Whither Quality? Incentives in the Sugarcane Market in Pakistan

Farooq Naseer[1]

Preliminary. Comments welcome.

Version: November, 2005

[1]I am extremely grateful to Professors Michael Boozer, Robert Evenson, and Christopher Udry for their advice and support. This paper also benefitted from the discussions I had with Asim Khwaja, Steve Nafziger, Siddharth Sharma and Tavneet Suri as well as comments made by participants at Yale University seminars. I thank Robert Knapp (USDA) and Ghazala Mansuri (World Bank) for providing the data. I would also like to thank the management and staff at Shakarganj Sugar Mills and JDW Mills for answering my many questions about the mill process. The usual disclaimer applies.

Abstract

The world market in sugar has become increasingly competitive over the years. However, the sugar industry in Pakistan continues to suffer from low productivity, requiring government protection from cheap sugar imports. Existing research points to a failure of the allied sugarcane market which does not *explicitly* reward high quality cane farmers. However, that argument does not account for the informal premiums that may still be applied to encourage better quality. Using cross-sectional household data from a recently concluded survey, this paper is the first to examine returns to sugarcane quality for a farm household. I study two key outcome variables for a farm household: price received on the market and delay in final payment settlement. I find that the market provides no returns to the use of quality-enhancing inputs. Secondly, despite the presence of substantial mill effects in payment lags, we observe that only a few households ($< 11\%$) switch mills over time indicating frictions in the market. We conclude that the evidence is consistent with a model of coordination failure between agriculture research and processing industry, rather than inadequate control rights for mills over sugarcane.

1 Introduction

Pakistan is the 7th largest producer of sugarcane in the world. The sugar industry in Pakistan, which is the primary consumer of sugarcane crop, is the second largest manufacturing industry in the country. It accounts for 8.5% of value added and 10.7% of employment, respectively, in the large-scale manufacturing sector. It comprises of 76 private sugar mills that have a combined production capacity upwards of 5.5 million tons. But the performance of this industry is not impressive. A study of Pakistan sugar industry carried out by National Development Finance Corporation (NDFC) in 2000 categorized 70% of its outstanding debt as "stuck-up".[1] Over the past 5 years, the number of sugar mills listed on the Karachi Stock Exchange has dropped from 41 to 21, while 7 of those still listed have had their shares trading below par. Furthermore, in spite of having massive processing capacity, Pakistan is not a major exporter of sugar on the world market where it loses out to other low cost producers.[2]

It is widely believed that the problems facing Pakistan sugar industry are caused by its relatively low productivity as indicated by a comparison of its rate of sugar recovery with other countries in the world (see Table 1). The recovery rate, or equivalently a mill's productivity per unit of cane input, is determined primarily by the quality of locally produced sugarcane. In addition, simple calculations show that even a 1% increase in the recovery rate implies a change in mill's profits big enough to turn around some of the sick units.[3]

The quality of sugarcane is defined as the amount of recoverable sugar contained per unit of sugarcane. The argument that cane quality is much lower in Pakistan than its potential is relatively old and figures prominently in every analysis of the market. For instance, 'National sugarcane yield for the past one decade has been in the range of 39 to 47 tons per hectare...yields range can be raised...to 90-110 tons per hectare...Likewise, sugar recovery can be improved from the low level of 8.7% to 10-11% by sucrose enrichment in sugarcane.'[4] The above statement, based on agronomy of the sugarcane plant, reflects

[1] sic., cited in SPDC report (2002, p. 9). The term refers to the proportion of total outstanding debt owed by the industry to the non-bank financial sector, on which it was considered likely to default.

[2] See Table 1 for a comparison with major cane sugar producers in the international market. The rankings are based on cross-country data obtained from the Food and Agriculture Statistics division at USDA.

[3] A rough calculation, using typical sugar price and production data, indicates that a percentage point increase in recovery rate implies a sales increase of Rs. 50 million.

[4] Source: PSMA-Sindh Zone Annual Report 2001, pp. 23-24 ('sucrose' is an alternative word for sugar). A similar view was expressed by Mr. Shifaat Zaidi, President of Pakistan Society of Sugar Technologists, during the author's meeting with him in Karachi, January 2003.

the common belief that sugar yield in Pakistan can be improved further. Such proposals generally do not mention the role of mill technology in improving productivity. The reason is that most mills in Pakistan use a standard best-practice technology, of similar make and build, which is unlikely to explain the observed variation in productivity across mills.[5] However, there is considerable debate about how to bring about such improvements and whether it is possible at all to increase quality without changing the existing market structure.

In the face of persistent performance issues, mills have historically focused their lobbying efforts on greater control or, at least, supervision over a grower's farming decisions. The 2001 annual report of the industry lobby, Pakistan Sugar Mills' Association (PSMA), mentioned a proposal made by industry representatives to government policymakers in which the 'pivotal point... was to establish "development zones" with the sugar mills as model farming areas with incentives to the farmers and the millers'.[6] But such proposals are usually deemed retrogressive given the liberalization reform that was undertaken several years ago (see section 2). More significantly, as I argue in this paper, simply changing the property rights in the market may not bring about sustained improvements in quality. In general, such simplistic solutions for the problem reveal a protectionist view of the market which may be increasingly out of sync with developments in global sugar markets.[7]

Existing independent research on this subject has come up with a few policy recommendations, too. One thing that has puzzled many researchers is that the mills seem to provide little incentives to cane growers for quality investment, despite the universally recognized need for quality improvement. In this respect, it is instructive to read the laundry list of proposals put together by SPDC Report (2002), which includes *inter alia* the suggestion that mills make quality-contingent payments to its growers. So far, little progress has been made in this direction.

In this paper, I re-examine this puzzle bringing together relevant insights from economic theory and agronomy literature to address this very important policy question. Moreover, unlike prior research on this issue, I have access to household-level survey data on sugarcane production as well as market transactions. I use this data to rigorously test the claim that, in practice, mills might be able to adjust prices so as to provide farmers with quality incentives. I show that, despite some anecdotal evidence to the contrary, farmers receive

[5]For illustration, I correlate a mill's recovery rate with its age (a measure of capital vintage) and find it to be 0.10.

[6]PSMA Annual Report 2001, pp. 10-11.

[7]Just this year, the WTO ruled that export of subsidized sugar by the EU was illegal. See "European sugar subsidies ruled illegal", http://www.guardian.co.uk/globalisation/story/0,7369,1472941,00.html

no incentives for investment in quality and conclude that the sugarcane industry in Pakistan will continue to struggle unless the market moves to a new equilibrium where mills make such incentive payments.

The rest of this paper is organized as follows. Section 2 provides more background information by reviewing the existing research on this problem. In section 2.1, I review the agronomy literature on sugarcane which eventually guides the empirical specification. Section 2.2 reviews the relevant economic literature to provide a conceptual framework and formulate an empirical strategy. Section 3 provides a description of the data and section 4 discusses the model and results. Section 5 concludes.

2 Background

The problems facing sugar mills have inevitably affected the suppliers of their raw material, viz. the sugarcane farmers. Every year, numerous reports appear in the local media regarding disputes between mills and cane growers whereby the former are accused of delaying the start of crushing season, not making full payments on time and a general disregard for government regulations. The sugar mills, for their part, accuse the government of ad-hoc and unnecessary interference in the markets and complain that the growers do not produce good quality sugarcane. Sometimes, these disputes lead to civil unrest and organized protest with each party asking the government to intervene on its behalf. But thus far no adequate solution has been found to these problems.[8]

A sugar milling plant operates for a 4-month production cycle each year, wherein the mill purchases sugarcane from independent cane growers from surrounding agricultural areas. Almost all sugar mills in Pakistan are registered private companies and there is no vertical integration of processing mills and cane suppliers. As such, all market participants are free to choose their trade partners.[9] As might be expected, there is a large disparity between the size of a mill and its typical farmer-suppliers. A cane farmer, assuming average farm size and cane yield, produces nearly 50 tons of sugarcane in a year whereas the capacity of a mill, on average, is nearly 5000 tons of cane crushed *per day* during the crushing season.[10]

Historically, sugar mills all over the world played an active role in developing cane

[8]Source: Daily *Dawn*, various issues.

[9] This was not always the case, however. Prior to 1987, government regulation required virtually all farmers to sell their cane to the nearest mill thereby setting up local monopsonies. Since then, the market has been liberalized with many new firms allowed to enter.

[10]Author's calculation. Data Source: Pakistan Census of Agriculture (2000) and SPDC Report (2002).

farming and transport infrastructure upon the introduction of modern milling technology.[11] To undertake such long-term investments, it helped that mills enjoyed strong control over surrounding cane farms. Much the same way, sugar mills in Pakistan were initially granted exclusive exchange rights over farmers located within a certain perimeter around the mill (called that mill's 'zone').

But the market structure was changed as a result of the liberalization reform that took place in 1987. As part of this reform, farmers were freed from the obligation to sell to the closest mill (in order to provide market discipline against any abuse of mills' monopoly power). This re-definition of property rights was accompanied by a loosening of government controls on the entry of new sugar mills in the existing cane growing regions. As a result, there was a massive surge of investment, in the form of new sugar mills, in 1990s. Indeed, the size of the sugar industry has nearly doubled over the years; today there are 76 registered sugar mills as opposed to 43 mills by 1987.

Nowadays, the old zone-*bandi* system with its exclusive sales restrictions, is presented as a solution for the problem of low cane quality.[12] In a liberalized market, without such property rights, it is argued that a mill would tend to under-provide quality related infrastructure as undertaking such costs make it open to opportunistic exploitation from the farmers. In other words, having benefited from improved seeds or extension services, a sugarcane farmer might then behave opportunistically at the time of harvest by selling the crop to a rival mill (for a better price). But as we show in this paper, sugar mills still retain significant control over their farmer-suppliers.[13]

This raises an important question as to whether mills provide farmers quality incentives so that they may choose their production inputs in order to deliver high quality raw material (given existing technology). It turns out that the market currently makes payments on the basis of crop weight rather than its sugar content. Payment on the basis of quality is desirable though difficult, as sugarcane quality is multi-dimensional and much harder to measure accurately. In a continuous processing plant where an individual farmer is minuscule compared to the daily needs of the mill, the only feasible way to measure individual shipment's quality is to do so before processing. Even though it is technologically possible

[11] See Dye (1998) for a historical analysis of early Cuban sugar industry.

[12] To be fair, PSMA (2001) seems to be advocating model farms rather than monopoly zones but a lot of people are, in general, wary of the eventual outcome. See, for instance, [25].

[13] Even though farmers can transport their cane to whichever mill they choose, the actual competition for cane supply is limited by the government regulation that allows only licensed individuals (usually mill agents) to set up a weighing scale close to cane farms in a village. That could explain why we do not observe much turnover in mill-farmer relations in the data. See section 4 for details.

to do so, the methods presently used for quality measurement by sugar mills in Pakistan make that virtually impossible. Currently, the only reliable way to measure quality is by conducting laboratory tests on samples taken from individual cane loads. The process is too slow and cumbersome (in terms of staff and logistical requirements) to be of any general use and does not seem to be used in any systematic fashion.[14]

In a way, it is easy to fault market liberalization for the low quality of sugarcane. If one were to look at private mills in the Indian state of U.P., it would indeed appear to be the case. The mills in U.P. still operate under zone restrictions and return an average recovery rate of 9.83% as opposed to an average recovery of 8.74% for Pakistan. But that comparison masks the fact that U.P. is likely to be more comparable with the province of Sindh (avg. recovery: 9.32%) than Punjab due to its location close to the tropical belt.[15] We will return to this topic in the following section when we look at the agronomy literature on sugarcane carefully to identify various factors associated with cane quality.

2.1 Sugarcane Agronomy

> *'The discrepancy between the efficiency in the factory and in the field is obvious... It seems as if the scale where the cane is weighed before entering the factory, forms a boundary between low and high efficiency.'* Van Dillewijn [28], p. xxii.

Sugarcane is a tropical crop and as such needs high temperature and moisture environment for ideal conditions in the initial growth phase. But as it nears maturity, the plant's physiology requires low external temperature and moisture in order to divert the produced sugars away from growth and towards storage. Pakistan is located in a climatic zone where the summer is hot and rainy while the winters are generally mild and dry. Therefore, it makes sense that sugarcane cropping calendar has evolved such that harvest takes place during the winter months of November to March after the cane plant has ripened.

Besides these environmental factors, the quality of sugarcane is influenced heavily by the amount of nutrients available in the soil during growth. Controlling for soil fertility, the availability of nutrients in turn depends on the amount of fertilizer used by the farmer as well as the choice between various fertilizers, each of which is said to have a unique

[14] The Government of Sindh requires mills to pay farmers a premium based on *average* quality, a figure which is routinely computed by the mills. But the mills have challenged this policy in courts. Such a pricing scheme, if ever implemented, will have little economic value.

[15] Interestingly, a report [13] submitted to the Indian parliament in 2003 looked at sick industrial units in the Indian sugar industry and identified low cane quality as a likely culprit, among other things.

impact on sucrose accumulation process.[16] If farmers have appropriate incentives on the market, we would expect them to optimally choose fertilizer on their cane plots in order to maximize sugar yield.[17]

The amount of recoverable sugar in a sugarcane plant also depends on such factors as the presence of extraneous waste, the degree of mechanical handling of crop and the length of time interval between cane harvest and crushing. This last factor is due to the fact that sugarcane is extremely perishable and mills generally aim at crushing all of the harvested crop within a maximum of two days, post-harvest. This is one of the oldest known facts about sugarcane, which helps explain the need for improved transport infrastructure and the institution of exclusive monopoly rights during the early days of modern sugar industry.

Last but not the least, sugar yield also depends on the technological innovation in the development of new sugarcane varieties. Under careful plant breeding, such plant attributes like sugar yield as well as resistance to disease and drought can be manipulated to yield commercial advantage. The quote at the beginning of this section was taken from a book on the science of sugarcane plant published in 1952. Since that time, many countries in the world have made strides to close the gap between agriculture research and farming practice. But in the case of Pakistan, the gap between potential sugar yield and the actual yield is still quite large.[18] As Byerlee [5] points out in the case of cereal crops, the additional improvement in sugar yield is likely to come through a strengthening of agricultural research in the country as well as a number of relatively small and incremental changes in farm management. We now look briefly at the existing sugar research programs in the country.

Much of the agricultural research being done in Pakistan is adaptive in nature. Sugarcane is no exception. Of the 76 private sugar mills in the industry, a couple are known to have active plant breeding programs. Besides, there are government research stations in Faisalabad and Mardan. Local research stations import plant germplasm from foreign sources and attempt to experimentally cross-breed it to develop varieties suitable for local conditions. Sugarcane researchers occasionally meet each other at seminars or conferences but there is a general lack of coordination between the activities of private sector and pub-

[16]See Humbert [14], Ch. IV. In brief, the literature reviewed tends to suggest that a high concentration of nitrogen in soil near harvest is detrimental for sugarcane quality whereas high levels of phosphate and potash are helpful.

[17]This assumes that there is no ambiguity about the optimal amount of fertilizer needed and uniform soil types. I feel justified in maintaining the former assumption as there has been no recent change in farming technology for sugarcane. The latter is a simplifying assumption which will be relaxed when we do empirical analysis.

[18]See, for instance, footnote 4.

licly funded research programs. In comparison with Indian sugarcane research program, it can be concluded that the output of sugarcane research programs in the country is seriously lacking and has considerable scope for improvement.[19]

2.2 Economics of Sugar Yield

One of the oft-cited research analyses about Pakistan sugar industry was Appleyard's (1987) claim that Pakistan had no comparative advantage in producing sugarcane; hence implying that the sugar industry was liable to fail without government protection.[20] His report computed domestic resource cost coefficients for growing sugarcane by valuing the inputs and output at their border prices. But the methodology used for the study is sensitive to exchange rate fluctuations and economic pricing of all inputs like pesticides, fertilizer etc. which tend to be used more intensively for some other crops, like cotton, relative to sugarcane.

Yet as the discussion in the sections above demonstrates, there is clearly a room for substantial productivity improvement in this sector. Proposals that rely on a re-definition of property (or control) rights ignore the fact that higher cane quality can be achieved through a number of ways, all of which require the farmer to exert more effort or incur a greater cost through, for instance, better crop management or appropriate fertilizer application. In the extreme case where a mill bought all the surrounding land and decreed the use of only the best farming methods, it might gain maximum control over the choice of seed type and inputs but would still not be able to overcome the information asymmetry regarding the amount of effort put in by the vast cadres of its farm workers.

Thus, there is a fundamental incentive problem in the market which lies at the heart of low cane quality, viz. the incentives faced by an individual cane farmer.[21] If we assume that a sugar mill acts as a (local) monopsony dealing with a large number of identical farmers exerting unobservable effort on their cane farms. As mentioned in the review of agronomy literature above, sugarcane quality is directly related to this effort. In a situation like this, assuming quality can be observed (imperfectly), it makes sense for a mill to give farmers high-powered incentives by making payments contingent on their crop's quality such that

[19] See [13].

[20] This is a general point noted by Mookherjee (1999) in the case of such agro-processing industries where the raw material is extremely perishable. The processing firm is then dependent on local supplies, naturally shifting a comparative advantage in crop production to a comparative advantage in processing.

[21] A fact that is supported by the reported failure of the mills to eliminate some of the bulkier, low quality varieties of sugarcane from circulation even with government's assistance.

they exert optimal effort despite asymmetric information.[22]

This would certainly help improve the farming techniques used with existing crop varieties. An equally important component of a sustained productivity improvement must come through the development of high-yielding sugarcane varieties. However, as sugarcane research infrastructure is a public good with high fixed costs, it is unlikely that a few private mills can make an impact on their own. Crucially, any research program includes in its clients farmers as well as mills. Therefore, for such a plant breeding program to succeed, it must take account of farmers' priorities and incentives.

Currently, the cane farmers have no stake in sugarcane quality. As noted in the section above, one constraint is technological as mills currently do not have the means to measure quality very precisely. Such a technology *is* available, though, and is currently being used at places elsewhere in the world, like Australia and Brazil. The real puzzle is why no mill has so far invested in such a technology considering its benefits towards resolving long-standing quality issues.

The reluctance to adopt new technology, together with a lack of a comprehensive plant research and dissemination infrastructure, points to a possible coordination failure in the market whereby the industry is stuck in a bad equilibrium with no mill willing to make the necessary investment. The set up is analogous to a model with inter-sectoral complementarities described in Bardhan and Udry (1999). Multiple equilibria arise in this model due to infrastructure requirements of the new technology, which can not be provided unilaterally by a mill, given large fixed costs of its provision, even though it is collectively affordable (in addition to being socially optimal).[23]

Thus, it is entirely plausible that the new quality measurement technology does not get adopted by any sugar mill unless the entire industry adopts it, in addition to sharing the provision of agriculture research infrastructure, because there is little point in quality measurement unless there is adequate research and extension to accompany quality incentives. If true, the model has a clear policy recommendation. The government should encourage mills to invest in a technology that allows them to make quality-contingent payments in the market. Furthermore, the government should facilitate a partnership between public and private research organizations to encourage research and its wider dissemination.

The importance of providing quality incentives to individual farmers has been empha-

[22]Refer to Salanié [23]. We come back to the degree of observability of individual cane load's quality in the last two paragraphs of this section to develop a testable hypothesis.

[23]The model is due to Murphy, et al. (1989). See Ch. 16 in [3] for a simpler exposition.

sized before.[24] I have talked to a number of mill executives and they seem to share the belief that market prices for sugarcane are adequately linked to quality. The claim is that mill's technical staff is always present at the time of cane unloading at the factory to determine whether the sugarcane is of certain minimum quality grade. Therefore, if mill staff observes sugarcane that shows signs of nutrient stress, the person on duty has the authority to assess a penalty to that farmer thereby lowering the net price paid.[25]

This price adjustment, which takes place on the basis of visual observation, coupled with lab testing, is likely to be quite a noisy indicator of sugarcane quality.[26] But if we believe the mills' claim that the final price paid to a cane farmer has a quality component, we would expect to find the price distribution to be systematically (and positively) related to quality-enhancing inputs, like fertilizer intensity and access to water. The empirical section of this paper presents a rigorous test of this hypothesis.

3 Data and Descriptive Statistics

The data used for this paper come from second round of the Pakistan Rural Household Survey (PRHS-II) conducted in 2004. The survey covered randomly sampled households in two most populous provinces in the country, Punjab and Sindh.[27] Two of the most heavily sampled districts in the survey, Badin and Faisalabad, also tend to have the greatest concentration of sugarcane farms. For this paper, I will use data on sugarcane growing households in PRHS-II located in the cane rich regions of our sampled area.

The survey asked each farm household detailed questions about production and inputs for the last agricultural season. In addition, for the specific subset of households relevant for our research, we also have detailed data on the transactions made on the sugarcane market over the last 3 years. Each household was asked to identify all the buyers of its sugarcane crop over the last three seasons along with the mill's distance from their farm. Then, for each mill and year, additional questions were asked regarding quantity sold, price received, time of sales, and length of delays (if any) before the final payment was received.

[24] See SPDC Report [25], p.11.

[25] Of course, this does not preclude other kinds of price manipulation in the market. Mookherjee (2004) notes various methods observed by researchers in the context of Indian sugar industry.

[26] But note that the agronomy literature supports the possibility that trained staff can visually sort the sugarcane into different grades of quality. Please refer to Figure 76 in Humbert [14], p. 132, in addition to relevant sections of Ch. IV.

[27] Although some of the households and districts were purposively sampled in the first round of the survey, the overall survey was designed to be broadly representative of the two provinces. See Mansuri and Jacoby (2005, manuscript online). Together these two provinces constitute more than 87% of the area under sugarcane in Pakistan (Ag Census, 2000).

Moreover, I use industry and mill-specific data available from the annual reports published by Pakistan Sugar Mills' Association besides referring to relevant statistics collected from a variety of secondary sources in SPDC report (2002) on the sugar industry.

Table 2 gives the summary statistics for some of the key variables used in this analysis. Overall 189 households, constituting nearly 12% of the overall PRHS-II sample, reported growing sugarcane on a household operated plot in 2003-04. The table also reports retrospective information on market transactions from these households. After dropping those households which did not have all the requisite information, we are left with 126 households having full production and sales information in 2003-04.

As panel A in Table 2 indicates, 25 sugar mills reportedly bought sugarcane from our sample households. Given that average mill size in Pakistan is 4000 tons cane crushing capacity per day, it is interesting to note that even the largest cane farm in our sample is quite small compared to the *daily* cane requirements of a sugar mill run at full capacity during the grinding season.

We see considerable variation in the fertilizer usage across farmers, although nitrogenous fertilizer tends to be used in larger quantities than Phosphate. Similarly there is much variation in household per capita expenditures and plot features, with roughly half the plots having good soil types and one-half located in a favorable location with better access to irrigation water.

In terms of market transactions, the table shows a decline in the average price paid for sugarcane as well as the mean payment delay over the last three years. We will examine later whether this variation in price is driven entirely by year effects or other mill and farmer attributes. Even within a year, there is considerable variation in prices and delays, which is not surprising given the fact that there is no uniform contract in the market and price is determined by a variety of factors as outlined elsewhere in the paper. Also notable is the proportion of sales made in the last part of grinding season. This fraction has increased over the last 3 years, reflecting a gradual onward shift in the start of crushing season.

It may also be interesting to note that while liberalization has theoretically granted a farmer lots of freedom to choose the mill it wants to deal with, in practice, there appear to be a large switching cost involved with such decisions as only about 11% of the households are seen to switch from one mill to another, despite the fact that there are significant mill effects in payments.

4 Empirical Model and Results

In light of our review of the agronomy literature on sugarcane, one can posit a cane quality production function that takes as its arguments: inputs used in farm production like water (x_w) and fertilizer (x_f), as well as soil fertility (x_s). Denote the cane quality output (i.e. sugar yield) as q and the production function as $g(\cdot)$. The sugarcane quality is then given by:

$$q = g(x_f, x_w, x_s)$$

where $\frac{\partial q}{\partial x_i} > 0$ for $i \in w, f, s$.[28]

Now if the mills were able to measure quality reasonably well to give an individual farmer a return based on his or her sugar yield, we will expect market price and sugar yield to be positively related. Therefore, given the partial derivative of quality with respect to inputs, we would expect price and production inputs to be positively related as well. As we do not observe sugar yield in our data, we can use a linearized form of the quality production function to test for market return to investment in cane quality.

Algebraically, our main empirical specification is as follows:

$$P_{ijt} = \beta_0 + \beta_{\mathbf{1}} \mathbf{Q_{it}} + \beta_{\mathbf{2}}\, \mathbf{X_{ijt}} + \beta_3 \gamma_j + village_i + \epsilon_{ijt}$$

where, P_{ijt} is the price (for a unit weight of) cane sold by household i to mill j in period t, $\mathbf{Q_{it}}$ is a vector of quality-enhancing inputs and $\mathbf{X_{ijt}}$ captures other household or firm-specific controls that might matter for returns on the market, for instance, distance from the mill, time of sales during a crushing season, and household demographics. γ_j captures the mill fixed effect and village$_i$ is village effect.

Thus, controlling for village- and mill-invariant factors, we want to find out whether there is any return to quality-enhancing inputs on the sugarcane market. The underlying empirical question is analogous to the one posed in the literature on returns to human capital. The analysis, in this case, will tell us whether individual farmers have an incentive in the current market structure to improve sugarcane quality. As stated above, we can think of $\mathbf{Q_{it}}$ as a linearized version of quality production function and estimate the above equation.

In order to identify this equation, we need some exogenous source of variation and will use fertilizer prices as instrumental variables. The other farm attributes like plot's location

[28]In this specification, we ignore the role played by sugarcane variety in determining quality as IFPRI data on Pakistan shows little variation across farmers, and within the two provinces, in terms of the seed variety used. Refer to Table XX.

on water channel and soil quality are assumed to be exogenous to cane market prices. In addition to these instruments, our identification strategy relies on the use of village (and mill) fixed effects to control for geographic and firm heterogeneity. One could think that area planted is also endogenous to price. But sugarcane is not planted every year as farmers generally obtain multiple harvests from the same crop planting thereby reducing its dependence on any given year's price.

Table 3 gives reduced form estimates of our price regression. Columns (1) and (3) present an over-specified, encompassing model which is then tested to yield a parsimonious specification reported in (2) and (4). The equation decomposes the total fertilizer usage further into nitrogenous and phosphatic fertilizers, each of whom plays a distinct role in sucrose accumulation process within sugarcane such that its deficiency leads to identifiable chemical and visual deficiencies in a mature plant.[29] Equation (1) also breaks down a potential effect of sales timing on price by including the interaction terms between time of sale and distance. These terms are included to distinguish between a pure timing effect from one that arises from mills having to purchase cane from farther areas in the latter half of the season. Also included are dummy variables indicating a better plot location vis-a-vis irrigation water availability as well as a better soil type.[30] In particular, notice the variable on area planted with sugarcane. Since the wealth of rural agricultural households is mostly landed, this variable is likely to capture any advantages accruing from having more resources (through perhaps a better access to the latest farming technology and market information). Thus, one would expect this coefficient to be positive *apriori*.

In order to find a well-specified and parsimonious model, we first estimate the OLS model in column (1) of Table 3 that includes all the variables plausibly linked with market price. Then we dropped those variables that were jointly insignificant and conceptually unrelated to the market dynamics.[31] The resulting specification is presented in column (2). But the OLS specification does not account for the fact that sugarcane markets are geographically limited and hence market outcomes are likely to be determined by local conditions. Therefore, columns (3) and (4) estimate the respective OLS models with village fixed effects. Not surprisingly, the village effect explains a large proportion of the price

[29] See Figure 1 for an example of such visual symptoms of potash deficiency. This stark example is good for illustrative purposes. In much the same way, a lack of nitrogen or phosphate, the two most commonly used fertilizers in Pakistan, is known to cause distinct symptoms.

[30] For a complete description of the data, refer to the appendix.

[31] The F-test for the joint significance of dropped variables: nitrogen use, saletime-distance interaction, plot location on the irrigation channel and access to perennial irrigation; was $F(5,105) = 1.26$ with a p-value of 0.286.

variation as shown by the substantial improvement in R^2.

The negative coefficient estimate for farm size in the OLS models is puzzling, although it disappears once we include village fixed effects. Moreover, we do not find any correlation of price with long-term exchange relations in the market as may be expected in simpler models of reputation for farmers' quality.

Overall, the evidence presented in Table 3 indicates that, controlling for village characteristics, those households which get a higher price on the market tend to make their sales in the later parts of the crushing season. The reduced form also shows a positive correlation between price and household's distance from the mill. This could be due to strategic competition over households located farther from the mill or transport premiums given to those households which use their own transport for supplying cane. We discuss this possibility of strategic competition over cane supply after presenting the IV estimates below.

Based on this evidence, market prices are not correlated with the intensity of input usage in sugarcane production. However, since the intensity of fertilizer use is a production choice, it is likely to be endogenous to the pricing mechanism in the market. Therefore, in order to identify this equation, we use community-level fertilizer prices as instruments for fertilizer input variables. Table 4 presents the IV estimates.

The results stay unchanged, viz. the only factors causing variation in price received by a household are those linked to geography and time of sales. Column (1) presents the instrumental variables model with village fixed effects. The village effects are jointly significant and the overall model provides a good fit for price distribution. Adding mill effects to this model in column (2) does not change much, except that distance effect seems to be soaked up by the mill effect. The mill effects themselves are, however, jointly insignificant. This might be explained by the fact that many villages in our sample (21 out of 29) supplied cane to a unique mill which makes it quite likely that the village effect accounts for the mill-specific effect as well.

Hence we find that despite the informal farmer-specific premia that mills apply to sugarcane price, there are no returns on the market to the use of quality-enhancing inputs. This result is robust to alternative specifications of the model and rejects the hypothesis that mills provide incentives to the cane farmers using the existing means at their disposal.

However, the price effect from timing of sales is quite large. Column (1) in Table 4 indicates that a farmer who is able to put off harvest until a later point in the season gets Rs. 3-4 per maund more than a farmer in the *same* village who sells it in the start of the season.[32] But we would like to look more closely at our data to see what gives rise to such a time-related premium in price. It could be an outcome from increased strategic competition later in the season between rival mills over remaining supplies of cane. Or else, it could also result from a deliberate incentive given by mills to the cane farmers in order for them to delay their cane harvest. In the former case, one would expect a greater turn-over in the market due to households choosing between competing mills. We will return to this issue when we look at the evidence for switching in our data below.

Another way to examine returns from late harvest is to ask whether such late sellers are being paid promptly. We look at the association between length of delay (or lag) in final payment and the time sales were made, controlling for various household and mill attributes. Table 5 presents some reduced form estimates on correlates of payment delays.[33] The first two columns report estimates from a linear model containing mill fixed effects (column (2) also contains village effects, in addition). A number of households in our sample reported receiving immediate full payment for their cane sales, leading to a point mass at zero for the observed delay distribution. The Tobit model in column (3) takes care of any bias resulting from such 'censoring' of the dependent variable. The Tobit model also allows for mill-level clustering of error terms by including a mill random effect.

It is notable that, apart from the location of sugarcane plot on the irrigation channel (i.e. the water course), no other variable appears to be consistently significant in each of the first two regressions. Depending on which model one looks at, either timing of sales or distance from the mill seems to matter for delays in payments. If one were to believe the point estimates reported in column (2), it appears that payment lag tends to be associated with mill-farmer distance in an inverted U-type relationship, attaining a maximum at a distance of 39.7 kilometers and declining thereafter.[34] This non-linear pattern in payment lags could be driven by the fact that mills find it infeasible to operate their normal payment cycle with farmers located farther away and must pay them on the spot (which is true for 52% of 19 such observations).

However, the distance variables drop out in the more robust Tobit specification. Instead, what re-appears is the positive association of late harvest with the length of payment lag

[32]This translates to a revenue increase of Rs. 6000-8000. Given the latest GNI figures for Pakistan, it is equivalent to the income an average Pakistani makes in 2-2.5 months.

[33]The reason we do not attempt to identify this regression is due to a lack of instruments and also because it is of secondary importance to our central question. It is clear that a lag in clearing farmers' dues is a perverse (and politically costly) way of creating any incentives and, more likely than not, is an outcome of unobserved mill productivity shocks.

[34]A total of 19 (or 15.1%) observations lie to the right of this maximum point.

reported in column (1). This positive correlation, while controlling for a range of other covariates including farm size and input usage, is a bit puzzling. It suggests that sales made in the last couple months of the crushing season, on average, tend to be associated with a 56 days longer delay in reaching final payment settlement as compared to sales made in the start of the season. Coupled with the result on prices (see Table 4), this would suggest that sugar mills tend to promise higher prices for late harvests but are unable to pay as promptly; thereby lowering the net price received (NPV) by a farmer in the late season. However, we would like to urge caution in interpreting these results because even though we control for mill random effects, it does not preclude our *timesale* variables from picking up an unobserved mill effect.[35]

Given these results, it will be interesting to look at the mill choice of farm households in the liberalized sugarcane market. Table 6 uses the expanded recall data on market transactions to estimate OLS and probit models for the correlates of a household's decision to switch from one mill to another. We use three alternative measures of switching. One obvious candidate in 3-year data is to check whether a household actually reports changing mills from one period to the next. The resulting estimates are reported in columns (1) and (2). However, such a variable fails to account for cases where the household might indicate its mill preference by persistently choosing to travel to a mill located farther away from the farm. This idea underlies the construction of switchD which is analyzed in columns (3) and (4). Finally, we can also define switching based on the sales decisions of other households in the same village. Since our sample is representative at the village level, we take the household's decision to sell to a mill that is not the primary buyer from its village as evidence of a switch.[36] All the estimated models use 2-year recall data from crushing seasons 2002-03 and 2003-04. The table reports marginal effects, corresponding to sample median values, for the non-linear probit models.

Overall the results from these reduced form switching regressions are mixed. For the first two measures of switching, columns (1) through (4), our estimates indicate that there are no significant correlates (in both statistical and economic terms) of a household's switching behavior. In fact, there were no switcher households in the province of Sindh according to *switchD* criterion.[37] This explains the negative coefficient on Sindh dummy in the OLS

[35]For instance, a less productive mill that faces high interest rates in the formal credit market (to the point of being effectively credit constrained) will face a worsening liquidity crisis as the season goes on due to increasing liabilities to cane farmers. The existence of such credit-constrained mills would then give rise to similar reduced form results.

[36]The notes to table 6 give precise definitions of these variables.

[37]It has to do with the fact that *switchD* was defined based on distance 'bins' rather than actual

regression in column (3) and also why the probit model estimation in column (4) dropped a large number of observations.

However, we do observe significant correlates of village-based switching measure in columns (5) and (6). Not surprisingly, Sindh dummy is negatively correlated with price. Moreover, we find that households are less likely to switch mills near the middle or end of a crushing season relative to its start. It is possible that the higher probability of switch in the beginning of season (Nov-Dec) reflects a decision by some cane farmers to clear their cane plot for next season's crop (usually wheat, which must be planted by end-November). Such a correlation can also be caused by distress sales in the beginning of season by those households that are credit-constrained. The latter possibility is further strengthened when read together with the price premium in later periods.[38]

5 Conclusion

The quality of sugarcane in Pakistan has a strongly negative impact on the productivity of domestic Sugar industry thereby adversely affecting its comparative advantage in the international market. So far, the industry has enjoyed a certain level of government protection. But this issue has gained prominence due to a rising global trend towards trade liberalization as well as improving bilateral relations with neighboring India, which has a massive low-cost sugar industry. Thus continued reliance on government protection is hazardous and might, in the long run, turn out to be counter-productive.

It is often claimed that mills in Pakistan apply informal premiums to cane prices (nominally set on the basis of weight) with a view to encourage better quality product. We test this hypothesis using data from a recently concluded household survey but we find no returns to cane growers from the use of quality-enhancing inputs. Moreover, using retrospective information on a household's trading partners on the market, we find that the markets are still highly segmented with mills enjoying monopoly power in their surrounding cane area as very few households are seen to switch from one mill to another despite strong mill effects in prices and payment delays.

These results indicate that the sugar mills should provide direct quality incentives to individual farmers in order to turn around industry's overall performance. I propose that

household-mill distance (in kilometers) which was not available for all possible pairings, only the ones actually observed in the data. Limited accuracy of the data thus constructed was recognized by only comparing the mills in different bins.

[38]Notice that we are unable to conclusively assert this given the fact that late sales also seem to be associated with longer delays in payments. The net price effect is therefore ambiguous.

the lack of such incentives in the existing market structure might have to do with a co-ordination failure in the market in the absence of an adequate research infrastructure to support substantial quality gains. The government should encourage agricultural research in this crop through a partnership between public and private research entities. It should also provide incentives for mills to adopt the latest technology for scientific measurement of quality and establish standards for a transparent quality payments mechanism which is acceptable to the sugarcane growers. It is only through active engagement of each stakeholder that the market can move to a better equilibrium.

Data Appendix

Agriculture Data Detailed primary data on inputs used and total output on sugarcane plots of households in our study was obtained from Pakistan Rural Household Survey-II. The survey also provided various features of sugarcane plots such as soil type, access to perennial irrigation and location on the water channel. The fertilizer input data was available according to the commonly used types of fertilizer; it was used to construct the intensity of nitrogen and phosphate use on a plot by using the standard industrial concentration of these elements in the named fertilizers. See, for instance,
http://www.simplot.com/agricultural/plant/urea_fert4600.cfm

Sugarcane Market Transactions The above survey instrument also collected retrospective information on household market transactions over a 3-year period from 2001 to 2004. The households were asked to identify the buyers of their crop on the market before being asked further questions about each market transaction. Thus we have household-mill-year level data on sugarcane sales, time of sale during the season, price received, credit advanced, distance to the buyer, as well as payment lag. The enumerators were explicitly trained by the author to define Price as the price per unit received at the point of sales, including any quality or transport premia. Payment lag was defined as the # of days elapsed between the time of sale and final settlement of dues for that transaction. The variable switch was defined based on the data from this section. However, since we did not have data on distance from the household to every potential mill in the market, *switchD* was defined in terms of categorized distance information obtained on the basis of a household's GPS coordinates.

Sugar Mills We have detailed information on the sugar mills in Pakistan based on secondary data sources and learned from qualitative interviews. PSMA Annual Reports, 2000-2004, provide aggregate as well as detailed mill-specific data on sugar production and recovery rates. SPDC Report on the sugar industry nicely put together current, as well as historical, information from various sources such as the Pakistan Census of Manufacturing Industries and Global Commodity Markets. Lastly, the Annual Report of Shakarganj Sugar Mills 2002 had details on the sugarcane research carried out by SSRI and the # of varieties at various stages of development.

Other sources of (secondary) data for this research include the following:

US Department of Agriculture Food and Agriculture Statistics division at USDA maintains an international database containing country-year level data on area planted with sugarcane, sugarcane production, amount of sugar manufactured, consumed and exported for all the major sugar producers over the last 10-15 years. This provided data used for Table 1.

Food and Agriculture Organization The FAO website has detailed description of issues and structure of the sugarcane markets in various parts of the world, especially Australia, Thailand and India. For instance, see [15]. All these studies provided much useful background information for this paper.

PSMA Online PSMA provided some useful information on its website, especially Government of Pakistan laws and regulations governing the operation of sugarcane markets in the country. See: www.psmaonline.com

References

[1] Alexander, A. 1973. *Sugarcane Physiology.* Amsterdam: Elsevier.

[2] Appleyard, D. 1987. *Comparative advantage of agricultural production systems and its policy implications in Pakistan.* FAO Economic and Social Development Paper No. 68. Rome: FAO.

[3] Bardhan, P. and C. Udry. 1999. *Development Microeconomics.* Cambridge: MIT Press.

[4] Biswas, B. 1988. *Agroclimatology of the Sugarcane Crop.* Geneva: World Meteorological Organization.

[5] Byerlee, D. 1989. "Technological Challenges in Asian Agriculture in the 1990s." In *Agricultural Development in the Third World*, 2^{nd} edition. Edited by Eicher, C. and J. Staatz. Baltimore: Johns Hopkins University Press.

[6] Das, S. and D. Mookherjee. 2004. "Ownership form and contractual inefficiency: Comparing performance of cooperatives and private factories in the Indian Sugar Industry." Mimeo. Department of Economics, Boston University.

[7] Deaton, A. 1997. *The Analysis of Household Surveys: A Microeconometric Approach to Development Policy.* Baltimore: Johns Hopkins University Press.

[8] Dye, A. 1998. *Cuban Sugar in the Age of Mass Production: Technology and the Economics of the Sugar Central, 1899-1929.* Stanford: Stanford University Press.

[9] Dye, A. 1998. "Why did Cuban cane growers lose autonomy? 1889-1929." In *Latin America and the World Economy Since 1800.* Edited by Coatsworth, J., and A. Taylor. Cambridge: Harvard University Press.

[10] Evenson, R. and Y. Kislev. 1975. *Agricultural Research and Productivity.* New Haven: Yale University Press.

[11] Faruqee, R (ed.). 1999. *Strategic Reforms for Agricultural Growth in Pakistan.* Washington: The World Bank.

[12] Government of India. 2000. *Cost of Cultivation of Principal Crops in India.* Delhi: Directorate of Economics and Statistics.

[13] Government of India. 2003. "Sick sugar industry and sugar development fund." Mimeo. Presented to Lok Sabha on 12/23/2003. Available online at: http://164.100.24.208/ls/committeeR/Food/27.pdf

[14] Humbert, R. 1968. *The Growing of Sugarcane.* Amsterdam: Elsevier.

[15] Kansal, S. 1997. "Factors determining Indian sugar production and its comparative advantage." Mimeo. Proceedings of the Fiji/FAO 1997 Asia Pacific Sugar Conference. Available online at: http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/005/X0513E/x0513e16.htm

[16] Martin, J., W. Leonard and D. Stamp. 1976. *Principles of Field Crop Production.* New York: Macmillan.

[17] Mookherjee, D. 1999. "Contractual constraints on firm performance in developing countries." Mimeo. Department of Economics, Boston University.

[18] Murphy, K., A. Shleifer and R. Vishny. 1989. "Industrialization and the big push." *Journal of Political Economy* 97(5): 1003-1026.

[19] National Fertilizer Development Center. 2000. *Fertilizer Use at Farm Level in Pakistan.* NFDC Publication No. 4/2000. Islamabad.

[20] North, D. 1990. *Institutions, Institutional Change and Economic Performance.* Cambridge: Cambridge University Press.

[21] PSMA Annual Report, various issues.

[22] Saini, G. 1979. *Farm Size, Resource Use Efficiency and Income Distribution: A Study in Indian Agriculture with special reference to Uttar Pradesh and Punjab.* Bombay: Allied Publishers.

[23] Salanié, B. 2000. *The Economics of Contracts: A Primer.* Cambridge: MIT Press.

[24] Schmitz, A., T. Spreen, W. Messina and C. Moss (eds.). 2002. *Sugar and Related Sweetener Markets: International Perspectives.* Wallingford: CABI Publishing.

[25] SPDC Report. 2002. "Key Issues in Pakistan's Sugar Sector." Mimeo. Karachi: Social Policy and Development Center.

[26] Sugar Mill (various) Annual Reports, various issues.

[27] Tirole, J. 1988. *The Theory of Industrial Organization.* Cambridge: MIT Press.

[28] Van Dillewijn, C. 1952. *Botany of Sugarcane.* Waltham: Chronica Botanica.

[29] Wooldridge, J. 2002. *Econometric Analysis of Cross Section and Panel Data.* Cambridge: MIT Press.

Table 1: Ranking of Major Sugarcane Producing Countries [+]

Countries	Sugarcane production '000 tons	Sugar production '000 tons	Sugar production Rank	Sugar yield* (%)	Sugar yield* Rank	Sugar exports '000 tons	Sugar exports Rank
Brazil	322070	21411	1	14.42	1	11821	1
India	222503	17724.8	2	10.84	11	466.8	9
China	81361	7934	3	9.65	23	262.4	14
Mexico	44840	5283.6	5	11.78	9	352.8	10
Thailand	43984	5684.4	4	10.63	15	3874.3	4
Australia	37601	5162.5	6	13.76	2	4063.8	3
Pakistan	36633	3532.4	7	8.76	28	191.8	19
Indonesia	26020	1832.6	13	7.04	32	3.4	33
United States	22651	3445.7	8	12.42	7	171.5	21
South Africa	20938	2609.2	10	12.51	5	1250.7	7

[+] Source: FAS, USDA. The table above reports ten largest countries in the World, sorted by sugarcane production. All the figures and rankings are based on data averaged over the 10-year period, 1996-2005.

* Sugar yield was computed as the percentage $\frac{\text{amount of sugar produced}}{\text{amount of sugarcane used in milling}} \times 100\%$.

Table 2: Summary Statistics on Cane Growing Households

A. General			
Number of districts	7		
Number of villages	32		
	2001-02	2002-03	2003-04
Number of households	94	113	126
Number of mills	19	20	25
B. Inputs and Cane Price	2003-04		
	Mean	Min	Max
Area under cane production (kanals)	26.9	3	128
Total cane produced (tons)	58.6	0	400
Nitrogen, fertilizer use intensity (kgs/kanals)	10.2	0	54.0
Phosphate, fertilizer use intensity (kgs/kanals)	3.62	0	21.6
Per-capita expenditure ('000 Rs.)	1.39	0.3	8.71
Whether good plot location	0.54	0	1
Whether good soil	0.52	0	1
Price in first part of the season, timesale==1	38.2	28	50
Price in second part of the season, timesale==2	38.6	25	50
Price in third part of the season, timesale==3	39.9	30	45
C. Market Transactions*	2001-02	2002-03	2003-04
Price at which sold (Rs./maund)	40.4	39.8	39.0
	[25, 70]	[28, 50]	[25, 50]
Quantity sold (tons)	60.2	63.5	57.0
	[4.8, 600]	[6, 800]	[4, 1400]
Payment delay (weeks)	4.89	4.90	3.74
	[0, 64.3]	[0, 52.1]	[0, 52.1]
Distance to buyer (kms)	16.6	17.9	18.1
	[2, 50]	[2, 80]	[2, 100]
Dummy variables (min 0, max 1):			
Whether sold in mid-season	0.48	0.45	0.43
Whether sold in end-season	0.25	0.28	0.30
Whether switched mill	–	0.11	0.07
Whether switched mill; *switchD*	0.03	0.03	0.05
Whether switched mill; *switchV*	0.20	0.22	0.24

Source: Pakistan Rural Household Survey-II.
* The mean of each non-categorical variable is listed at the top followed by [min, max] directly below.

Table 3: Price Regression: OLS and Village effects

Dependent Variable:	Sugarcane Price in 2003-04			
	OLS		FE	
	(1)	(2)	(3)	(4)
Fertilizer use, nitrogen	-0.008		-0.038	
	(-0.13)		(-1.11)	
Fertilizer use, phosphate	-0.045	-0.008	0.038	0.013
	(-0.39)	(-0.09)	(0.30)	(0.09)
Area under cane	-0.033*	-0.035*	-0.056	-0.041
	(-2.01)	(-2.37)	(-1.70)	(-1.37)
Distance from mill	0.042	-0.042	-0.146	-0.154
	(0.41)	(-1.01)	(-1.06)	(-1.30)
Distance squared	-0.000	0.000	0.005	0.005^{+}
	(-0.51)	(0.27)	(1.68)	(1.89)
timesale==2	1.717	0.368	1.866	2.481*
	(0.84)	(0.33)	(1.16)	(2.39)
timesale==3	2.692	1.485	3.631**	3.521**
	(1.34)	(1.47)	(2.82)	(4.52)
timesale==2 × distance	-0.075		0.037	
	(-1.01)		(0.84)	
timesale==3 × distance	-0.067		-0.003	
	(-0.93)		(-0.05)	
Same mill in the past?	-0.096	-0.032	-0.201	-0.134
	(-0.12)	(-0.04)	(-0.09)	(-0.06)
Good irrigation?	-3.969^{+}	0.021	-4.228	-0.323
	(-1.84)	(0.03)	(-1.16)	(-0.33)
Good location on Water course?	3.585*		3.367	
	(2.05)		(1.05)	
Perennial irrigation?	1.701		2.501	
	(1.31)		(1.27)	
Good soil?	-0.109	0.035	0.466	0.114
	(-0.11)	(0.04)	(0.48)	(0.12)
Constant	37.62**	38.80**	35.10**	36.80**
Village effects	No	No	Yes	Yes
p-value	0.000	0.000		0.000
R^2	0.209	0.168	0.651	0.635
N	126	126	126	126

Notes: 1. Other explanatory variables include household economic and demographic controls like # educated males, average consumption expenditure, ownership of bullocks & tractors; cane inputs like total fertilizer used etc. Of these, # educated males and bullock ownership had significant coefficients in OLS regressions but not in (3) and (4). The rest were estimated to be statistically no different from zero.

2. Columns (1) and (3) represent the initial, encompassing specification. We dropped those variables that were jointly insignificant in (1) from the specification in (2) and (4). See the results section for details.

3. Significance levels: ** Signficant at 1%, * 5%, $^{+}$ 10%; t-statistics robust to village-level clustering

Table 4: Price Regression: Mill and Village effects, with instruments

Dependent Variable:	Cane Price in 2003-04	
	FE-IV	FE-IV
	(1)	(2)
Total fertilizer used[1]	-0.089	0.172
	(-0.98)	(1.40)
Fertilizer use, phosphate[1]	0.673	0.574
	(1.37)	(1.27)
Area under cane	0.003	-0.083
	(0.09)	(-1.61)
Distance from mill	-0.161	-0.035
	(-1.09)	(-0.18)
Distance squared	0.006$^+$	-0.001
	(1.92)	(-0.39)
Same mill in the past?	0.096	-1.857
	(0.08)	(-0.89)
timesale==2	3.161**	3.650$^+$
	(2.61)	(1.82)
timesale==3	3.938**	5.248*
	(2.93)	(2.49)
Per capita consumption expenditure	0.000	-0.001
	(0.73)	(-0.92)
No. educated people in HH	-0.435	-0.273
	(-0.82)	(-0.45)
Good irrigation?	-0.134	-0.173
	(-0.13)	(-0.12)
Good soil?	0.683	0.178
	(0.65)	(0.13)
Constant	35.645**	33.015**
	(12.29)	(7.30)
Village effects?	Yes	Yes
Mill effects?	No	Yes
p-value	0.000	0.000
R^2		
N	124	124

Notes: 1. Fertilizer choice variables were instrumented. Instruments are cash and credit price of the most commonly used fertilizers: DAP, Urea.

2. Explanatory variables are the same as in final specification, columns (2) and (4), in Table 3 above. The effect of bullocks and tractor ownership on price was not significant and thus not reported due to space contraints. Two observations had to be dropped because of insufficient data on instruments.

3. Significance levels: ** Signficant at 1%, * 5%, $^+$ 10%; t-statistics reported in parentheses.

Table 5: Correlates of Payment Delay: Mill and Village effects

Dependent Variable:	Payment delay in 2003-04		
	FE		Tobit, RE
	(1)	(2)	(3)
Area under cane	-0.150	0.026	-0.403
	(-1.24)	(0.29)	(-1.52)
Distance from mill	0.762	3.80^{+}	1.199
	(1.19)	(1.80)	(1.21)
Distance squared	-0.006	-0.047^{+}	-0.001
	(-1.10)	(-1.77)	(-0.08)
Same mill in the past?	7.878	12.13	14.73
	(1.55)	(1.47)	(1.07)
timesale==2	8.287^{+}	1.636	33.41*
	(1.81)	(0.27)	(2.38)
timesale==3	25.53*	17.61	56.48**
	(2.11)	(1.26)	(3.35)
No. educated people in HH	3.754^{+}	3.376	2.363
	(1.99)	(1.28)	(0.69)
Avg per capita expenditure	0.001	-0.000	0.004
	(0.23)	(-0.16)	(0.80)
Good location on Water course?	13.40*	16.58*	10.04
	(2.07)	(2.08)	(0.94)
Fertilizer used, nitrogen	0.678	1.112	1.327
	(0.67)	(1.16)	(1.44)
Fertilizer used, phosphate	-0.581	0.581	-0.023
	(-0.73)	(0.33)	(-0.01)
Whether own tractor?	27.34	32.25	34.82**
	(1.26)	(1.23)	(3.43)
Mill effects	Yes	Yes	Yes
Village effects	No	Yes	No
p-value	0.000		0.001
R^2	0.886	0.923	
N	126	126	126

Notes: 1. The dependent variable, *payment delay*, measures the amount of time that passed after sale before sugarcane farmer received the final payment. Government regulation requires mills to pay all growers within 14 days of receiving their crop. In reality, we observe much longer payment lags. See Table 2.

2. Other explanatory variables include interaction of fertilizer use with distance and ownership of bullocks. None of the variables omitted were statistically significant.

3. Significance levels: ** Signficant at 1%, * 5%, $^{+}$ 10%; t-statistics robust to village-level clustering

Table 6: Switching Regression: OLS and Probit, (2002-04)

Dependent Variable:	switch		switchD		switchV	
	OLS	Probit	OLS	Probit	OLS	Probit
	(1)	(2)	(3)	(4)	(5)	(6)
Price last period	-0.004	-0.003	-0.000	-0.002	-0.003	-0.007
	(-1.06)	(-0.92)	(-0.19)	(-0.47)	(-0.66)	(-0.91)
Payment delay last period	-0.001	-0.000	-0.000	0.000	0.000	0.000
	(-1.39)	(-1.01)	(-0.14)	(0.07)	(0.43)	(0.25)
No. of mills $\leq$ 80 kms. away	0.011	0.008	-0.006	-0.011	0.012	0.018
	(0.59)	(0.50)	(-0.56)	(-0.51)	(0.50)	(0.52)
Per capita consumption expenditure	0.000^{+}	0.000	-0.000	-0.000	0.000	0.000
	(1.78)	(1.49)	(-1.20)	(-0.77)	(0.28)	(0.37)
Whether owned tractor	0.008	0.010	-0.026	-0.024	-0.001	-0.011
	(0.16)	(0.21)	(-0.88)	(-0.56)	(-0.01)	(-0.11)
Sindh Province	-0.013	-0.012	-0.077*		-0.248**	-0.340**
	(-0.24)	(-0.25)	(-2.52)		(-3.32)	(-3.37)
timesale==2	-0.027	-0.018	0.006	0.025	-0.219**	-0.285**
	(-0.50)	(-0.40)	(0.19)	(0.39)	(-3.01)	(-2.97)
timesale==3	-0.002	0.003	-0.012	0.002	-0.272**	-0.334**
	(-0.04)	(0.07)	(-0.36)	(0.04)	(-3.41)	(-3.29)
Year 2003-04	-0.065	-0.066	-0.001	-0.002	0.004	-0.003
	(-1.50)	(-1.23)	(-0.02)	(-0.04)	(0.07)	(-0.03)
Constant	0.213	–	0.136	–	0.576*	–
p-value	0.465	0.448	0.507	0.870	0.000	0.000
R^2	0.042		0.040		0.146	
N	208	208	208	121	208	208

Notes:

1. **Dependent variables:** *switch* is defined based on a household's transaction history, =1 if household sells to a different mill as compared to the one last year. *switchD* is based on distance, =1 if the household chose a mill located farther away (in a greater distance bin) compared to the one located closer. *switchV* is based on the overall choice of the village, =1 if the household chose a mill that was *clearly* second string in the village making less than 65% of the top mill's purchases in the village.

2. For the probit models, the columns report marginal effects evaluated at the sample median values.

3. The probit model for *switchD* dropped 87 observations from Sindh province, because none of the households there was seen to switch according to this criterion thereby perfectly predicting failure.

4. Significance levels: ** Signficant at 1%, * 5%, $^{+}$ 10%; t-statistics (z- for probit) reported in parentheses

Fig. 76. Potassium-deficient cane at Xicotencatl, Mexico. The older leaves show characteristic orange-brown color with marginal firing. The younger leaves are dark green in color and appear to have developed from a common point, giving a bunched-top appearance. Courtesy of David McKay Co., Inc. (ref. 568a).

Figure 1: Sugarcane shows signs of a specific type of nutrient stress. Source: Humbert [14] p. 132, (colored).

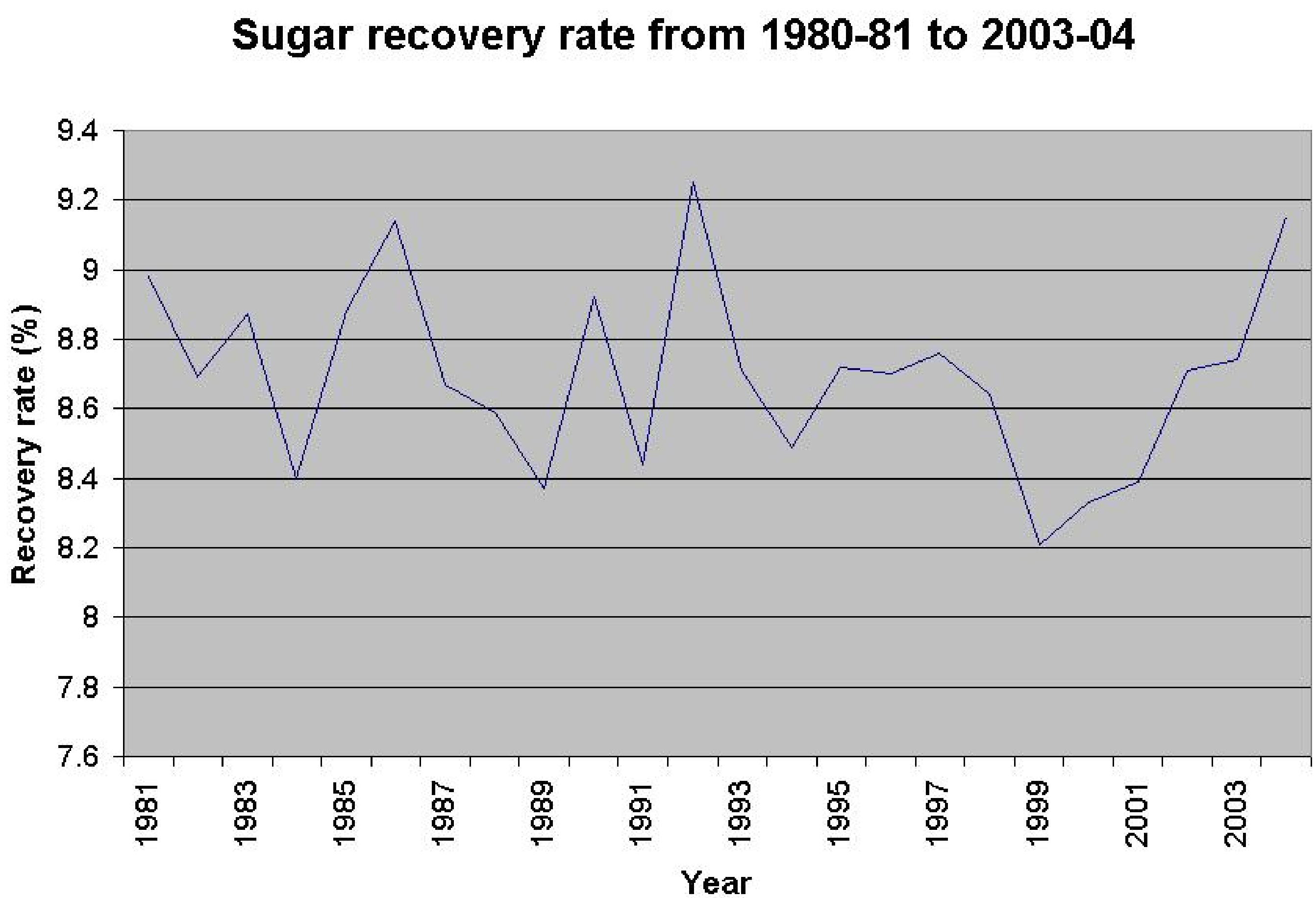

Figure 2: Average Sugar Recovery Rates in Pakistan, 1981-2004. Source: PSMA Annual Reports, 2001-2004.