Does an Improved Crop Cultivar Impact on Land Values?

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Title	**:**	**Does an Improved Crop Cultivar Impact on Land Values?**
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Abstract

Based on empirical evidence, it is found that an adoption of new improved crop cultivar impacts on perceived values of land. For this study of an improved variety of castor, the estimates show that the trend of land values significantly differ among groups of farmers with varying degree of the risk aversion of adopting a new variety. The group, who is relatively more willing to adopt the new crop, values their land more. This evidence has implication for impact assessment that the benefits of adopting new varieties could be underestimated since the assessment does not account for the appreciation of value of their most important asset.

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1 Introduction

Land is important in rural agrarian economies. It generates income through crop production as an input. It is the most stable asset to store value, accounting for more than 50% of total assets hold by rural households in India (Sharma, 1994). Owning land also symbolizes social status such as entitlement, power, and privileges (Sharma, 1994). In Korea, the author's native country, owning land causes such jealousy and envy that there is saying, "if a cousin buys a plot of land, I have a stomach ache."

Despite the importance of land in socioeconomic aspect of rural societies, research on how farmers actually determine the value of land and what kind of external factor influences the perception is hard to find. The motivation of this paper is to fill this gap.

I look for the link between technology adoption, one of possible external factors, and land value. Specifically, this paper tests the hypothesis that an adoption of new improved variety impacts on the perceived land value. Since a controlled experiment of a crop adoption by farmers is seldom feasible, the main hurdle of the empirical analysis is to tease out the impact of the adoption from other factors that influence land value.

In an non-experimental study, the preferred situation would be that we have one group that adopts a new variety and another similar group who does not due to some exogenous reason. Then the comparison between two groups would reveal the land value appreciation associated with the adoption assuming the econometric model is correct. However, when most farmers in a village adopt the variety, a different approach for the analysis is needed.

I attempt an roundabout way to deal with this problem. By identifying and comparing groups with different degree of risk aversion in crop adoption, I show the systematic difference in perception of land value among the groups. This way, I find the relationship between adoption and land value.

Cropping pattern was used as a proxy for the degree of risk aversion. Risk loving farmers fully adopt the new crop in the initial year when the seeds were available, while other groups adopt partially. The group, which is more willing to adopt the new improved crop, expect higher profitability from the land. Hence, the group would value the land higher than other groups after the initial year of adoption.

My analysis shows that there is a statistically significant difference in the land value between a group with full adoption and another group with partial adoption after controlling for other factors. I find no evidence of any difference among groups in the trend of land value before the adoption.

The analysis is based on the historical event of the adoption of Castor Aruna, a high yield variety, in Aurepalle Village in early 80's. Aurepalle was one of six study villages of ICRISAT's Village Level Studies project in semi-arid tropics in India. I present the historical background in the main section.

The theoretical framework of the analysis is two fold: 1) I evaluate the determinants of land values based on Ricardian Rent Theory; and 2) I develop a simple model that explains the different degree of risk aversion of adopting a new crop leads to varying level of land value.

Followed by the framework, I introduce an econometric model based on opinions of land valuation gained from farmers who were the respondents of the VLS data. Since the perceived land values are recorded by the farmers themselves, this ensures the specification to capture important factors influencing land values.

Least Squares Dummy Variable Method was used for the estimation. The method exploits panel structure of data to control for important unobserved time-constant factors, such as road access.

Finally, I discuss the results and conclude with implications of the analysis.

2 Literature Review

This paper's unique contribution is to investigate whether an adoption of new technology, an improved crop, has influences on land values. While I do not find similar papers that link crop improvement and the land value, the literature provided insights related to this issue.

Goodwin et al. (2003) explain that the value of the farm land has to take account for the option of being converted to alternative uses, such as commercial or residential real estate in the future. Omission of non-agricultural demands may bias estimates.

Just and Miranowski (1993) tell us that inflation not only reduces the rate of capitalization of future returns but land serves as a hedge against inflation. But they warn that mechanism by which inflation affects land values is not clear.

Coughlin and Keane (1981) raise an important issue about information: the sale of land at prices above those that had prevailed in an area will tend to increase the value of all land since prices convey information and owners will therefore raise their expectations. Even if only relatively small amounts of land are sold for non-agricultural uses, the land values in the affected area will tend to rise.

Folland and Hough (1991) look at the impact of a nuclear power plant on nearby agricultural land value. They argue that the nuclear effect enters not by altering the rental rate of land, but by altering the *probability* of receiving that rent. They let people differ in their degree of risk aversion and beliefs about the probability of a meltdown. The subjective probabilities of an accident will increase over time as the reactor ages.

Roka and Palmquist (1997) argue that the functional form of a hedonic pricing model must be determined empirically. They recommend a limited Box-Cox analysis using linear, semilog, and double log specifications. Their land value analysis is also based on farmers' opinion hence they raise the concern the mismatch between perceived land value and the market value.

Xu et al. (1993) also use hedonic pricing of land: 1) a given parcel can be identified by a unique set of attribute levels and 2) the value of a land parcel is an aggregation of the values of its individual attributes. These are proxy for the expected net return to land which are generally unobservable. Land value is affected by the presence of the large and rapidly growing urbanized area. Also, land value has speculative component which arises from the expectation that land values will follow some trend into the future. The market for large parcels is thinner with fewer buyers because of the need for access to more substantial financial resources. There is a positive effect of irrigation systems. Having water access would have impact on the farmers dryland value as well as irrigated land value.

3 Historical Background

First I describe Aurepalle Village during 70's and 80's where my analysis is based on. Then I explain the historical event of the adoption of new variety, Castor Aruna.

3.1 Aurepalle Village

Aurepalle is a rural village in Mahbubnagar District in Andrah Pradesh, India. The village belongs to semi-arid tropics where annual rainfall ranges from 400 to 1,200 mm (Walker and Ryan, 1990). Semi-arid agriculture depends on monsoon and suffers frequent drought (Kurosaki, 2005). Rainfall is low and its annual fluctuation is high. Red soil with low moisture retention capacity is the most common soil type in the village. Monsoon season, *Kharif*, is the main cropping season. On rain-fed land, pearl millet, sorghum, castor are grown whereas on irrigated land, paddy is cultivated.

Aurepalle has diverse economies. Production of sheep and toddy were two very important non-crop activities (Pender and Kerr, 1998). About half of Aurepalle households are low caste shepherd or toddy tappers. Hence the village has large proportion of low caste people and many of them are relatively well-off. These groups have become prosperous due to rising prices of meat and toddy. Both have invested in the purchase and improvement of agricultural land, due to the paucity of alternate investment opportunities.

Land is an attractive asset for the villagers. Farmers explain that land is prized as an asset that holds its value (Kerr and Pender, 2005). As income rises, villagers, including the landless, tend to purchase land. Many purchased land through self-generated savings (Walker and Ryan, 1990). Agricultural produce is not taxed in India, further enhancing the attractiveness of land relative to alternative assets (Kerr and Pender, 2005).

However, Walker and Ryan also point out that acquiring more rain-fed land was a much less profitable alternative than investing in irrigation and seizing the limited off-farm investment. Therefore, there were less acquisitive pressures on predominantly rainfed land in the study villages including Aurepalle. Imigration and emigration has not contributed significantly to change in ownership in 70's and 80's as well (Walker and Ryan, 1990). Concentration of landholding has not increased appreciably in any of the study villages that time.

3.2 Adoption of Castor Aruna

Castor Aruna, an early maturing high yield variety, was introduced in late 70's in Andrah Pradesh. It was a successful cultivar that was grown by farmers for more than two decades since its introduction (Padmaiah, personal communication, 2009). Farmers in Aurepalle were no exception. Farmers had access to Aruna seeds since 1981 through private input shops and Agricultural Office in Amangal, a bigger town near Aurepalle. The Agricultural Office promoted Aruna to farmers. Within two years of initial introduction of Aruna, more than 80% of gross cropped area of castor was covered by Aruna (see Figure 1 on page 6).

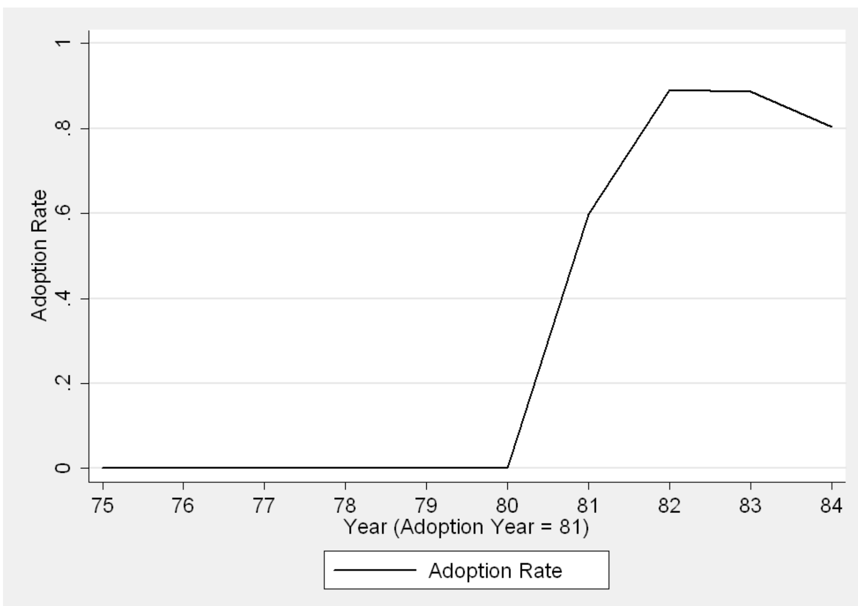

Figure 1: Percentage of Total Acreage Planted with HYV Castor in Aurepalle Village

Many factors contributed the success of Aruna. The yield was higher compared to the local variety. Farmers told me that traditional variety produced 3-400 kg per acre whereas Aruna produced 5-600 kg per acre. The plant was shorter and therefore it was easier for farmers to harvest. Aruna had shorter duration compared to local variety, which is an important trait in drought-prone semiarid tropical environment faced by the villagers. According to farmers in the village, there were no differences in prices between the local variety and Aruna.

However, Aruna also had unfavorable characteristics. Farmers said that Aruna was more prone to diseases, particularly Powdery mildew, whereas the local variety was resistant to it. Fusarium Wilt, a fungal disease becomes a serious problem in 90's for Aruna (Padmaiah, personal communication, 2009). Botrytis Grey Rot was another fungal disease that were appeared in epidemic form during 1987 in Andhra Pradesh (Directorate of Oilseeds Research, 2005). Due to these problems, otherwise successful Aruna was replaced by other varieties and hybrids such as Kranthi, which was officially released in 1996. Resistant to Botrytis and wilt becomes an important trait. Most varieties and hybrids released after mid-90's have resistance characteristic to them (Lavanya and Mukta, 2008).

Farmers could not identify any name of the local variety grown in Aurepalle. I speculate that this is due to the castor's highly cross pollinating nature. A study documented that pollen traveled 270m from the source in the windward direction if the sky is clear and the wind velocity is above 20km per hour (Directorate of Oilseeds Research, 1990). Hence the local variety is likely to be a mixture of several varieties. Farmers generally described the local variety as having a tall plant height with lower yield potential compared to improved varieties or hybrids.

4 Model of Land Value

In this section, I develop a theoretical framework for the empirical analysis.

Table 1: Sales of ICRISAT input supply store in Aurepalle in 1981-82

Castor Type	Unit Price (Rs/kg)	Total sales (kg)	No. of farmers who purchased
Aruna	7.3	488.5	68
GAUCH-1	9.6	49.5	8
R-63	7	16.5	5

Source: ICRISAT (1984)

Price of any commodity is determined by the forces of demand and supply. However, variations in the perceived land value come from only demand side since the supply of land is more or less fixed. A major determinant of land demand is the expected profitability of using land.

4.1 Expected profitability

According to Ricardian Rent Theory, the value of farming land is a function of the expected profitability of the land. In mathematical terms,

$$landvalue = f(E\left[\sum_{t=1}^{\infty} \frac{R_t}{(1+k)^t}\right]) \tag{1}$$

where *landvalue* is current value of land, R_t is the expected net returns to land in time t, and k is the discount rate. This implies that the current land value is the sum of total discounted present value of net returns to land.

4.2 Other Demand Factors

Other possible demand factors are: demand of land as an attractive asset to store value, the speculation that the land value would increase no matter what as time passes by, etc. I incorporate these factors in vector **D**. Hence,

$$landvalue = f(\pi, \mathbf{D}), \qquad \pi = E\left[\sum_{t=1}^{\infty} \frac{R_t}{(1+k)^t}\right] \tag{2}$$

4.3 Change in Technology : HYV Castor Adoption

An introduction of new technology enables the land to be used more profitably and this information will be capitalized in the value of land. When there is a technology improvement, future net returns to land, R_t will change to R_t', where $R_t < R_t'$ for all period t. This results in higher π and, other things equal, land value will increase.

$$\frac{\partial landvalue}{\partial \pi} = \frac{\partial f}{\partial \pi} > 0 \tag{3}$$

Will farmers form different expectations on profitability when High Yield Variety (HYV) Castor is being introduced? Yes, if farmers have varying degree of risk aversion on adopting new technology, even if other conditions are assumed to be the same among farmers. Relatively risk-loving farmers will be more optimistic in estimating profitability. Hence, farmers' risk taking behavior influences π.

Growing a new variety has risks. Risks come from the lack of information: farmers do not know whether the HYV castor would indeed show higher yield; the new variety might fetch less price compare to a local one; it might be more vulnerable to pests or diseases and hence more crop failures would occur, etc.

4.4 Model: Expected Profitability Discount

Suppose there are three farmers A, B, C who have been growing a local castor variety. Each has an identical one-acre plot. Farmer A is the most risk loving among three; he is willing to adopt the new technology. B is more cautious and a moderate risk taker. C has reservations on adoption, i.e. relatively risk-averse.

Other than differences in degree of risk aversion, I assume other characteristics that affect profitability of land do not differ.

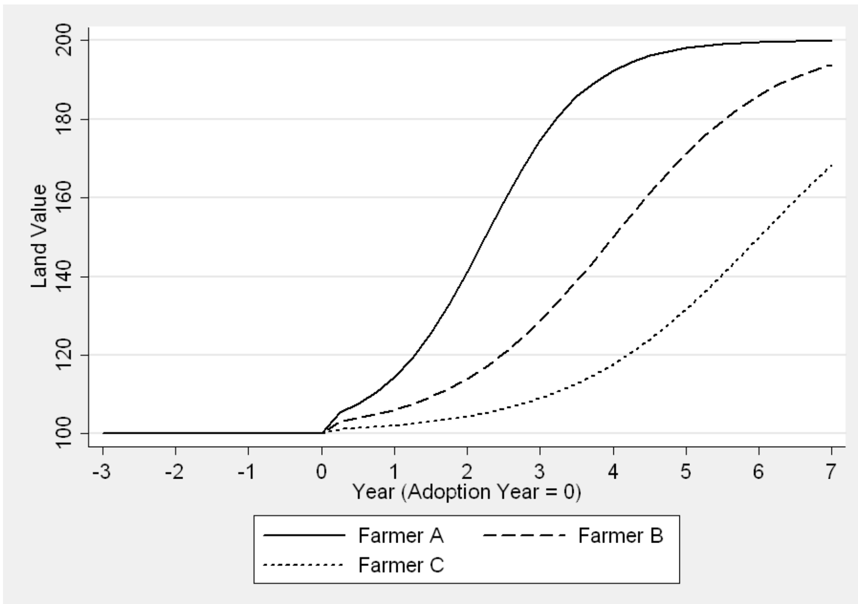

Figure 2: Adoption Risk and Change in Land Value

I introduce the benchmark expected profitability of all future period $\overline{\pi}_t$, with complete information and all risk factors properly incorporated, calculated at year t. Each farmer discounts the benchmark with a scaling factor θ, due to risks that come from incomplete information. $\overline{\pi}_t$ is a special case of π_t^i with $\theta_t = 1$, that is, no discount. The risk-loving Farmer A discounts the expected profitability less than others. She has a higher θ.

$$\pi_t^i = \theta_t^i \overline{\pi}_t, \qquad i = A, B, C \tag{4}$$

$$0 < \theta_t^C < \theta_t^B < \theta_t^A < 1, \qquad \text{for all } t \geq 0$$

where π_t^i is the expected profitability of farmer i's one-acre plot at year t and θ_t^i is the scaling factor of farmer i at year t.

Before the initial year of the introduction of the new crop (initial year $t = 0$), the land values are same for all farmers. The improved crop is not available and thus there is no risk due to an adoption of a new variety. When they have access to the new technology, all adjust the expected future net return since now they expect higher returns. Farmer A has the highest expectations and C the least. That is,

$$\pi_t^A = \pi_t^B = \pi_t^C, \qquad t < 0 \tag{5}$$

and,

$$\pi_t^C < \pi_t^B < \pi_t^A, \qquad t \geq 0 \tag{6}$$

Therefore, if other factors $\mathbf{D}$ does not differ among them, Farmer A tends to value her land more when the new crop is introduced.

$$landvalue_t^C < landvalue_t^B < landvalue_t^A, \qquad t \geq 0 \tag{7}$$

where $landvalue_t^i$ is the value of the land of farmer i at time t.

As farmers gain more experience in growing the new crop, they have more information. Risks are more accurately adjusted and discounts become less. As a result, the scaling factors for all farmers increase and converge to one as years go by. The difference in the expected profitability and land value among farmers narrows. That is,

$$\text{For all } i, \qquad \theta_t^i \longrightarrow 1 \quad \text{as} \quad t \longrightarrow \infty \tag{8}$$

This implies,

$$\pi_t^i \longrightarrow \overline{\pi}_t, \tag{9}$$

$$landvalue_t^i \longrightarrow \overline{landvalue}_t \tag{10}$$

where $\overline{landvalue}_t = f(\overline{\pi}_t, \mathbf{D})$.

Figure 2 on page 10 explains the model visually. Assume that the true impact of adopting new technology enables farmers' land value to double from 100 to 200. Holding other things equal, farmers discount the impact on the land heavily during initial years but gradually reach the true value as they have more information. In the figure, Farmer A reaches the true land value in less than six years. Farmer B and C lag behind but slowly catch up.

5 Econometric Models and Estimation Methods

Freedman asks following fundamental questions regarding empirical analysis (2006): 1) Which variables to enter in the regression? 2) What functional form to use? and 3) What assumptions to make about parameters and error terms? In other words, understanding on how data were produced is crucial. My approach is to ask farmers in Aurepalle village, the actual generators of data.

I test the hypothesis that farmers value lands differently due to the risk of adoption. First, using the information obtained from farmers, I list important factors that affect the land value to tease out the impact of new castor from other sources of change in land value. Second, I classify these factors into two types: time variant and time invariant. Third, I divide farmers into three groups with different degree of risk aversion. And finally, I introduce an estimation method suitable for the data analysis.

5.1 Determinants of Land Valuation

To draw inference from a finite data set when there are potentially an infinite number of parameters, some prior information is needed which constrains the ranges of the parameters (Leamer, 1983). The prior information for this analysis comes from Aurepalle farmers who were the actual respondents of the old VLS data.

To identify the factors influencing land value and to specify an adequate econometric model, I asked the farmers in Aurepalle how they actually value their lands (see Table 2 on page 15). Farmers seem to mostly rely on: 1) inherent soil quality; 2) infrastructure for farming, especially the distance from roads; 3) water source; and 4) any information on land transaction when they value their land.

Soil quality, infrastructure and water source are related to the productivity of land as farm use. More productive land is likely to lead to higher net returns. Therefore, these factors are associated with the expected profitablity of land π.

Information on recent land transaction influences every farmer's land. One respondent of VLS said that he adjusts the value of his land according to the recent purchasing price of lands that share similar land characteristics with his. This way, farmers incorporate the updated information on other demand factors on their land valuation. This factor exert an upward pressure on land prices since land sellers adjust the price floor (minimum price they willing to accept from buyers) according to transaction information.

Farmers did not think that urbanization was an important factor in 70's and 80's.

I also add the component of the impact of the introduction of HYV castor on the expected profitability (hyv) with its scaling factor θ.

I specify the econometric model as,

$$\begin{aligned}\log(landvalue) &= \beta_0 + \beta_1 soil + \beta_2 water + \beta_3 infra \\ &+ \beta_4 transactions + \theta hyv + \varepsilon\end{aligned} \tag{11}$$

where $soil$ is the soil type, $water$ is water source, $infra$ is infrastructure for farming, and $transactions$ is the adjustment of land value accroding to recent land transactions. ε is the error term.

The functional form for the dependent variable is logarithmic. This choice is based on the observation on farmers's way of land valuation. They seem to use ratios between plots with different characteristics, rather than attaching specific monetary values for them. For example, farmers say, the value of a plot x with characteristic a and b is q times higher than another plot with characteristic c and d. They do not say, for characteristic a add r rupees and for b substract s rupees. In other words, the perceived land value is determined by percentage differences for varying characteristics. Therefore, logarithmic dependent variable is more suitable functional form than using linear dependent variable.

5.2 Time Variant and Invariant Factors

Other than water source and land transaction, all other factors that influence land value remained constant between 1975 and 1984 (see Table 2). Soil type rarely changes over time. According to farmers that I interviewed, including a former patwari (land record clerk), a land middleman, and the old VLS respondents from different caste backgrounds, no new road was built between 1975 and 1984. Road improvement only started in early 1990s. Electric grid did not change either.

I assume the presence of palm trees were time-invariant. Marginal cost of

Table 2: Farmers' List of Determinants of Land Valuation

Factors Influencing Land Value	
Factors	Time Variant
• soil quality	No
• access to road	No
• water source	Yes
• any new transaction of land purchase in the village	Yes
• electricity (for using electronic water pump)	No
• presence of palm trees	No

Factors NOT Influencing Land Value
• price of crops or seeds
• any bumper harvest or drought in a given year
• chemical application
• land size (affect land price only when on sale)
• soil erosion

Source: Personal Interviews

keeping a palm tree that occupies small land plot is negligible compared to marginal benefit of profit one can earn from tapping toddy and its aesthetic appeal.

Existence of water source changed over time. Open dug wells have increased by 26% between 1974 and 1984 period (ICRISAT, 1984). Farmers have incentives to establish water source since increased water access enables more irrigation. Also, because wells are mostly privately owned (80 %), a farmer retains all the benefit of investment on wells. In fact, most of investment made by farmers in Aurepalle in that period were related to digging or deepening wells (ICRISAT, 1984).

Information on land transactions constantly affects every farmer's land valuation and therefore a time variant factor.

5.3 Groups with Different Degree of Risk Aversion

I use the cropping pattern in VLS data as a proxy to the risk-aversion characteristics of farmers. When HYV castor was initially available to Aurepalle villagers in 1981, one group fully adopted the new variety (Group A). Despite the information deficiency on the new crop, Group A readily adopted the HYV castor. Another group planted both the local and the high yield variety (Group B). Group B seems less enthusiastic about the new crop compare to the former. Others continued to grow the local castor (Group C). This group might have waited until the first harvest of other groups came out.

5.4 Estimation Method: Least Squares Dummy Variable Method

I use Least squares dummy variable method for the estimation to account for all unobserved, time-constant factors that effect land value (Greene, 2003). This method uses dummies for each plot id and household id to control for heterogeneity so that least squares method can consistently estimate coefficients.

The general econometric model is,

$$\log\left(landvalue_{it}\right) = \boldsymbol{x}\boldsymbol{\beta} + \alpha_h + \delta_i + \gamma_t + \varepsilon_{it} \qquad (12)$$

where $\log\left(landvalue_{it}\right)$ is the value of plot i at time t, the vector $\boldsymbol{x}$ contains all explanatory variables that varies over time, α_h is household fixed effect, δ_i is plot fixed effect, γ_t is year fixed effect, and ε_{it} is the error term.

Soil quality, access to road, electricity, presence of palm trees are all time invariant and hence included in δ_i.

α_h controls for individual farmers' characteristics such as education level, management skill or castes that might influence perception on land value.

Though soil type rarely changes over time, I also add soil type dummies as explanatory variables because of a high correlation between certain soil type and water source would cause multicollinearity problem. The actual magnitude of difference in land value due to differing soil types is interesting in itself as well.

I control water source by adding irrigation source dummies.

Transaction information is capitalized to land value every year for all villagers when the land values are recorded in the VLS data. Since the information affects everyone but changes over time, year fixed effect γ_t contains this factor.

Group A,B,C vary in the scaling factor θ_t, and it gradually tends toward one every year. Group A has the highest θ_t. An increase in the scailing factor (θ_t) increases the expected profitability, and hence land value. Therefore, the year fixed γ_t effect also contains θ_t which differs among groups.

The final specification is,

$$\log\left(landvalue_{it}\right) = \boldsymbol{S\beta} + \boldsymbol{W\eta} + \alpha_h + \delta_i + \gamma_t + \varepsilon_{it} \tag{13}$$
$$\gamma_t = g(transaction_t, \theta_t)$$

where $\boldsymbol{S}$ is soil type dummies and $\boldsymbol{W}$ is water source dummies.

Since $transaction_t$ is assumed to affect all group in same manner for each year, the difference in γ_t for each group primarily comes from θ_t.

6 The Data: ICRISAT-VLS

Kurosaki (2005) sums ICRISAT Village Level Studies (VLS) Data well. He explains:

> ... the ICRISAT implemented both intensive and extensive household surveys to collect socioeconomic information at the micro level.

> These surveys conducted in the ten-year period from 1975 (cropping year 1975/76) to 1984 (cropping year 1984/85) are famous for its detailed information on agricultural production as well as rural economy.
>
> This dataset is called "old VLS" ... (it is also called "First generation VLS" among several ICRISAT economists).
>
> ... within each of six survey villages, forty households (ten each from farming categories of landless laborers, small farms, medium farms, and large farms) were surveyed each year. Out of the six villages, three (Aurepalle, Shirapur, and Kanzara) are especially famous among development economists, because they were surveyed continuously throughout the tenyear period. Because of its rich information, the old VLS dataset has been used extensively in the literature on microeconometric analysis of development.

I use Plot and Cultivation Schedule (Schedule Y) of old VLS for the analysis. Only Aurepalle village data are analyzed. The data contain the household number, plot code, area of the plots, irrigation source, soil type, value of land, crop patterns, etc. The manual written by Singh et al. (1985) offers detailed explanation on the data set.

Variables that are used for the empirical estimation is presented in Table 3 on page 19.

The manual describes the value of land variable as,

> Per acre estimated value of the plot in 'Rs. 100' are recorded based on the information obtained from either patwari or some knowledgeable person in the village. While recording the values of the plot potential sale value of the plot considering location of plots, irrigation, topography ect. are considered.

However, the land value variable is actually the perceived land value by farmers. Farmers whom I interviewed indicated that it was respondents themselves who recorded land value on the Plot and Cultivation Schedule questionnaires. While it is possible that knowledgeable person might have helped respondents to record land value and set the benchmark value for the initial year, it is unlikely that people other than respondents continued recording land valuations. I

Table 3: Variable Descriptions

Dependent Variable : $log(landvalue)$	
landvalue	per acre percieved value of the plot (in Rs. 100)
Independent Variables	
$y76 - y84$	year fixed effects (e.g., for y76, =1 if year is 1976, 0 otherwise)
$GrpA76-$	interaction terms, GroupA dummpy (=1 if Group A, 0 otherwise)
$GrpA84$	times year fixed effects
Soil Type	
soilmb	=1 if a plot is medium black soil, 0 otherwise
soilsb	=1 if a plot is medium to shallow black soil, 0 otherwise
soilsr	=1 if a plot is shallow red soil, 0 otherwise (reference dummy)
soilgr	=1 if a plot is gravelly soil, 0 otherwise
soilbad	=1 if a plot is problem soil, 0 otherwise
Irrigation Source	
irrtk	=1 if irrigation source is a tank, 0 otherwise
irrem	=1 if the source is an open dug well with an electric motor, 0 otherwise
irreo	=1 if the source is an open dug well with an oil engine, 0 otherwise
irret	=1 if the source is an open dug well with a traditional device, 0 otherwise
irrnd	=1 if the source is not defined while the plot is irrigated, 0 otherwise

Table 4: Summary Statistics

Variable	**Mean**	**Deviation**	**Minimum**	**Maximum**
soilmb	.097	.296	0	1
soilsb	.211	.408	0	1
soilsr	.646	.478	0	1
soilgr	.017	.128	0	1
soilbad	.028	.165	0	1
irrtk	.025	.157	0	1
irrem	.361	.481	0	1
irreo	.019	.138	0	1
irret	.037	.188	0	1
irrnd	.005	.072	0	1
Number of Observations = 1,141				

asked a residence investigator in Aurepalle, who deals with VLS data collection for ICRISAT, about the issue and his answer was also that farmers are the ones who writes land values.

I modify actual irrigation variable to “irrigability” variable. The irrigation source was recorded only when the actual irrigation has taken place to plots. This is misleading for land valuation purpose. If a farmer has an open dug well in his field, it is more or less permanent water source. In the dataset, irrigation source disappears if the plot is not irrigated. Since water source exits regardless of irrigation, I looked for earliest irrigation source and put it to all subsequent years as a permanent irrigation source. I also checked if there is any change in irrigation source for each plot. Changes were rare. Only available irrigation source in 70’s and 80’s was tanks and open dug wells, which is quite costly for farmers to build.

I also constructed plot identification number from plot code of Schedule Y. The manual describes plot code:

> Main plots are coded with one-letter codes such as A, B, C, etc. Subplots receive two-letter codes such as AA, AB, AC, etc. These subplots refer to subplots of main plot, A. Sometimes even the subplots are further divided into small plots and they are coded as AAA, AAB, AAC, etc. These plots refer to part of main plot A and subplot AA.

Each plot id numbers is generated by adding the household number, which is multiplied by 100, and one-letter main plot code that is converted to numerical number. For example, if the household number is 32 and plot code is B, the plot id becomes 3202.

I only use main plot codes and ignore subplot codes. While the code for main plots do not vary, subplots codes seem to change across years. The problem of using subplot code is that the subplots, which were recorded in schedule Y, do not seem to be based on the physical location of each subplot. Rather, my view is that subplots were divided by cropping patterns each year. Therefore subplot codes are not useful for my analysis. The main reason of creating plot id is to use them in the estimation to account for time-constant unobserved factor, particularly road access, of plots. If subplot codes A has different physical location every year, plot id cannot do the job. Thus I stick to the main plot code for plot id.

Using only main plot code for plot id is equivalent to implicitly assuming that the subplots of a main plot shares same unobserved factors that affect land value. This assumption can be strong in some cases. One example is the distance from the road. Subplots could have quite different distances from the road, especially if the main plot is large in size. However, large farmers tend to classify their whole land with higher number of main plots (usually two or three but some even have more than ten). I shall maintain this assumption for the analysis.

As mentioned earlier, I identify three groups with different degree of adoption risk aversion using crop pattern as a proxy. The crop pattern variable in Schedule Y divides castor into two category: a local variety and HYV. Group A is defined as farmers who grew only HYV castor in 1981. The crop pattern of Group B contains both local and high yield variety in that year. Group C cultivated only the local variety.

7 Empirical Results

The main objective of the estimation is to compare the trend of land values among different groups. My hypothesis is there is a difference in the trend after controlling for all relevant factors determining land values. The trend captures the different level of discount of expected profits. The year fixed effect estimates

Table 5: Comparison of Means for Groups A, B, and C

Variable	Group A	Group B	Group C
soilmb	.06	.1	.1
soilsb	.19	.22	-
soilsr	.73	.49	.7
soilgr	.00	.2	-
soilbad	.02	-	.19
irrtk	.02	.01	-
irrem	.35	.16	-
irreo	.04	-	-
irret	.03	.05	.1
irrnd	.00	-	-
Number of Large Farmers	8	1	1
Number of Medium Farmers	2	3	2
Number of Small Farmers	5	1	1
Total Number of Farmers	15	5	7*
Number of Observations	698	215	106

Note: mean values are computed using plot area as weights
* three laborers belong to Group C

the trend and hence tests the hypothesis.

Table 6 on page 23 shows the year fixed effects of three different groups after controlling for soil quality, water source, household and plot fixed effects. Reference year is 1976. The coefficients are interpreted as the percentage change in land value from 1976. For example Group A's coefficient of $y78$ means the land value has increased about 56% from the land value in 1976. More precisely, it is about 75% since $e^{.56} - 1 \approx 0.75$.

Prior to 1983, two years after the initial adoption of Aruna, the trend of land value among groups do not vary much. Except the year in 1977 in which there are 13% difference in the trend between Group A and Group C, other years before 1983 have less than 10% difference.

However, later years shows significant difference, especially Group A and Group B. The coefficient of Group A's year fixed effect is 1.28 in 1983, which is much higher than that of Group B (1.04) or Group C (0.94). Group A's land value becomes 32% higher in 1984, the last year we have in data. Figure 3 on

Table 6: Regression: Year Fixed Effect by Group

Dependent Variable = $log(landvalue)$			
Model	(1)	(2)	(3)
Variables	Group A	Group B	Group C
$y76$	0.03	-0.01	0.07
	(0.03)	(0.06)	(0.05)
$y77$	0.37***	0.43***	0.50***
	(0.03)	(0.06)	(0.05)
$y78$	0.56***	0.55***	0.60***
	(0.03)	(0.06)	(0.05)
$y79$	0.60***	0.65***	0.65***
	(0.03)	(0.06)	(0.05)
$y80$	0.68***	0.74***	0.69***
	(0.03)	(0.05)	(0.05)
$y81$	0.84***	0.76***	0.77***
	(0.03)	(0.05)	(0.05)
$y82$	0.89***	0.80***	0.73***
	(0.03)	(0.05)	(0.05)
$y83$	1.28***	1.04***	0.94***
	(0.03)	(0.05)	(0.05)
$y84$	1.50***	1.18***	1.11***
	(0.03)	(0.05)	(0.05)
Observations	698	215	106
R^2	0.93	0.93	0.94
$\overline{R}^2$	0.92	0.92	0.93

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

page 24 explains the trend graphically.

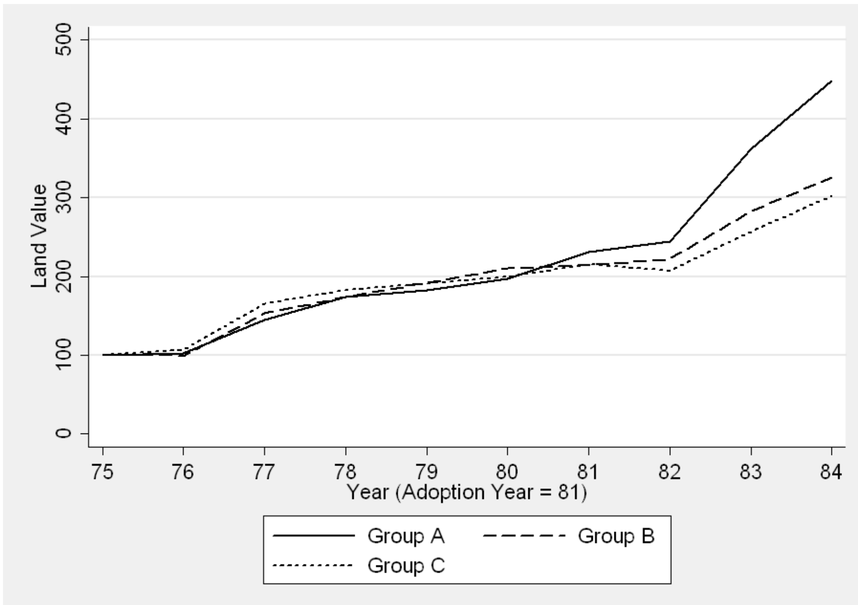

Figure 3: Land Value Index (1975 = 100)

In the first two years of adoption, 1981 and 1982, I do not find much difference in land value for any group. The heavy discount of expected profitability due to uncertainty of the yield of Aruna might be the reason behind it. Nonetheless, Group A has higher coefficients starting from 1981, which is consistent with the model that Group A has higher expectation on profitability of the new crop and hence higher increase in the trend of land value.

To check whether the year fixed effects of Group A and Group B are statistically different, I pool Group A and Group B and run another regression with the same specification but added interaction terms with Group A dummy (1 if a plot belongs to Group A and 0 otherwise) and year dummies. Statistically significant interaction terms imply that there are differences in year fixed effects between two groups (Table 7 on page 25).

Not surprisingly, interaction terms in 1983 and 1984 are highly significant.

Table 7: Pooled Regression: Interaction terms (groupA * year)

Dependent Variable = $log(landvalue)$	
Model	(1)
Variables	Pooled
$GrpA76$	0.03
	(0.07)
$GrpA77$	-0.05
	(0.07)
$GrpA78$	0.00
	(0.07)
$GrpA79$	-0.05
	(0.07)
$GrpA80$	-0.06
	(0.06)
$GrpA81$	0.08
	(0.06)
$GrpA82$	0.09
	(0.06)
$GrpA83$	0.25***
	(0.06)
$GrpA84$	0.32***
	(0.07)
Observations	913
R^2	0.93
$\overline{R}^2$	0.92

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The interesting case is if interaction terms are statistically different from zero, which means there *is* a difference, in first two harvest years of the initial adoption. I expect the coefficients of Group A to be higher. Therefore, against the one-sided alternative, I test

$$\mathrm{H}_0 : \mathrm{GrpA81} = 0 \text{ against } \mathrm{H}_1 : \mathrm{GrpA81} > 0 \tag{14}$$

and

$$\mathrm{H}_0 : \mathrm{GrpA82} = 0 \text{ against } \mathrm{H}_1 : \mathrm{GrpA82} > 0 \tag{15}$$

The p-values are about .115 for 1981 and .074 for 1982. While not strong, there is some evidence against the null hypothesis in both cases.

Compare the Figure 2, the hypothetical situation based on the model, and Figure 3. The trend of land value of the former shows horizontal before the adoption but the latter has an upward slope. The upward slope is caused by the gradual increase in Vector **D** while I assume it to be constant in the former's case. Consistent with the model, the estimated trend of land value diverges among groups after the initial year of adoption. The estimate shows there is at least 30% difference in land value between Group A and Group B.

I do not have data to evaluate whether the trends would converge as Figure 2 shows. I expect that the growth rate of land value of Group A slows down and both Group B and Group C will catch up as farmers gain more experience in growing Aruna. But the availability of data limits further analysis.

Why did the land values increase with faster rate for all groups after 1983? One possible explanation of the increase in the growth rate of land value for all groups is the externalities of castor seed production. Since castor is a highly cross pollinated crop, the presence of local variety in neighboring farm causes the parental lines of Aruna to deteriorate when the seeds are reused.

However, By 1983, more than 80% of castor growing area was covered by Aruna. As the proportion of Aruna growing area dominates, there is less chance of seed deterioration. Since quality seeds can potentially maintain the good characteristics for at least four to five years (Directorate of Oilseeds Research, 2007), less deterioration of seeds reduces the input cost of buying seeds from input shops and possibly increase the expected profitability of all groups growing castor.

Another possible reason is that there was a land transaction with the purchasing price that were significantly higher than what farm owners have valued. This can cause farmers to adjust their land value upward. While the information on land value is widely shared within the village, it might be the case that the information was not available to villagers with lower caste with non-farm occupations. When they buy lands that are over-priced due to lack of information to properly evaluate land, this type of transaction could act as a signal to land owners that their land can fetch more. it would exert upward pressure on land value of all land owners.

8 Robustness

This section contains, 1) a comparison of regression results with and without fixed effects, 2) a test for functional form choice using Box-Cox method, and 3) a sensitivity analysis with outliers.

Without any fixed effect that controls for time-constant variables, such as road access, estimates are biased due to omitted variable problem. To compare the estimate results using various specification, I pool all groups with variations in fixed effects. Model (1) in Table 8 on page 36, which do not include fixed effects α_h and δ_i, shows wrong signs in *soilgr* and *irrtk*. Since gravelly soil has inferior crop productivity compare to shallow red soil (reference soil type), I expect a negative coefficient for *soilgr* whereas the estimate shows a positive one. Presence of irrigation source is expected to increases the land value, but model (1) predicts that irrigation significantly *decreases* the land value by 12%. *irrnd* has expected sign in Model (1) and (2) but opposite sign in Model (3) and (4). However, only the coefficient of Model (2) has statistically significant from zero. Other models with fixed effects seems to show expected signs.

Only small number of observations have the value of 1 for *soilgr*, *irrtk*, *irrnd* (19, 29, 6 respectively out of 1,141 observations). Coefficients for these variables can be quite sensitive to changes using different specifications and one must be careful in comparing coefficients of variables with such small number of observations. Nonetheless, wrong signs with statistical significance of the coefficients of these variables suggest that model (1) which does not control for heterogeneity might be misspecified. I suspect that *irrnd* might be a reporting error. Observations with irrigation without water source do not seem reliable.

Model (3) and (4) have similar results whereas the Model (2) is somewhat differ in coefficients. The values of coefficients of Model (2) seem to be in between those of Model (1) and Model (3), (4). Model (2) has household fixed effect but do not account for plot-specific time-invariant factors. It might be possible that household fixed effect adequately captures heterogeneity even without plot fixed effects. If so, do the trends of land values from Model (2) differ from Model (4), the original model?

Figure 4 on page 35 shows the result. Except first two initial years of adoption, the overall result points toward the same conclusion; Group A values land higher than Group B and Group C. However, unlike the original specification, I do not see the difference in the trend in 1981 and 1982 from Group A and Group B.

I chose the functional form of the dependent variable using a priori information of interviews of farmers. Here I do a formal test, using a method based on Box and Cox (1964). The procedure is simple (Dougherty, 2007). The main idea is to compare the residual sums of squares of regressions using linear and logarithmic dependent variable, *landvalue* and log(*landvalue*) respectively. Since the residual sum of these two regressions are not directly comparable, the observations on *landvalue* are scaled by dividing the geometric mean of the values of *landvalue* in the sample.

Define $landvalue_i^*$ as,

$$landvalue_i^* = \frac{landvalue_i}{\text{geometric mean of } landvalue} \tag{16}$$

where,

$$\text{geometric mean of } landvalue = (landvalue_1 \times \cdots \times landvalue_n)^{\frac{1}{n}} \tag{17}$$

Using $landvalue_i^*$ and $\log(landvalue_i^*)$ as dependent variables, I run regressions with original specification. Then the residual sum is comparable and the lower sum provides better fit. The residual sum of linear dependent variable is 111.06 whereas the residual sum of logarithmic dependent variable turns out to be 28.68. The test clearly favors the functional form of logarithmic dependent variable.

I conduct a sensitivity analysis with outliers to see if the conclusion is robust to exclusion of outliers in the sample. I follow Acock (2008) to identify outliers: first, run a regression with original specification and compute the residuals; second, standardize the residuals; and finally, look for residuals whose absolute values are greater than 2.58, corresponding to the two-tailed 0.01 significance level under the normality assumption. Using this procedure, I found 29 outliers in the sample (see Table 9 on page 37).

Regression estimates do not change much when outliers are excluded (compare Figure 5 on page 38 and Figure 3). The original specification is not sensitive to the presence of outliers.

9 Conclusions

So does an adoption of new cultivar impact on the perception of land value? I find empirical evidence that, after two years when the new cultivar becomes available, there are at least 30% difference in the trend of land value between a group willing to adopt a new cultivar and another group who are less willing.

To draw precise estimates, I paid particular attention to data generation process. Without understanding of how data are generated, no amount of statistical maneuvering will get very far (Berk and Freedman, 2003). Since farmers themselves produced data (perceived land values), I incorporate their opinions to answer the questions regarding the data generation: Which variables to enter in the regression? What functional form to use?

There are limitations. While the difference in the trend of land value among groups is statistically significant, this does not automatically imply that the adoption *causes* the land value to rise. Using regression with non-experimental data cannot establish causation only with statistical significance. Also, while unobservable heterogeneity was controlled for by exploiting panel structure of data, information on road access of each plot, one of important factors determining land values, is missing. Availability of road access would give more complete picture on how each component of factors contribute land values. Another weakness of the analysis is that minority of farmers belong to Group B and C. More balanced distribution of numbers of farmers for each group would help in comparing land value trends.

An implication of the empirical evidence from the analysis is that the impact assessment of crop adoption potentially underestimates the benefit of farmers since it does not account for the appreciation of value of their most important asset. Farmers not only gain from increased crop productivity using improved technology but also from appreciation of asset values arising from the capitalization of increased profitability due to adopting the technology.

Adopting a new cultivar might have spillovers. It is obvious that farmers, who adopt the new cultivar, benefits. The benefit can also accrue to who do not grow the crop but have plots cultivable for the crop. When the land values increase for farmers who *do* grow the crop, which lead to visible market transactions with increased prices, the vector **D** also increases. The vector **D** affects *every* land owners and lands values are adjusted in the next period.

Another implication is equity consideration. Appreciation in land value, as well as increases in profits, due to the adoption makes land owners better off. But laborers might lose out. While laborers also benefit from increased yield and productivity (e.g., share-cropping), higher proportion of benefit goes to land owners if an adoption of new cultivar impacts on land values. Laborers would also find it harder to purchase lands due to an increase in value.

An extension of this study would be an application of the models and the methodology described in this paper to different data with similar events of cultivar adoption and check the results. For example, Bt-Cotton replaced castor as the dominant cash crop in Aurepalle in last three years. Does the new hybrid impact on land value as well? Application to other data also has an added benefit of testing the plausibility of the estimation results of this paper. As Berk and Freedman (2003) point out, empirical generalizations from any single dataset is difficult. More application would reveal the strength of the argument presented here.

Aurepalle has experienced the influences of urbanization in recent years. The construction of Rajiv Gandhi International Airport and Fab City, an industrial zone, which are about 40 km away from the Aurepalle Village, displaced farmers near that area. They purchased plots in Aurepalle with the financial compensation from the government. This event introduced sudden boom in real estate in the village. In other words, the vector **D** has increased significantly. Conversations with farmers suggested that now variables that are related to urban use of land, such as road access and electricity grid, became much more important compare to variables for crop productivity, the traditional factor in determining land value. The study of this historical event would be another interesting research topic that links perception of land value and important changes that villagers face over time.

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Appendix

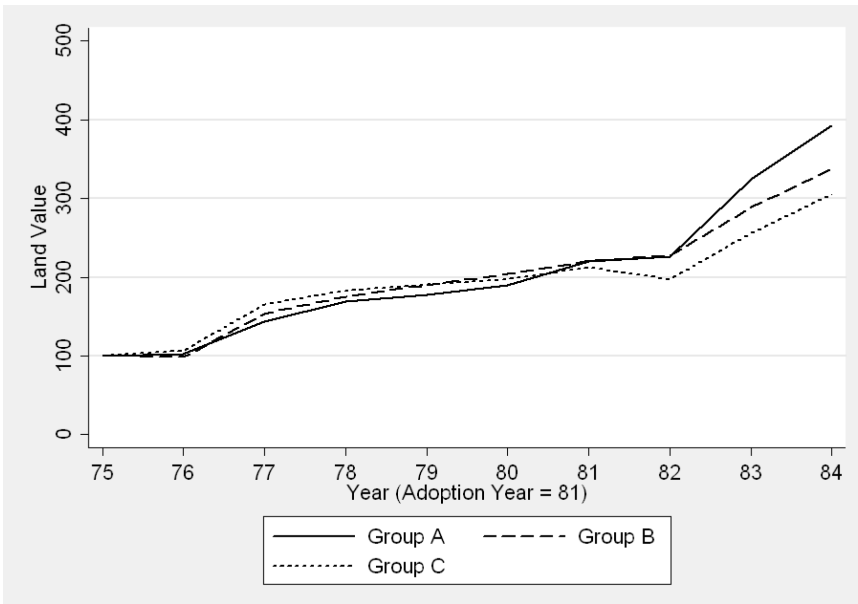

Figure 4: Land Value Index: Plot Fixed Effect Excluded (1975 = 100)

Table 8: Regressions with Varying Fixed Effects

Dependent Variable = $log(landvalue)$				
Model	(1)	(2)	(3)	(4)
Variables	No FE	Only α_h	Only δ_i	Both α_h δ_i
soilmb	0.56***	0.47***	0.25*	0.25*
	(0.03)	(0.03)	(0.13)	(0.13)
soilsb	0.29***	0.26***	0.27***	0.27***
	(0.02)	(0.02)	(0.06)	(0.06)
soilgr	0.23***	0.04	-0.36**	-1.99***
	(0.06)	(0.06)	(0.18)	(0.35)
soilbad	-0.31***	-0.19***	-0.38***	-1.84***
	(0.05)	(0.06)	(0.10)	(0.29)
irrtk	-0.12**	0.05	0.19***	0.19***
	(0.05)	(0.05)	(0.06)	(0.06)
irrem	0.56***	0.44***	0.24***	0.24***
	(0.02)	(0.02)	(0.04)	(0.04)
irreo	0.14**	0.26***	0.15***	0.34***
	(0.06)	(0.09)	(0.06)	(0.11)
irret	0.25***	0.15***	0.31***	0.51***
	(0.04)	(0.04)	(0.06)	(0.13)
irrnd	0.14	0.27***	-0.08	-0.08
	(0.11)	(0.09)	(0.19)	(0.19)
*y*76	0.01	0.02	0.02	0.02
	(0.03)	(0.03)	(0.02)	(0.02)
*y*77	0.38***	0.39***	0.39***	0.39***
	(0.04)	(0.03)	(0.02)	(0.02)
*y*78	0.53***	0.54***	0.55***	0.55***
	(0.04)	(0.03)	(0.03)	(0.03)
*y*79	0.56***	0.57***	0.60***	0.60***
	(0.04)	(0.03)	(0.03)	(0.03)
*y*80	0.60***	0.65***	0.68***	0.68***
	(0.03)	(0.03)	(0.02)	(0.02)
*y*81	0.73***	0.78***	0.80***	0.80***
	(0.03)	(0.03)	(0.02)	(0.02)
*y*82	0.73***	0.80***	0.83***	0.83***
	(0.03)	(0.03)	(0.03)	(0.03)
*y*83	1.05***	1.12***	1.17***	1.17***
	(0.03)	(0.03)	(0.03)	(0.03)
*y*84	1.21***	1.29***	1.35***	1.35***
	(0.04)	(0.03)	(0.03)	(0.03)
Observations	1141	1141	1141	1141
R^2	0.80	0.88	0.92	0.92
$\overline{R}^2$	0.80	0.87	0.91	0.91

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9: List of Outliers in the Sample

Houshold id	Plotcode	Year	Soil Type	Water Source?	Standarized Residual
30	CS	84	Shallow Red	Yes	3.23
30	CT	84	Shallow Red	Yes	3.23
30	CU	84	Shallow Red	Yes	3.23
30	F	76	Shallow Red	No	3.28
31	A	75	Problem Soil	No	4.93
31	CS	84	Shallow Red	Yes	2.89
31	CT	84	Shallow Red	Yes	2.89
31	CU	84	Shallow Red	Yes	2.89
31	D	75	Shallow Red	No	3.10
31	D	76	Shallow Red	No	2.98
31	E	84	Shallow Red	Yes	2.61
31	F	76	Shallow Red	No	3.59
31	F	78	Shallow Red	No	-2.88
32	A	75	Shallow Red	No	-2.90
32	A	76	Shallow Red	No	-3.01
32	A	78	Shallow Red	No	3.68
32	D	83	Medium to Shallow Black	No	2.61
41	AK	78	Shallow Red	Yes	2.65
41	AL	78	Shallow Red	Yes	2.65
48	B	84	Medium Black	No	-2.87
52	CAA	76	Medium to Shallow Black	Yes	-2.64
52	CAB	76	Medium to Shallow Black	Yes	-2.64
52	CBA	76	Medium to Shallow Black	Yes	-2.64
52	CBB	76	Medium to Shallow Black	Yes	-2.64
52	CCB	76	Medium to Shallow Black	Yes	-2.64
54	BAS	83	Shallow Red	Yes	4.07
56	D	76	Medium Black	No	2.90
57	BA	76	Gravelly	No	4.36
57	EK	84	Medium Black	No	-3.27

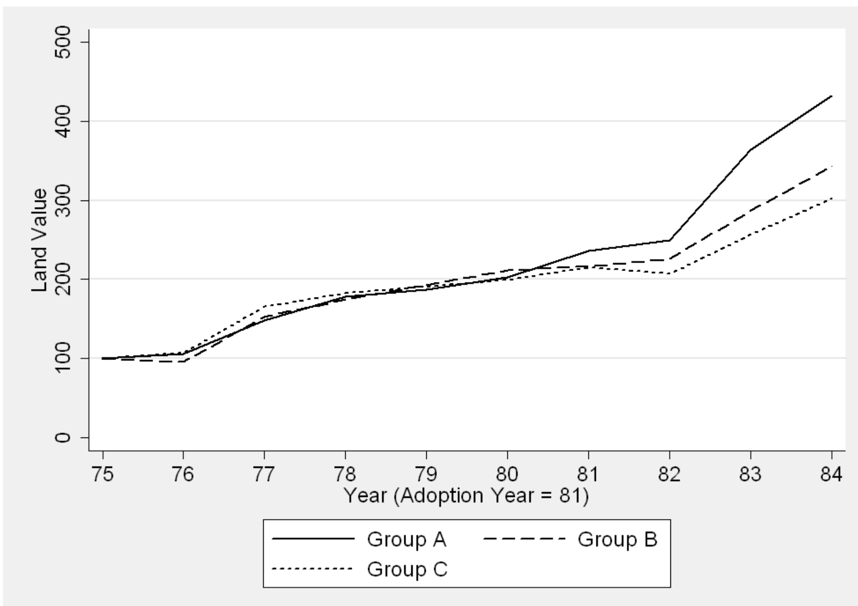

Figure 5: Land Value Index: Outliers Excluded (1975 = 100)