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Ownership Structure and Economic Outcomes: The Case of Sugarcane Mills in India*

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Abstract

An old theoretical and empirical literature has struggled with how ownership structure affects economic outcomes. We seek to answer this question by examining the effect that different ownership structures have on the outcomes of sugarcane farmers in India. The econometric strategy exploits the zoning system - whereby farmers living within a zone are forced to sell sugar to the mill designated to that zone - to estimate this effect, by surveying farmers at the boundaries of the zones. We use two unique sets of data - satellite images merged with GPS maps of command area borders to measure crop choices along the borders, and a survey to determine the effects of crop choices on farmer welfare. We find that private mills encourage sugarcane production, and that this effect is concentrated on farmers that own less land. Private mills appear to provide more loans for poorer farmers, thereby encouraging them to cultivate cane. Consumption is also relatively higher for poorer farmers living on the private side of the border. Soil testing confirms that results are not driven simply by variation in soil quality. These results suggest that government subsidization of cooperative or public mills is unnecessary.

JEL codes: D29, L23, L33, O25

Keywords: ownership, agriculture

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1 Introduction

How does ownership structure affect economic outcomes? An old theoretical and empirical literature[1] has struggled with this question. This issue is particularly important in the presence of market failures, where government or cooperative ownership is often viewed as ameliorating these problems. In the case of agriculture, for example, raw produce takes a long time to grow but must be processed immediately after harvest and processing plants require large-scale investments. The resulting threat of monopoly causes many governments to nationalize processing plants or convert them into cooperatives.

Conceptually, however, the benefits of government or cooperative ownership are unclear since some theories emphasize efficiency gains while others emphasize capture. Cooperatives, for example, have rarely been successful in their aims of uplifting the rural poor (Simmons and Birchall, 2008). Often, they are subject to capture by powerful landowners, politicians and the rural elite (Banerjee et al., 2001). Management failures are common, necessitating government subsidies and support to keep the cooperative afloat. On the other hand, the problems seen as characteristic of private firms - monopsony power, hold-up, etc - may in fact be mitigated by repeated interactions between these firms and farmers. Whether governments should subsidize and promote cooperatives is therefore an empirical question, one that assumes significant importance in developing nations like India where rural growth lags far behind urban growth and with a history of missteps in agricultural policy.

Estimating the causal impact of ownership poses an inference challenge: theory predicts ownership will be correlated with other, partly unobservable, economic outcomes. An institutional quirk for South Indian sugar mills provides a way to address this challenge. Mills are subject to a zoning system wherein every farmer in a given "command area" must sell to an associated mill; these areas are historically fixed, clearly delineated and the borders can be considered to be randomly placed. Command area boundaries provide a regression discontinuity design since farmers on either side of the boundary must sell to mills of different ownership types - cooperative, private, and public - even though other factors such as weather, soil quality, institutions, etc. are constant across the borders. Thus any differences in farmer outcomes will be associated with differences in ownership structure right at the border.

In addition to the econometric advantages, the sugar industry has several other features to commend it as a setting in which to examine government intervention. Sugarcane is one of the biggest cash crops in India, and the sugar industry employs a substantial number of the rural population. The technology of sugar production means that opportunities for monopsony power and ex post hold up by mills exist. Since sugarcane must

[1] Shleifer (1998) and Megginson and Netter (2001) review the theoretical and empirical literature.

be crushed as soon as it is harvested, farmers cannot sell their cane to mills that are far away, and mills thus have local monopsony power and the opportunity to hold up farmers ex-post. Farmers may anticipate these problems and undersupply cane, and one might expect this problem to affect private mills more than it does cooperatives.

Our study uses two unique sets of data. First, we merge satellite images with GPS maps of command area borders. Using multi-spectral analysis on the satellite images, we directly measure crop choices along the borders. Second, we conducted a survey to determine the effects of crop choices on farmer welfare, asking detailed questions about both income and farming practices to tease out the mechanisms. Finally, we conducted soil testing to ensure that results are not driven simply by variation in soil quality.

We find that private mills encourage sugarcane production more than cooperative mills. Overlaying satellite images on maps of command areas, we determined that the sides of the borders owned by private mills are actually planted with a greater proportion of sugarcane than those owned by cooperative or government mills (21.6% vs. 20.2%). This result is mirrored in the surveys of farmers with plots that are close to the borders. Conditional on owning or renting land, farmers are more likely to have cultivated sugarcane on the private side of the border. Further, we find that the effect is concentrated on farmers that own less land. Delving deeper into the data, we find that private mills appear to provide more loans for poorer farmers, thereby encouraging them to cultivate cane. Consumption is also relatively higher for poorer farmers living on the private side of the border. Meanwhile, soil testing confirms that there are no differences in soil quality across borders.

While a vast theoretical literature exists on the appropriate boundaries between public and private firms and the appropriate scope for government ownership of firms[2], clean empirical estimates of the impact of private ownership on economic outcomes are not as common. Megginson and Netter (2001) suggest two reasons for this difficulty: first, it is difficult to find comparison private firms especially in developing nations, and second because of endogeneity issues (for example, selection - governments may choose to sell the worst-performing units - or corruption - the value of state units may be deliberately suppressed).[3] Thus while a large amount of valuable, comprehensive empirical works

[2]See, for example, Hart et al. (1997); Boycko et al. (1996); Hart (2003); Laffont and Tirole (1991, 1993); Stiglitz (1994); Schmidt (1996)

[3]The challenges they highlight are applicable to industry studies in which the authors compare productivity in state-owned and private enterprises via structural models of cost structure (Ehrlich et al., 1994; Porta et al., 2002); to country-specific studies in which the profitability of existing state-owned, mixed, and private enterprises is compared (Majumdar, 1996; Tian, 2001; Boardman and Vining, 1989, 1992; Dewenter and Malatesta, 1997); and to comparisons of privatized and remaining state firms in the transitional economies of Eastern Europe (Frydman et al., 1999). The empirical methods in these studies are dominated by cross-sectional comparisons or difference-in-differences methods; even when selection bias is explicitly considered (Frydman et al., 1999) via firm-fixed effects, strong assumptions on parallel trends in a changing economy are required.

exists there is till room for improvement in terms of causal inference.

Our paper introduces empirical innovations on two margins. First, with the regression discontinuity design, it expands the causal inference frontier in a particularly important context. Second, the unique satellite and survey data allows us to measure outcomes at many levels. Previous work comparing outcomes under cooperative and private sugar mills by Das and Mookherjee (2007) in fact finds that the distortions to supply are highest for privately owned factories. This, of course, implies extreme short-sightedness on the part of private mills as they fail to anticipate the supply response to constant hold up. The empirical approach in this paper offers several advantages over this previous work, as it compares mills in the same state as opposed to comparing private mills in Uttar Pradesh to cooperatives in Maharashtra, includes detailed farmer-level rather than mill-level outcomes, and has current data rather than data that ends in 1991.

Finally, the paper also speaks to the debate over privatization of government and cooperative firms, which is extremely lively in policy circles. As a number of state-owned and cooperative firms are up for privatization in India and elsewhere, this question takes on acute relevance.

The rest of the paper proceeds as follows. Section 2 provides some background on the zoning system and the sugar industry in Tamil Nadu. Section 3 describes the empirical strategy and shows that a discontinuity does indeed exist at the border. Section 4 presents the sample selection procedure and summary statistics. Section 5 discusses the results, and section 6 concludes.

2 Background

2.1 The Sugar Industry and Ownership Structure

Sugarcane is a cash crop that is grown in large parts of India, from the semi-arid tropics in the south to the sub-tropical plains of the north. The sugar industry took off in north India after sugar tariffs were imposed in the 1930s, with the establishment of private British and Indian sugar producing factories in Uttar Pradesh and Bihar. After Independence, the federal government as well as state governments made their way into sugar production. The cooperative sector burgeoned in the western state of Maharashtra in the 1950s, from where it spread to other states. [4].

Historically, cooperatives were a response to the government's distrust of powerful landowners and private industry. Public funds were (and still are) used to set up mills, provide bailouts when they faced threats of bankruptcy, provide subsidized loans for operation, as well as provide state guaranteed loans for many other purposes. In addition

[4]For more on the history of the Indian sugar industry, see Baru (1990)

to funding cooperatives, both State and Central governments have also heavily regulated the sugar industry.

The historical context has affected current distribution of mills across India. While ninety percent of the mills in Maharashtra are cooperatives, the story is different in the north. The majority of the mills are privately owned, with the remainder split between government and cooperatives. Only in the southern states of Karnataka and Tamil Nadu do we see a more even distribution of private and cooperative mills.[5] Table 1 presents the list of currently operating mills in Tamil Nadu, along with their ownership structure.

2.2 The Sugar Production Process

Sugarcane is a water and fertilizer intensive crop that takes a year to grow. Irrigation is usually necessary, although rainfall is also important since it reduces irrigation costs. Sugar is made by crushing sugarcane via massive rollers to extract sucrose-rich juice. Lime is then added to the juice to balance pH and clump together impurities, sulphur is bubbled through to bleach it, and the juice is boiled and refined to make processed crystalline sugar.

While the intrinsic sucrose and water content of sugarcane determine the potential amount of sugar that can be extracted from it, a large role is played by the efficiency and organization of the mill. Once cane is harvested, it dries out rapidly, and hence must be crushed within hours of cutting. Given the generally poor transportation infrastructure in rural India, this means that farms cannot be located more than 15-20 kilometers from the factory. The coordination and efficiency of the mill determine how much sugar is obtained per ton of cane crushed. Mills need to coordinate cane harvesting in order to run the factory exactly at capacity every day. If too much cane arrives at the factory gates daily, some of it cannot be crushed and dries out. If too little cane arrives, recovery is also lower due to the fixed width between the rollers. Moreover, keeping the rollers running is costly, so it may not be cost effective to run the machinery for small quantities of cane. Machinery breakdowns are also extremely costly, since the cane at the factory starts drying out, and the harvesting schedule must be readjusted.

The crushing season usually runs from October/November through April/May, starting right after the monsoon ends in September. As a result, later cutting dates mean drier and lighter cane. Since prices paid paid to the farmer are per tonne of cane (regardless of quality), drier cane brings in less to farmers. In order to ensure a regular supply of good quality cane, mills provide seeds, loans, and agricultural extension services to farmers. Each factory pays its farmers a unique price per metric tonne of cane. A single price for sugarcane is paid per year on the basis of weight alone. Usually, a price is announced just

[5]Source: Indian Sugar Mills Association Yearbook, 2006.

before the beginning of the season (in September/October), and adjustments (upwards only) made at the end of the season. Sugar prices and rainfall affect cane prices, as does the recovery rate of the mill, as statutory prices are tied to this recovery rate.

2.3 The Command Area System

The constraints imposed by the fact that cane must be crushed immediately after harvest means that sugar factories cannot bring in cane from large distances. Moreover, there are large economies of scale in cane crushing, and thus gains to be had from building large factories. Finally, unlike in Brazil where cane is grown in plantations owned by the sugar factories themselves, cane in India is grown by a large number of individual farmers. Combined, these factors mean that ensuring adequate supplies of cane is a first-order problem for sugar mills in India.

The government's solution to this problem was to designate reserved sugarcane zones for each mill, thereby limiting competition between mills for cane and providing incentives for the mill to assist in cane development within their zones. This was an old idea; in a meeting of the Sugar Committee in 1933, a Mr. Noel Deerr noted that:

> With the adoption of a zone system, that is to say, with an area given over to the miller to develop in sympathy with the small holder, there should follow at once an association of agriculture and manufacture for the common benefit of both interests. It will be the object of the mill to reduce the price of the raw material and this can best be done by increasing the production per acre, and with an increment in the yield the net income of the small holder will increase even with a decrease in the rate paid per unit of raw material. (as cited in Baru (1990), p 33)

The policing of the command areas is left to the mills, who have strong incentives to ensure that farmers do not sell their cane to other mills. In practice, the complex relationship a cane farmer needs to have with the mill to procure seed, fertilizer, credit, pesticide etc effectively binds her to her current mill.

In order to protect farmers from the monopsony power thus created, the government would set a floor for the price of cane to be paid by each mill, depending on the recovery rate of cane achieved by the mill. Currently, cane prices are regulated by both the national government, which sets a price floor called the Statutory Minimum Price (SMP), and state governments, which usually add to this with a State Advisory Price (SAP). Sale of processed sugar is also restricted, with a certain proportion (which varies over the years,

currently 10%) to be sold at a low rate ("levy price") to the Central Government, and the rest on the open market (at the "free price").

While some states have now abolished the command area system, replacing it with looser rules that require new factories to be built at least a certain distance (20-25km) away from existing factories, the system still exists in the state of Tamil Nadu. Most of the boundaries of the command areas of the 36 operating sugar mills in the state were historically set. Some followed natural geographical features, like rivers, canals, or hills. Others were set to equate the number of villages neighboring mills had in their command areas. Anyone who wished to establish a new mill had to obtain permission from the sugar commissioner, proving that she had the potential to obtain adequate supplies of cane from a heretofore undesignated command area, or that existing mills were not using cane from their currently assigned areas.[6]

3 Empirical Framework

3.1 Empirical Strategy

The approach to estimating the effect of ownership structures on farmer outcomes involves using regression discontinuity, similar to that followed by Black (1999) and Bayer et al. (2007). This approach takes advantage of a discontinuity in ownership structure at the border, while other characteristics – such as weather, soil quality, pest exposure, the institutional environment, etc – are continuous. The advantage of this approach over that of simply comparing farmers outcomes in areas served by private and cooperative mills respectively is that it is difficult to control for all pertinent characteristics that may affect these outcomes. Thus instead of estimating:

$$Y_{ij} = \alpha + X'_{ij}\beta + A'_j\gamma + \delta Private_j + \epsilon_{ij} \tag{3.1}$$

where Y is an outcome of interest for farmer i in area j, X are individual farmer

[6]Notes from meeting with Tamil Nadu Sugar Commissioner Mr. Sandeep Saxena and Tamil Nadu Sugar Corporation's Chief Cane Development Officer Dr. A. Sekar

characteristics, and A are area characteristics, and the outcome of interest is coefficient δ on a dummy variable indicating whether the area is served by a private mill, we estimate:

$$Y_{ib} = \alpha + X'_{ib}\beta + \sum_{1}^{B} \gamma_b + \delta Private_b + \epsilon_{ib} \tag{3.2}$$

where b is a particular border and a series of indicator variables γ control for characteristics that vary at the border. However, some borders may be very long, and there may be significant differences in characteristics on different parts of the border. In order to account for these differences, the eventual survey is based on sampling pairs of villages that are directly across from each other on different sides of the border. Instead of indicator variables for the border, we could include indicator variables for the village pairs, and estimate:

$$Y_{ipb} = \alpha + X'_{ipb}\beta + \sum_{1}^{P} \nu_p + \delta Private_b + \epsilon_{ipb} \tag{3.3}$$

where p refers to the village pair.

3.2 First Stage

This empirical strategy is valid if there is actually a discontinuity in ownership structure at the border and continuities in other characteristics. Whereas the law says that farmers must sell to the mill whose command areas their land is located in, it is possible that this law is flouted in practice. Some flexibility in this law may also be possible in case of cane shortages or overages on different sides of the border. We first check that the a discontinuity does indeed exist at the border; that is, farmers on one side of the border sell to the mill on their own side and not the other side. Moreover, we also check that other variables do not display a discontinuity at the border.

Data for these checks come from a small survey of 80 households implemented prior to the main survey. Sugarcane growers at various distances from the border (at a set of different borders) were asked about which mills they had sold sugarcane to in the last five years, their yields, and their land ownership and rental details. Not a single respondent

claimed to sell sugarcane regularly to the mill on the other side of the border. There are, however, farmers who have sold cane to the mill on the other side of the border occasionally over the last five years. Figure 1 represents the proportion of farmers who sell cane exclusively to their own mill. The x-axis measures distance from the border. Whereas the proportion drops to lower than one as we get closer to the border, it is still very high, as over 80 percent of farmers sell exclusively to their own mill.

Figure 2 presents these results by designating one of the pair of mills as Mill A and the mill on the other side of the border as Mill B. Even with the slightly biased graphic showing the proportion of respondents with land in the command area of Mill A who have ever sold cane to Mill B on the left hand side of the graph and those who exclusively sell to Mill B on the right hand side of the graph, the discontinuity at the border is clear. Since no one on the side of Mill A sells exclusively to Mill B, there will clearly be an even sharper discontinuity at the border and it is not worth showing these results.

3.3 Threats to Discontinuity Design

Lee and Lemieux (2009), in their excellent "user guide" to regression discontinuity designs for empirical researchers, suggest the careful consideration of three sets of questions for research designs that include geographical discontinuities: the process of boundary creation, the endogenous sorting of economic actors across boundaries, and differences between regions other than the treatment of interest. We next explicitly consider these threats to internal validity and explain how this project deals with them. In addition, we also consider a common criticism of regression discontinuity-type designs, namely the external validity of the results.

1. **Process of Boundary Creation** As described above, the boundaries of command areas were historically set, are clearly delineated, and unlikely to be endogenously placed. We will also directly test observable characteristics to ensure that they do not vary across borders. Moreover, as is standard in these analyses, we will exclude any parts of boundaries that follow natural borders such as lakes, rivers, hills, etc.

Finally, all decisions about which parts to include or exclude are transparent and available to anyone using Google Earth.

2. **Endogenous Location of Farmers** Given that the boundaries have been historically set, it is possible that farmers selectively move across borders by purchasing land. For example, farmers that work harder might move to mills that reward effort. However, this is not a threat to the validity of estimates but rather an interpretational issue. If farmers move because certain mills reward effort, this can still be interpreted as the causal impact of ownership structure, although due to selection rather than other mechanisms. Moreover, this kind of mobility can be measured to some extent by asking farmers directly. Finally, land sales in rural India are uncommon as few farmers have clear deeds to their property.

3. **Other Differences between Regions** We directly test other relevant characteristics to ensure that they do not jump discontinuously across borders. The most obvious characteristic is soil, and we can directly measure soil traits such granularity and chemical content that would affect crop choices and yields.

4. **External Validity** Since regression discontinuity estimates relate to observations close to the discontinuity, one concern is that they have limited external validity. Certainly in some contexts where the marginal complier is questionable or different from the rest of the population - for example a student in an ability distribution with high variance where the cutoff is some score - this concern is valid. However, in the sugarcane farmers context it is difficult to imagine that farmers close to the border are systematically different from those who are not. Finally, these results from the sugarcane industry are applicable to various similar industries in India and elsewhere - for example dairy and coffee.

4 Sample Selection and Data Description

Table 1 presents the list of sugar mills in the state of Tamil Nadu as of 2010. From the universe of potential borders between these mills, we did not consider those borders

that were along a river, or separated by large geographic features like canals, mountains where the two sides are likely to be very different. We conducted two different surveys at different times; Survey 1 was conducted at command area borders which overlapped taluk/district borders; Survey 2 was done at command area borders which did not overlap borders of these administrative divisions. There may be reasons to believe that either set of borders is endogenously determined; by doing two surveys, we can counter arguments made against either. In addition, we also collected soil samples from a subset of farmers in Survey 2 and tested these samples for various characteristics. Finally, we purchased satellite images from the National Remote Sensing Agency (NRSA) of India, as well as obtained some from LandSat, in order to determine how much sugarcane was grown on either side of the border.

4.1 Survey 1

Based on large-scale maps of the command areas, we identified approximately 800 villages that were close to the 29 mill borders. From these, we sampled 152 villages – five per border plus seven on three-way borders that we subsequently ignored – that had at least some households growing sugarcane. Given the difficulty of identifying exact locations of the villages on the paper maps, this was an oversample, with the idea being that at least three village-pairs per border were to be surveyed – the sampled village and the village across from it on the border[7]. To ensure validity of the regression discontinuity estimates, only villages that were right at the border were to be considered. The final survey thus consisted of 174 villages (29 x 6), of which 2 village pairs (4 villages) had to be dropped when it was determined after the survey that the villages in the pair (two separate cases) were actually next to each other rather than across the border from each other.

Within the village, we surveyed 10 households that either owned or rented or share-cropped agricultural land, randomly selected from lists of households obtained from the village sarpanch.[8]. Overall, we surveyed 1694 households, of which 1037 households were

[7]Some of the sampled villages were themselves across from each other

[8]This was a decentralized procedure, and we appear to have sampled mainly from lists of landowners rather than renters. The compositional issues this raises are discussed in the results section below.

from borders with mills having different ownership structures ("different-sample"), and the rest from border with mills having the same ownership structure ("same-sample").

Table 2a presents summary statistics on the 1037 different-sample households, divided by whether the mill whose command area they are in is privately owned or not. In general, the different areas appear to be balanced. Although have slightly less education, these differences are not significantly large. More concerning are the differences in the average amount of land owned, and overall land value. However, whether this is an issue of balance, or potentially a long-term consequence of the kind of farmers served by the different kinds of mills, will be discussed in the following section.

4.2 Survey 2

For this survey, we picked pairs of villages across from each other along command area boundaries that did not overlap any major administrative divisions. This gave us 32 village pairs (64 villages) along 20 mill pair borders. Within these villages, we compiled a list of all plots that were within a kilometer of the border by obtaining land records from the Village Administrative Officer (VAO). The VAOs also denoted whether the plots were farmed with sugarcane or not. Based on this information, we picked a stratified random sample of sugarcane growers and non-growers, aiming to survey 25 sugarcane farmers and 15 non-sugarcane farmers in each village. All regressions are weighted to account for these differential sampling probabilities.

Table 2b presents summary statistics for this survey, divided by whether the mill whose command area they are in is privately owned or not. In general, the different areas again appear to be balanced. Differences in the average amount of land owned, and overall land value remain, although this time they are in favor of private mill areas.

4.3 Soil Sampling

For a subsection of the survey 2 farmers – approximately 3 per village – we collected soil samples from their fields. The samples were collected according to the procedures

set forth by the Tamil Nadu Agricultural University on the following website: `http://agritech.tnau.ac.in/agriculture/agri_soil_sampling.html`. The same institution conducted the analysis on the samples, providing us with data on the texture, type of soil, and available amounts of nitrogen, phosphorus, and potassium in the soil samples.

4.4 Satellite Data Collection and Analysis

We obtained satellite images of the state of Tamil Nadu from two different sources - Land-Sat and the National Remote Sensing Agency (NRSA). These images were of resolutions ranging from 23m to 30m. The images are taken in September/ early October, when all sugarcane that will be crushed in the season has been planted and is growing but not yet harvested.

These images were uploaded unto ArcGIS and then mathematically transformed into an index called the Normalized Difference Vegetation Index (NDVI). NDVI uses the near infra-red and red wavelengths of the satellite images, using a standard algorithm to transform multiple spectral bands into a single dimension corresponding to physical vegetation parameters. Each pixel of the image becomes a value in between and including -1 and 1. The values represent the vegetation of the particular pixel; different crops correspond to different ranges within this range. It is safe to say that values zero and below do not represent vegetation. (See Figure XX for sample images and procedure)

We follow standard procedures in remote sensing to determine sugarcane planted in the areas surrounding particular mills. (See, for example, Rao et al. (2002); Rehman et al. (2004); Mehta et al. (2006)) Crops in general fall between 0.1 and 1 in the NDVI range. Although this range includes vegetation that may not be crops, we assume that this forms the denominator for our calculation as it applies to potential land available for growing sugarcane. By referencing coordinates of over 20 sample sugarcane fields in Maharashtra and Tamil Nadu, we calibrated sugarcane to lie between 0.3 and 0.6 in the NDVI range.[9]. This range covers healthy growing sugarcane, and as such captures a measure of quality of the crop as well as mere existence.

[9]Exact coordinates of fields available on request

Given these ranges of all crops and sugarcane, we created a catchment area of a 2 km zone around the borders of command areas. We calculated the number of pixels in the zone that were crops in general and sugarcane, and then the proportion of crops that were sugarcane.

Because there were instances of overlap and cutting off of the buffer mills when we overlayed them unto the NDVI images, we picked the NDVI images that included the greatest portion of the cut off buffer mills. Cloud cover for the downloaded satellite images also could pose minor problems. We of course chose the images with the least cloud cover but that does not mean that the images were cloudless; if there were clouds though they affected both sides of the border since the area was highly localized.

5 Results

5.1 Preliminaries

We first checked that the soil quality was indeed the same across either side of the border. Table 3 presents the results, which show no significant differences between private and cooperative/public mills. The coefficient on any of the soil characteristics is smaller than 5% of the standard deviation of one of these variables, which truly implies that there are no differences in soil quality.

5.2 Do Private Mills Discourage Cane Production?

Previous work has suggested that incentives for private mills to hold up farmers are higher and will hence result in an undersupply of cane to these mills. However, we find exactly the opposite result: private mills seem to encourage production of cane. We find that farmers on the private side of the border plant 8 percentage points more of their land with sugarcane. This is an economically significant effect, given that about 40 percent of overall land owned is planted with sugarcane in these areas.

In addition to planting more of their land with cane conditional on owning or renting

land, farmers are more likely to grow sugarcane at all on the private mill side of the border. Table 4 presents these results. Farmers are more likely to have cultivated sugarcane in the past five years on the private side of the border. These results are even stronger after controlling for education and including the village pair indicators rather than the border pair indicators. The results are qualitatively similar for survey 2 farmers, although not statistically significant.

Interacting the indicator for private with acreage, we find that the coefficient on the interaction term is negative. This implies that poorer farmers in private areas are more likely to grow sugarcane.

5.2.1 Satellite Data Analysis

These results are mirrored in the satellite data analysis. We find that more of the area within a 2km buffer zone of the border is planted with sugarcane in private mill areas - a difference of approximately 1.4 percentage points or 8%. Figure XX presents these results - as is clear from the figure, a greater number of mill pairs have more sugarcane growing on the private side of the border, and the amount of sugarcane grown overall is higher as well.

5.3 Farmer Characteristics

Given the more farmers grow cane on the private side, it is interesting to see the average characteristics of farmers. While cooperatives are meant to serve poorer farmers, it has been noted that political economy considerations mean that they are often captured by richer farmers. Table 5 presents results on farmer characteristics.

Overall, farmers on the private side of the border have less land than those on the cooperative side in survey 1, but more in survey 2. This pattern repeats itself for literacy. On average the value of the land per acre is slightly lower on the private side, although the coefficient is not statistically significant. Since we do not have any information on the landless, it is difficult to separate out compositional effects of people drawn into farming from actual effects of the mill.

5.4 How is Cane Process Affected?

Given these results on the marginal farmer, it will be difficult to separate compositional effects from any real effects of ownership structure on cane cultivation. No systematic differences seem to be observable if we consider the two surveys together. Table 6 presents these results. First, yields are significantly lower on the private side in survey 1, by about 4 tons per acre, but not in survey 2. Given that the average yield is about 36 tons per acre, this is an economically significant difference.

There are a number of potential explanations for this yield difference. First, it appears as though farmers on the private side invest substantially less in fertilizer. However, since the question asked is how much the respondent spent on fertilizer, and some mills provide fertilizer themselves, this may be misleading. A second potential reason is that farmers on the private side seem to apply pesticide more often, which might indicate that the poorer land quality may be responsible. Finally, farmers on the private side seem more likely to face delays in their cutting dates. Since more farmers plant sugarcane on the private side, individual farmers may face delays in harvest schedules which are coordinated by the mill. Since a later cutting date implies drier cane which weighs less, and since yield is measured entirely in weight, this may explain why yields are lower. On the other hand, a fair number of these variables are insignificantly different in survey 2.

Finally, it appears as though sugarcane growers receive more in terms of loans from private mills (Table 6). This might explain why poorer, less educated farmers are able to cultivate cane on the private side of the borders, as these loans help pay for seeds and fertilizer required to start growing cane.

5.5 How is Overall Welfare Affected?

Finally, we consider the effects on overall welfare of farmers. Sugarcane is an extremely lucrative cash crop. Farmers may choose not to plant it if they have no source of irrigation, or are liquidity constrained and cannot afford the upfront costs of seed and fertilizer, or fear that sugar mills may not purchase their cane or hold them up ex post. Therefore if

poorer farmers are indeed able to plant cane, this could have significant effects on their overall income and consumption.

The fact that poorer farmers grow sugarcane on the private side does appear to have some effect on their incomes (Table 7). Once we control for land owned consumption and harvest income seem to be higher on the private side of the border. None of these results are statistically significant, and not much weight should be placed upon them given the missing data.

6 Conclusion

This project attempts to step back from theory and ask a simple question: there are many places where the government feels it needs to intervene in markets in order to provide a good or service - what are the consequences of this intervention? The uniqueness and simplicity of the situation - where we see dissimilarly governed firms performing the same economically significant yet simple activity in the same place at the same time - allows us the opportunity to answer this question.

We find that contrary to existing evidence private mills encourage sugarcane production. Farmers are more likely to have cultivated sugarcane on the private side of the border, and devote a larger proportion of their land to sugarcane. Further, we find that the effect is concentrated on farmers that own less land. Delving deeper into the data, we find that private mills appear to provide more loans for poorer farmers, thereby encouraging them to cultivate cane. Consumption is also relatively higher for poorer farmers living on the private side of the border. Since all of these analyses control for the village pair - that is, two villages on either side of the border - we ensure that these results are not driven by differences in local conditions.

Contrary to popular perception, it does not seem as though the monopoly power wielded by private mills hurts poor farmers, nor does it lead to under-provision of sugarcane. Given these facts, it appears as though various state governments' policies to run publicly owned mills and/or to massively subsidize cooperative mills are unnecessary.

Given the high costs - one estimate puts the state government of Maharashtra's guarantees to be paid to mill at Rs. 4000 million - these policies seem particularly indefensible.

The main mechanism for encouraging sugarcane production appears to be loans. Sugarcane has a yearly harvest, hence the income stream of its farmers is lumpy, and providing loans can ameliorate cash flow constraints and encourage productive activities. However, private mills seem to be just as good at making these loans as cooperate and public mills, even without access to the massive agricultural credit flows that cooperative and public mills enjoy. Given that subsidized agricultural credit tends to be politically motivated and often wasted (Cole 2010), perhaps these policies should be abandoned as well.

The lessons from this study are applicable to various other realms where governments feel forced to intervene in agricultural markets in developing countries due to the threat of market failure. These interventions are costly, and the benefits of the intervention are likely to be captured by special interests. Therefore firm empirical evidence on the productivity or equity gains of these interventions is essential before they proceed.

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Figure 1: Proportion of Farmers Selling Exclusively to Own Mill

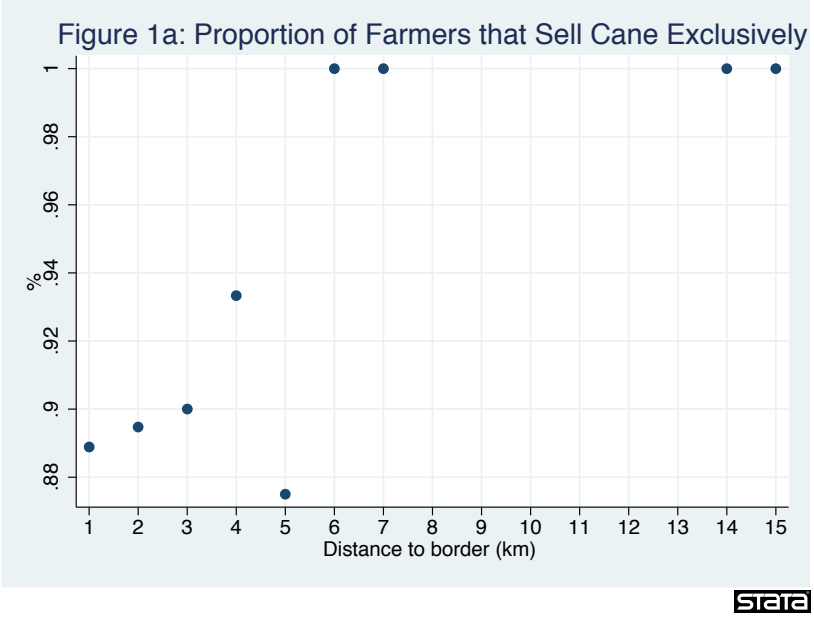


Figure 2: Proportion of Farmers Selling to Mill B

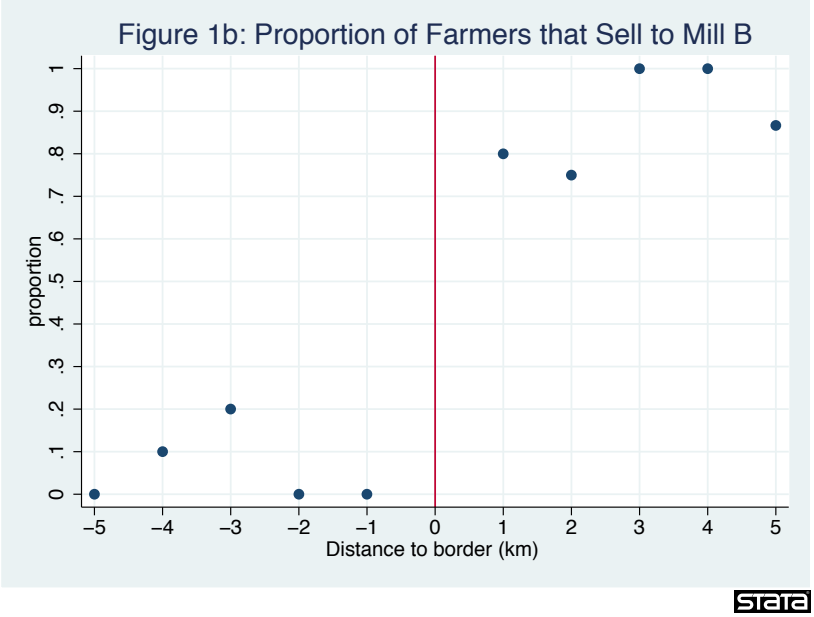


Figure 3: Proportion of area planted with cane from sugarcane analysis.

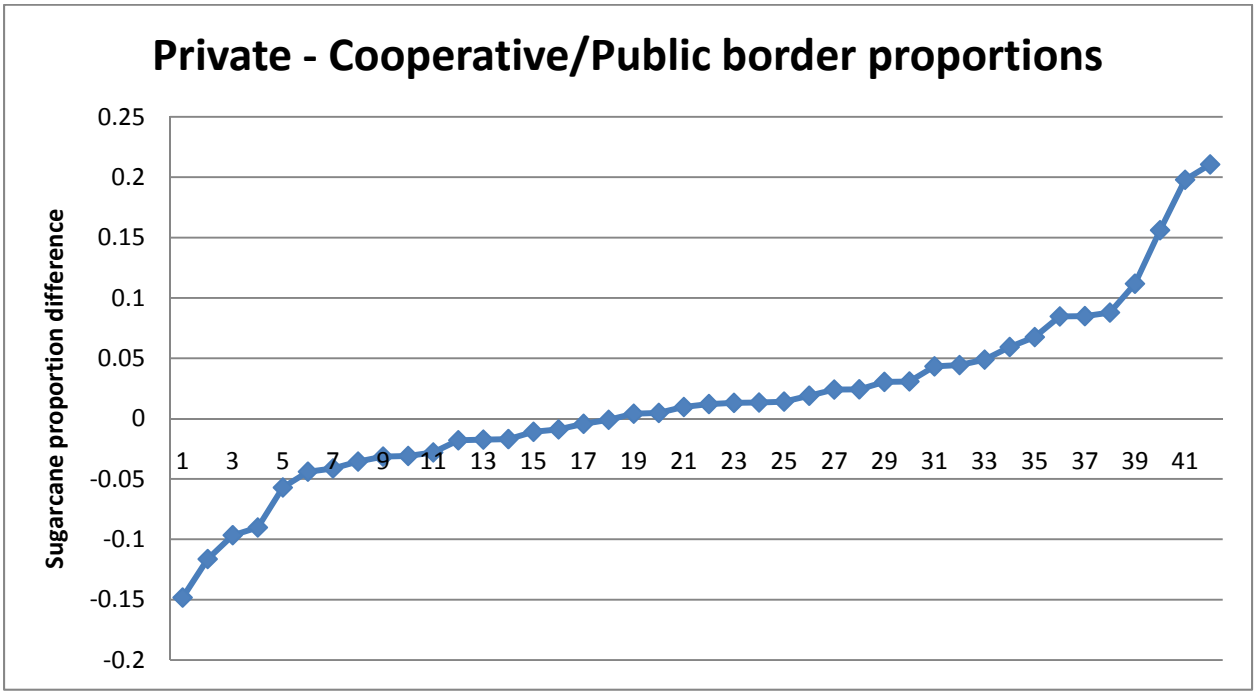


Table 1: List of Sugar Mills in Tamil Nadu

S No	Mill	Type	Survey 1	Survey 2	New mill?
1	Amaravathy (Krishnapuram)	Coop	Yes	Yes	No
2	Ambur (Vadapudupattu)	Coop	Yes	No	No
3	Arignar Anna (Kurungulam)	Public	Yes	Yes	No
4	Banniyariamman (Sathiyamangalam)	Private	Yes	Yes	No
5	Chengalrayan (Periyasevalai)	Coop	Yes	Yes	No
6	Cheyyar (Anakavoor)	Coop	Yes	No	No
7	Dhanalakshmi Srinivasan	Private	No	Yes	Yes
8	Dharani Unit I	Private	No	No	No
9	Dharani Unit II (Polur)	Private	Yes	No	No
10	Dharani Unit III	Private	No	Yes	New unit only
11	EID Parry (Nellikuppam)	Private	Yes	No	No
12	EID Parry (Pettavaithalai)	Private	Yes	No	No
13	EID Parry (Pudukkottai)	Private	Yes	Yes	No
14	EID Parry (Pugalur)	Private	No	Yes	No
15	EID Parry (Pugulur)	Private	No	Yes	New unit only
16	Kallakurichi I (Moongilthuraipattu)	Coop	Yes	Yes	No
17	Kallakurichi II (Kachirapalayam)	Coop	No	Yes	No
18	Kothari	Private	No	No	No
19	KRR Ramasamy (Thalaignairu)	Coop	Yes	Yes	No
20	Madras Cement	Private	No	Yes	Yes
21	MRK (Sethiathope)	Coop	Yes	No	No
22	National (B. Mettupatti)	Coop	Yes	No	No
23	Perambalur (Eraiyur)	Public	No	Yes	No
24	Ponni (Odapalli)	Private	No	Yes	No
25	Rajshree Unit I (Varadaraj Nagar)	Private	Yes	No	No
26	Rajshree Unit II (Mundiyampakkam)	Private	Yes	No	No
27	S.V. Sugars (Palayaseevaram)	Private	Yes	Yes	No
28	Sakthi (Sakthinagar)	Private	Yes	No	No
29	Sakthi (Sivaganga)	Private	Yes	No	No
30	Salem (Mohanur)	Coop	No	Yes	No
31	Shree Ambika (Pennadam)	Private	Yes	No	No
32	Shree Ambika (Thugili)	Private	Yes	Yes	No
33	Subramania Siva (Gopalapuram)	Coop	Yes	Yes	No
34	Thiruarooran (A.Chithoor)	Private	Yes	Yes	No
35	Thiruarooran (Thirumandangudi)	Private	Yes	Yes	No
36	Tirupattur (Kethandapatti)	Coop	No	Yes	No
37	Tiruttani (Tiruvalangadu)	Coop	No	Yes	No
38	Vellore (Ammundi)	Coop	Yes	Yes	No

Table 2a: Summary Statistics for Survey 1

	Coop/Government			Private		
	Mean	**SD**	**Obs**	**Mean**	**SD**	**Obs**
Grew sugarcane last 5 years	0.63	0.48	521	0.70	0.46	516
Can you read	0.72	0.45	326	0.66	0.47	323
Acreage	6.49	9.02	509	5.56	6.57	508
Cane Yield	38.55	12.22	289	35.14	12.13	300
Amount Fertilizer	18692	26445	250	11898	12816	256
Pesticide Applications	1.44	0.57	167	1.54	0.70	147
Paid on Time	0.69	0.46	274	0.72	0.45	261
Delay Cutting Date	2.74	1.32	137	3.30	1.85	210
Consumption	110769	98199	332	102611	116864	362
Mill loans	29930	52294	332	30734	90452	362
Log income	10.67	1.03	332	10.49	0.98	360
Harvest income	120506	213918	481	119507	254572	457
Value/acre (Rs)	197069	188731	507	183062	163264	505

Table 2b: Summary Statistics for Survey 2

	Coop/Government			Private		
	Mean	**SD**	**Obs**	**Mean**	**SD**	**Obs**
Grew sugarcane last 5 years	0.38	0.49	639	0.41	0.49	660
Can you read	0.70	0.46	642	0.71	0.46	660
Acreage	5.49	9.07	645	6.98	16.62	668
Cane Yield	36.55	12.14	137	34.21	14.70	101
Amount Fertilizer	25205	143000	237	13688	89379	254
Pesticide Applications	0.24	0.43	237	0.19	0.39	254
Paid on Time	0.91	0.28	126	0.82	0.39	93
Delay Cutting Date	0.86	0.35	131	0.88	0.33	98
Consumption	132690	184435	645	127868	103949	668
Mill loans	18522	57096	645	15768	50584	668
Log income	12.40	0.86	635	12.27	0.85	659
Harvest income	99806	131680	645	92364	118718	668
Value/acre (Rs)	57851	212957	621	58749	231967	648

Table 3: Is Soil Quality Different Across the Borders?

	Texture	Quality	Nitrogen	Phosphorus	Potassium
	(1)	(2)	(3)	(4)	(5)
Private	0.00575	0.128	19.79	4.846	26.85
	(0.172)	(0.110)	(25.69)	(7.610)	(18.91)
Observations	148	148	148	148	148
Dummies	Vill Pair	Vill Pair	Vill Pair	Vill Pair	Vill Pair

This table presents regressions of various indicators of soil quality on an indicator for being on the private side of the border. "Texture" refers to the size of the grain of soil. "Quality" is a crude indicator of whether the soil is loam, considered good for growing sugarcane. "Nitrogen" is the kg/hectare content of nitrogen in the soil; range is from 70-1989. "Phosphorus" is the kg/hectare content of phosphorus in the soil; range is from 8-455. "Potassium" is the kg/hectare conent of potassium in the soil; range is from 35-1456.

Standard errors clustered at the mill level in parentheses. *** p<0.01, ** p<0.05, * p<0

Table 4: Do Private Firms Encourage Sugarcane Production?

	Ever Grown Sugarcane in Last 5 Years				Currently Growing Sugarcane			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Private	0.354*	0.385*	0.0754	0.124	0.0453	0.0455	-0.0110	0.0482
	(0.211)	(0.217)	(0.105)	(0.120)	(0.148)	(0.143)	(0.0892)	(0.133)
Acreage		0.0271**		0.0168		0.0215*		0.0258
		(0.0109)		(0.0114)		(0.0113)		(0.0163)
Interaction		-0.007		-0.0110		-0.009		-0.0163
		(0.021)		(0.0120)		(0.021)		(0.0171)
Observations	718	699	1106	1106	998	978	1171	1171
Dummies	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair
Survey	1	1	2	2	1	1	2	2

Columns 1-4 are probit estimations of whether respondent has ever grown sugarcane in the last 5 years, and columns 5-9 are probit estimations of whether the respondent is currently growing sugarcane, on an indicator for being on the private side of the border and other controls. "Interaction" is the interaction of private and acreage. "Vill Pair" dummies correspond to indicators for village pairs across from each other.
Survey 1 refers to the survey at command area borders which overlapped taluk/district borders.
Survey 2 was done at command area borders which did not overlap borders of these administrative divisions.
Standard errors clustered at the mill level are presented in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Farmer Characteristics

	Acreage		Income		Average Land Value		Can You Read?	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Private	-0.815***	1.183**	-0.105	-0.00968	-9175	-2426	-0.196**	0.0573**
	(0.288)	(0.492)	(0.0713)	(0.0692)	(7109)	(16184)	(0.0790)	(0.0244)
Acreage			0.0518***	0.0161	-1713***	-1479***	0.0373**	0.00542***
			(0.00676)	(0.0105)	(574.6)	(481.8)	(0.0174)	(0.00186)
Observations	1037	1313	681	1294	1037	1313	595	1313
Dummies	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair
Survey	1	2	1	2	1	2	1	2

This table presents regressions of farmer characteristics on the private indicator and controls. "Acreage" is the number of acres owned by the farmer.
Survey 1 refers to the survey at command area borders which overlapped taluk/district borders.
Survey 2 was done at command area borders which did not overlap borders of these administrative divisions.
Standard errors clustered at the mill level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 6: How is Cane Cultivation Affected?

	Mill Loans		Cane Yield		Amount Fertilizer		Pesticide Applications		Paid on Time		Delay Cutting Date	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Private	6717	5110*	-3.919***	0.971	-6771***	388726	0.209***	0.0522	-0.120	-0.225***	-0.764***	0.00454
	(5350)	(2838)	(0.911)	(4.637)	(1861)	(2.10e+06)	(0.0448)	(0.0505)	(0.133)	(0.0658)	(0.122)	(0.0844)
Acreage	1525*	1138**	0.0297	0.000600	893.4***	49431	0.00130	0.00385	-0.0117**	-0.00677***	-0.00850	0.000619
	(811.0)	(457.2)	(0.0256)	(0.153)	(280.7)	(38047)	(0.00460)	(0.00421)	(0.00497)	(0.00174)	(0.00652)	(0.00257)
Obs	683	1313	580	238	500	491	308	491	478	176	552	229
Dummies	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair	Vill pair
Survey	1	2	1	2	1	2	1	2	1	2	1	2

This table presents regressions of cane cultivation process outcomes on the private indicator and controls. "Mill loans" refer to the total amount borrowed from sugar mill. "Cane yield" is the yield of sugarcane in tons per acre. "Amount fertilizer" is the amount in rupees spent on fertilizer. "Pesticide applications" refers to the number of times pesticides were applied in the first three months after planting. "Paid on time" refers to whether the mill paid the farmer on time for sugarcane delivered. "Delay cutting date" refers to whether the mill gave the farmer an appropriate cutting date.

Survey 1 refers to the survey at command area borders which overlapped taluk/district borders. Survey 2 was done at command area borders which did not overlap borders of these administrative divisions.

Standard errors clustered at the mill level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

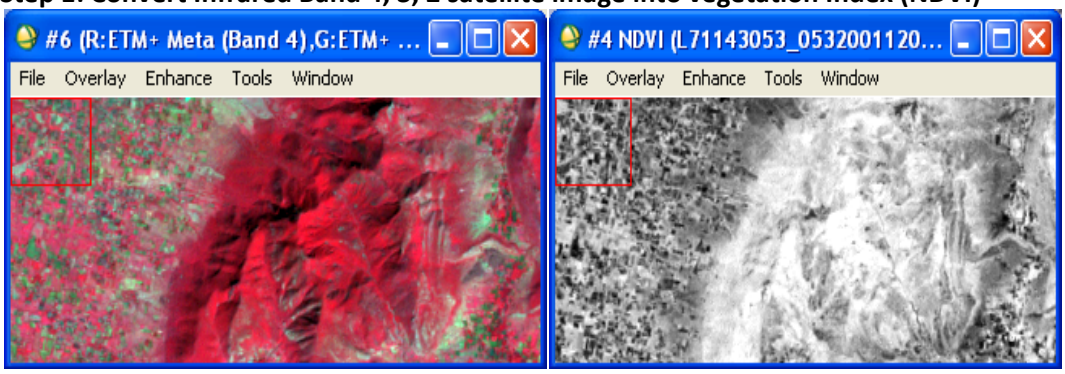
Table 7: How is Overall Welfare Affected?

	Log Income		Harvest Income		Consumption	
	(1)	(2)	(3)	(4)	(5)	(6)
Private	-0.105	-0.00968	9185	5486	3364	13507
	(0.0713)	(0.0692)	(9136)	(12365)	(7793)	(12035)
Acres Owned	0.0518***	0.0161	16491***	4554*	4678***	2649*
	(0.00676)	(0.0105)	(2450)	(2238)	(1072)	(1529)
Observations	681	1294	920	1313	683	1313
Dummies	Vill Pair	Vill Pair	Vill Pair	Vill Pair	Vill Pair	Vill Pair
Survey	1	2	1	2	1	2

This table presents regressions of overall farmer outcomes on the private indicator and controls. "Log income" is log overall income over the previous year. "Harvest income" is the income from crop harvests over the last year. "Consumption" refers to total consumption over the last year. Survey 1 refers to the survey at command area borders which overlapped taluk/district borders. Survey 2 was done at command area borders which did not overlap borders of these administrative divisions.
Standard errors clustered at the mill level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix A: Determining Proportion of Area Planted with Sugarcane

Step 1: Convert Infrared Band 4, 3, 2 satellite image into vegetation Index (NDVI)

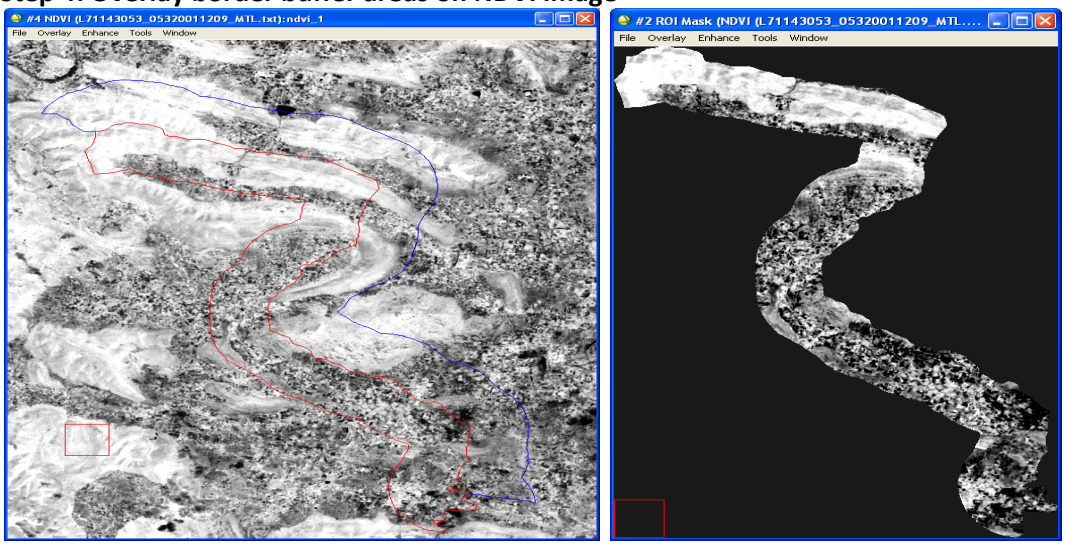


Step 2: Calibrate NDVI values of sugarcane using GPS coordinates of actual fields

Sugarcane field on left

Step 3: Use GIS shapefiles of border areas and create 2km buffer around border

Step 4: Overlay border buffer areas on NDVI image



Step 5: Divide pixel count of sugarcane NDVI range by pixel count of cultivable land NDVI range

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