-0.390	-0.036	**-1.810**	-0.083	-0.910	-0.048	**-5.960**
Crop attributes													
Product was harvested by farmer	yes=1	-0.153	**-1.750**	-0.077	-1.350	0.078	1.130	0.283	**4.850**	-0.766	-1.490	0.013	0.400
Product was milled	yes=1	0.076	1.600	-	-	-	-	-	-	-0.024	-0.110		
Product was dried	yes=1	0.055	1.310	-	-	-	-	-0.052	-0.300	1.047	**3.520**	0.323	**7.440**
Product was graded	yes=1	0.093	**1.810**	0.046	1.240	-0.024	-0.390	0.020	0.350	0.210	1.030	0.061	**2.500**
Product was packed	yes=1	0.017	0.670	0.016	0.380	0.025	0.530	-0.044	-0.670	-0.071	-0.300	0.036	1.490
Product was fumigated	yes=1	-0.223	-1.330	-0.002	-0.020	-0.088	-0.820	0.071	1.010	0.107	0.370	0.271	**5.160**
Product was washed	yes=1	-	-	0.007	0.070	-0.115	-1.640	0.248	**2.600**	0.331	0.730	-0.018	-0.290
Buyer dummies (omitted category is consumer)													
Buyer is trader	yes=1	-0.025	-0.420	-0.039	-0.780	-0.022	-0.430	-0.038	-0.500	0.126	0.260	-0.042	-1.400
Buyer is commission agent	yes=1	-0.076	-0.910	-0.029	-0.460	-0.054	-0.860	-0.011	-0.130	0.785	1.140	0.078	**2.130**
Buyer is other	yes=1	-0.039	-0.580	-0.104	-0.560	-0.199	-1.060	-0.239	-1.420	0.569	0.920	0.289	**3.510**
Place of sales (omitted category is at the farmgate)													
Contract farming	yes=1	0.086	0.820	-0.275	**-1.840**	-0.241	**-2.790**	-0.051	-0.570	-0.599	-1.420	0.013	0.240
Regulated market (RMC)	yes=1	0.057	1.330	-0.060	-1.040	0.158	**2.600**	-0.133	-1.300	0.275	0.700	0.055	1.610
Unregulated wholesale market	yes=1	0.022	0.420	-0.107	-1.760	0.104	**1.940**	-0.207	**-3.370**	0.211	0.720	0.007	0.230
Village market	yes=1	0.037	0.660	0.034	0.450	0.027	0.280	-0.084	-0.730	0.134	0.630	0.099	**2.180**
Other	yes=1	0.033	0.350	0.133	1.230	0.244	**2.520**	-0.172	-1.540	-0.138	-0.300	0.060	1.180
Time of payment dummies (omitted category is payment before sale)													
Payment at sale	yes=1	0.081	1.250	0.080	0.980	0.000	0.000	0.034	0.310	0.112	0.380	0.007	0.130
Payment after sale	yes=1	0.111	1.480	0.047	0.550	0.191	**1.920**	-0.092	-0.790	0.200	0.460	0.002	0.030
Monthly dummies		included but not shown											
State dummies		included but not shown											
Number of observations		400		540		846		805		181		2802	
R-squared		0.32		0.64		0.30		0.61		0.72		0.40	
Root MSE		0.19		0.30		0.40		0.51		0.66		0.52	

*variety dummies (or product dummies in the case of the pooled regression) and intercept included but not shown due to space restrictions

(median regression; dependent variable =log(producer price per kg))