Agricultural Suicides in India

The Role of Rainfall and Relation to Economic Theory

Rashmi Bhat

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Abstract

Undoubtedly, suicide is the result of cumulative causation. Though sometimes, too intent a focus on identifying all the causes can lead to more confusion than clarity. Using a fixed-effects technique, this paper examines a panel of suicide data for 25 Indian states from 1995 to 2008. The aim is to ascertain whether trends in agricultural suicides behave in a way that conforms to economic theory. I use the general utility maximizing framework as a starting point of the analysis and modify it to fit the situation of agricultural suicides in India. I focus on the predictive power of monsoon and annual rainfall which is assessed by a comparison of how agricultural suicide rates differ from non-agricultural suicide rates in the way that they respond to fluctuations in rainfall. Through analysis of the results, I provide possible pathways by which rainfall could have an affect the individual's decision to commit suicide. I find that while rainfall, both monsoon and annual, are significantly associated with suicides rates, real GDSP per capita, real agricultural output per worker and percent of the population employed in agriculture are not. I conclude that though this research is novel in that it is the first to construct and analyze a panel of agricultural suicides in India, more information needs to be collected about suicide victims before this type of analysis yield concrete results.

I. Introduction

Official reports by the National Crime Records Bureau claim that 223,528 farmers and agricultural laborers committed suicide between 1995 and 2008. (Accidental Deaths and Suicides in India, NCRB)According to 2001 employment census data, the suicide rate in agriculture (suicides per 100,000 agricultural workers) was 12.9 compared to 10.6 which was the general suicide rate. [1] The disparity between these two figures has only increased since then, as more individuals leave agriculture while the number of suicides in agriculture continues to rise. When suicide rates are significantly higher among a particular group in society, it is often an indicator that there are factors in the general environment which are placing selective pressure on the group in question. These factors vary in type from the economic (ex. unemployment), to the demographic (family structure) to the psychological (ex. mental illness). There is an ever growing body of social science research devoted to finding explanations for variations in suicide rates, and this paper hopes to contribute to this body of work.

The first economists to address the topic of suicide in their research were Daniel Hamermesh and Neal Soss. In their influential article *An Economic Theory of Suicide*, they construct a utility maximizing model of suicide with the intention to explain variation in suicide rates among different age and income brackets. Their empirical findings show that within age groups, suicide rates generally decline with income and that younger age groups tend to have lower suicide rates overall. (Hamermesh et.al. , 1974) Adapting this foundational work, Tomoya Suziki introduces income uncertainty into the model in an effort to better understand the persistence of higher suicides among middle-aged men in Australia. (Suzuki, 2008) In a slightly different vein, Cutler, Glaeser and Norberg seek to explain the rise in youth suicide rates in the United States by

[1] Based on author's calculation made using employment data from the Census of India (Avaiable:)

considering factors such as social contagion and family structure. These, along with other papers which have not been mentioned here to maintain brevity, have in common the goal of providing an explanation for heterogeneity in suicide rates across groups. It is with a similar motivation that I approach the topic of agricultural suicides in India.

First, it is worth mentioning that suicides among people employed in agriculture have been prevalent in countries other than India. As recently as 2006, a severe drought in Australia sparked enough suicides among farmers that it warranted international media attention. As it happens, despite the country's overall affluence and widespread use of modern capital intensive farming, agricultural suicides have persisted in recent years due to frequent drought. One major difference between the Australian case and the Indian case is the portion of the workforce employed in agriculture: in 2001, Indian agriculture employed 106.8 million people which is 300 times larger than the same figure in Australia. Two noticeable gaps in the literature are the lack of suicide research in developing nations and the lack of research on occupational specific suicides. With the exception of the Kaur & Pandey paper, the majority of the economic literature has focused on suicide cases in the developed world. At the same time, suicide rates in the United States and India are comparable: 10.6 versus 10.5 suicide deaths per 100,000 people according to the 2006 numbers (National Institute for Mental Health, Accidental Deaths and Suicides in India, 2006). A reason for this gap may simply be lack of information: developing world governments are notoriously ineffective at accurate data collection, with the major exception of India.

A unique contribution of this paper will be its occupation specific-approach. Some policy makers believe that the factors contributing to suicide are equivalent across professions, but the current analysis would like to challenge this assertion. (Meeta et al, 2006) More than any other profession, agriculture is a particularly interesting profession to study because a farmer's outcomes are subject to completely exogenous shocks. Individuals in other professions are most affected by

macroeconomic variables, but farmers have the additional factor upon which they are wholly dependent and completely unable to control: the weather. In addition, this study is novel in that it is the first to construct and all-India panel of agricultural suicides and to link agricultural suicides concretely to general economic theories about suicide.

In this paper, I seek to answer two questions:

1. Does the agricultural suicide rate respond to changes in relevant socioeconomic factors in a way that conforms to the general economic theory of suicide?
2. Are fluctuations in rainfall significantly correlated with fluctuations in agricultural suicide rates? And if so, what mechanisms could be help to explain that correlation?

The aim is to ascertain whether trends in agricultural suicides behave in a way that conforms to economic theory. The secondary aim of this paper is to evaluate whether rainfall has predictive power with respect to agricultural suicide rates. This predictive power will be gauged by a comparison of how agricultural suicide rates differ from non-agricultural suicide rates in the way that they respond to fluctuations in rainfall. Through analysis of the results, I provide possible pathways by which rainfall could have an affect the individual's decision to commit suicide. It should be clear that the purpose of the analysis is not to ascertain whether adverse rainfall shocks are the root cause of farmer suicides. Instead, the intent is to isolate any observable correlation between rainfall shocks and the occurrence of farmer suicides, using states as the unit of observation. Thus, the focus is not on rainfall as a major determinant, but as a relatively exogenous shock with a potential to influence outcomes. It is the hope that at the very least, the contribution of this work will be to add to the understanding of the specific stressors that put farmers at risk for taking their own lives.

The Case of Agricutural Suicides in India

As a whole, agriculture and allied activities account for only 25% percent of GDP while employing 57% of India's total workforce. Furthermore, between 1961 and 2005 the share of agriculture in GDP declined by more than 30% while agricultural employment has declined by less than 20%. (Dev,2008) At the same time, any researchers have remarked that farmer suicides have increased dramatically over time and that this fact is a reason to take a closer look and try to ameliorate the conditions that Indian farmers must deal with. While it is true that in the aggregate agricultural suicides have been rising, the more interesting aspect of agricultural suicides in India is the variation in prevalence that they exhibit, both across states and across time. Figure 1 is a state wise box plot of agricultural suicide rates for the study period (1995-2008) while figure 2 is a box plot of non-agricultural suicide rates.

Figure 1: Agricultural Suicide Rate by State (1995-2008)

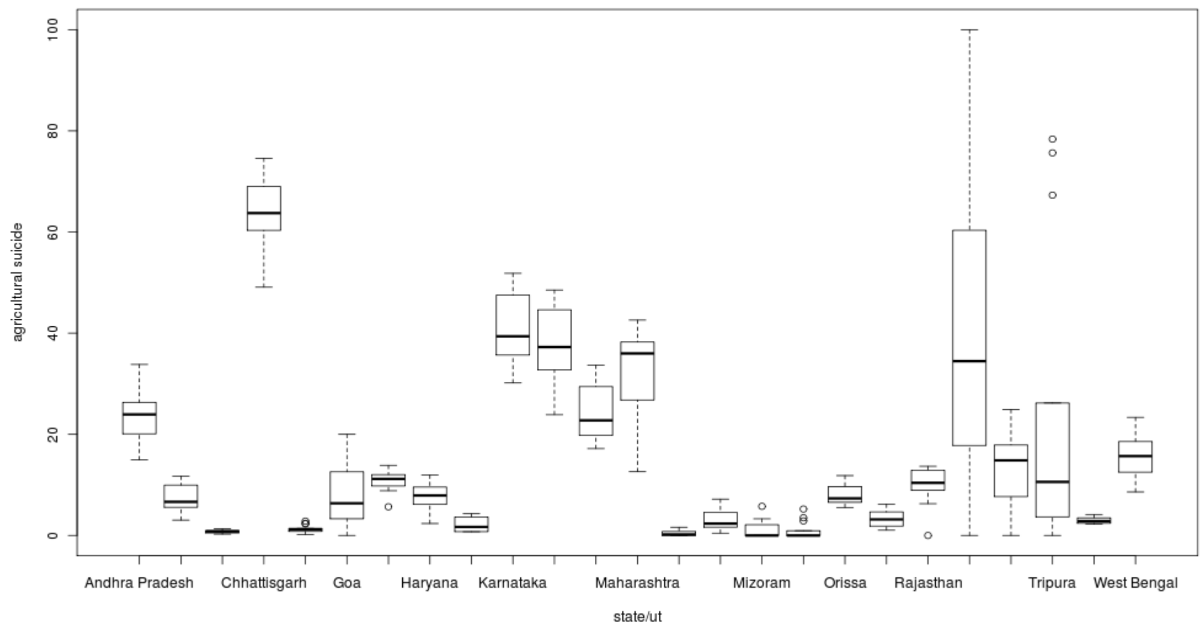
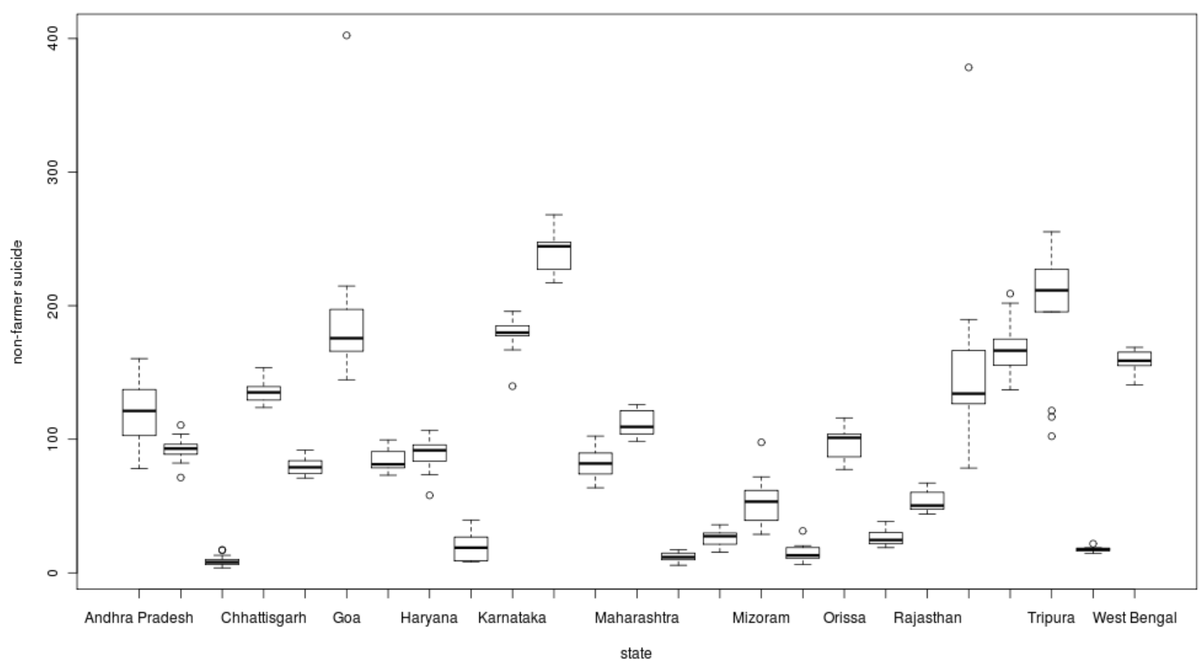


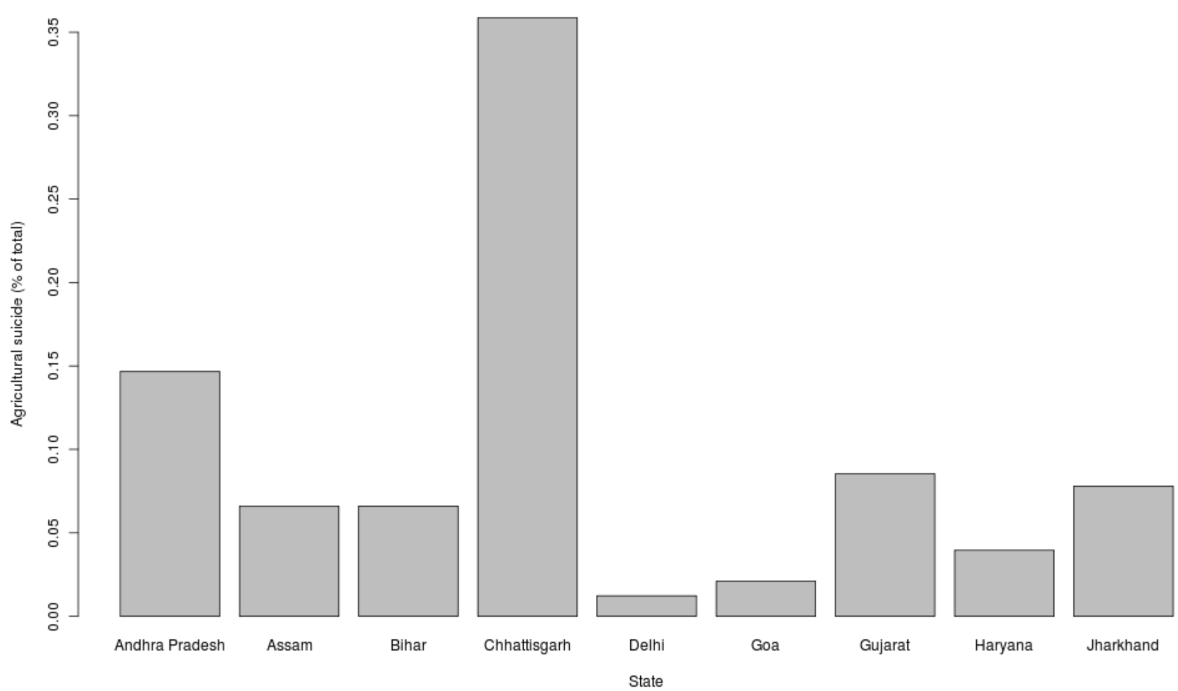
Figure 2: Non-Agricultural Suicide Rate by State (1995-2008)

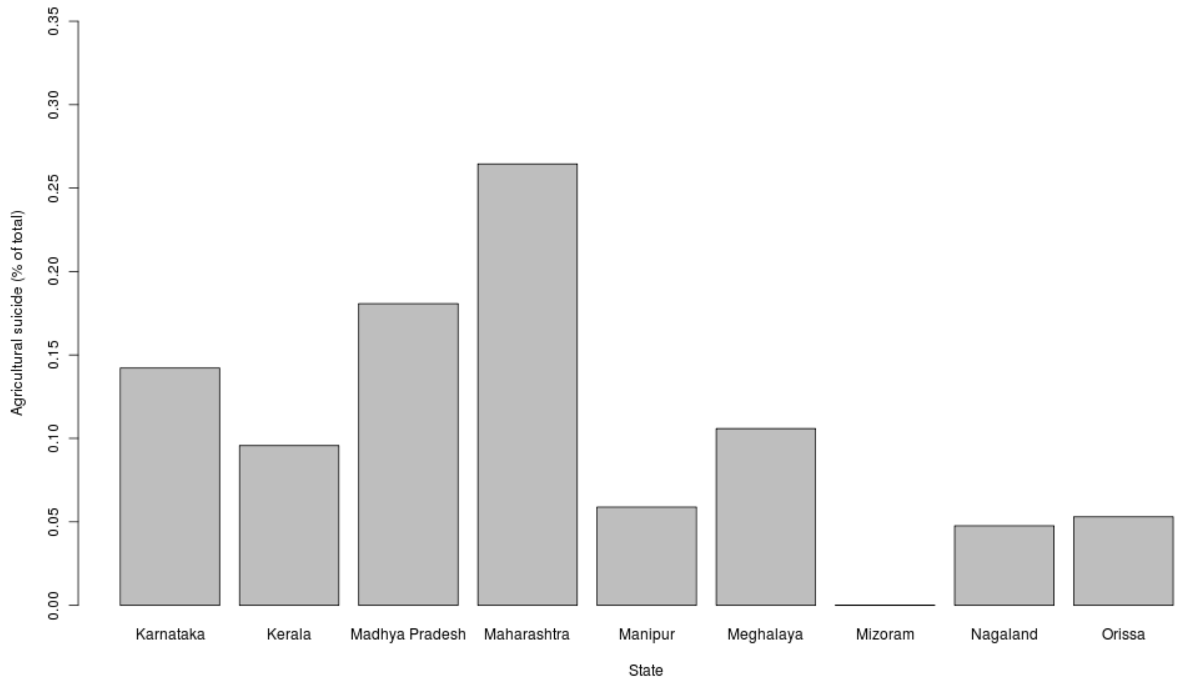


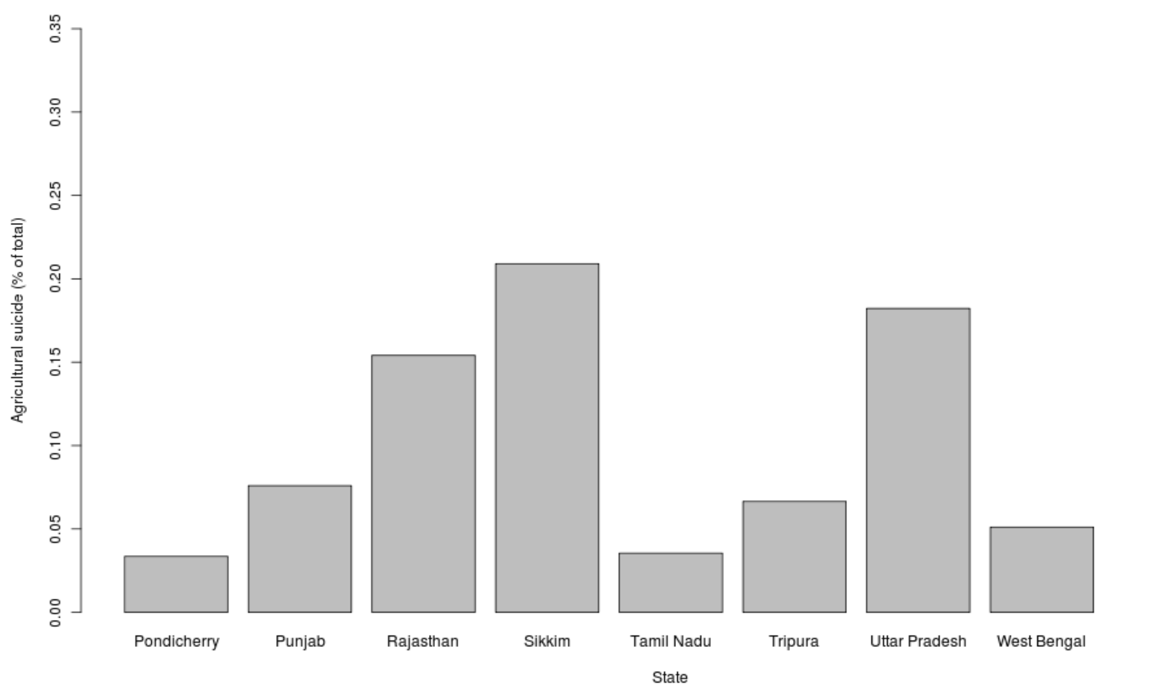
Note: States are ordered alphabetically along the x-axis, some state names have been omitted due to lack of space. Y-axis measures the suicide rates defined as suicides per 1,000,000 estimated mid-year population of the state. Agricultural suicides are defined as suicides by individuals employed in agriculture and non-agricultural suicides are defined as total suicides minus agricultural suicides

The heterogeneity in the variances of the agricultural suicide rate across states relative to the non-agricultural suicide rate is suggestive that there are state and time specific factors at work. In addition to exhibiting substantial variance across time, the relative prevalence of agricultural suicides across states varies significantly as well. The graphs below show agricultural suicides as a proportion of total suicides by state for selected states in 2008:

Figure 3: Agricultural suicides as proportion of total suicides (2008)




Agricultural suicide (% of total)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Karnataka
Kerala
Madhya Pradesh
Maharashtra
Manipur
Meghalaya
Mizoram
Nagaland
Orissa
State


Agricultural suicide (% of total)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
Pondicherry
Punjab
Rajasthan
Sikkim
Tamil Nadu
Tripura
Uttar Pradesh
West Bengal
State

As mentioned, researchers are interested in pinpointing specific factors which are potential suicide stressors and cause the variance representing the figure above. In the case of agricultural suicides in India, it seems that the factor of choice is "agrarian distress". As the matrix below demonstrates, "agrarian distress" has a plethora of causes:

A Matrix of Issues Related to Agrarian Distress

Issues	Supply side	Demand side
Credit	Formal sources: Decline in the number of branches, decline in agricultural credit/direct finance to agriculture as a percentage of NBC, and there is a shift to value addition activities. Increasing dependence on informal sources – relatively more among smaller farmers.	Formal sources not timely. Repayment difficult during crop loss and price shocks. Instead of getting them out of credit, the system draws them into it. Difficulties in meeting consumption requirements and other social obligations. An increase in market induced consumerism.
Input	No link between publicly funded research and its extension. This is particularly missing for crops/cultivation in dry land areas. Technological change is substantial and there is an increasing reliance on the unregulated private suppliers. Inadequate public investment in agriculture (spread of irrigation in arid regions is a casualty).	Supplier-induced-demand is on the rise. This is credit-intensive and an important reason for putting the farmer in a quagmire of indebtedness. There is deskilling. With new technology come new methods of cultivation. Social capital of knowledge in cultivation is rendered redundant. A case in point is the introduction of Bt Cotton seeds. Greater investments in assets like bore wells in Andhra Pradesh not only increases cost, but has also led to a tragedy when the investments failed.
Output/ Price/ Income	Increased volatility due to global prices. Price distortion through subsidies by developed countries. Low tariff in India. Minimum support price not functional. A case in point is the Monopoly Cotton Procurement Scheme (MCPS) of Maharashtra. Forward market – it is a virtual world that will hardly benefit the farmer. In fact, price volatility is the basis through which hedger/speculator can operate.	Cultivation not profitable. Income not sufficient for meeting higher education of wards, medical expenditure and other social obligations. Yield risk because of weather, water and power availability, pests, and spurious quality of inputs among others.
Other Issues	Interlinked credit, input and output markets. Non-farm income opportunities limited.	Political dominance of moneylender and/or input dealer and output buyer.

	Public health response to occupational health hazards of farming is wanting. Easy availability of pesticides and other hazardous substances.	Higher family size: more daughters – greater dowry burden. Lack of social support.

Source: Reserve Bank of India (2006)

While presenting relevant points, this matrix is overwhelming to say the least and does not provide a framework within which to understand the agrarian crisis. The analysis presented in the paper will hopefully demonstrate that there is value in focusing on the statistical impact of a single variable. And by focusing on rainfall specifically, I will show that perhaps stepping back from the matrix can provide a clearer perspective on this clearly complicated issue.

The rest of the paper will be organized as follows: Section 2 provides a review of relevant literature, Section 3 outlines the theoretical framework , Section 4 presents the data used to conduct the analysis, Section 5 outlines the empirical strategy employed and discusses the results, and Section 6 provides concluding remarks and a discussion of the wider implications of the paper's findings.

II. Literature Review

As mentioned in the introduction, Hamermesh and Soss' 1974 study is widely regarded as the foundational work in the economics of suicide. They constructed an utility maximization framework which includes income, age and unemployment as the major determinants of the decision to commit suicide. They hypothesize that as personal incomes rise, the propensity for suicide falls because of the utility attained through increased consumption. Conversely, as age and unemployment increases willingness to commit suicide should increase. They test their theory on 1947-67 time-series data for males and on 1970 cross-state suicide rates in the United States and find that for the most part, their predictions have empirical traction. (Hamermesh et. al. , 1974)

Modifying the Hamermesh-Soss model to include income uncertainty, Suzuki (2008) investigates the impact on the threshold wage of committing suicide when there are changes in the level of income uncertainty. The researcher indicates that theory predicts two potentially opposing effects of income uncertainty on the propensity to commit suicide; income uncertainty reduces the lifetime utility of the risk averse individual, but at the same time it creates a value to postponing suicide because if things go well incomes will be higher in the future. The model, which assumes that wage evolves according to a stochastic process, ultimately supports the former prediction and the author suggests that wage insurance policies may help mitigate the adverse effects of income uncertainty. (Suzuki, 2008)

In a time series study for the US for the period from 1947 to 1980, Bijou Yang finds that the suicide rate in a society is the result of interplay between economic and social factors. He uses per capita gross national product, unemployment rate, divorce rate, proportion of the population which is Catholic and female labor force participation as his explanatory variables. Rather than defining the cohort by age group, Yang creates four social groups which are defined by age and sex. He finds that there is a substantial amount of heterogeneity in the way that suicide rates of these groups respond to changes in the explanatory variables. For example, although an increase income levels have a negative effect on the overall suicide rate; it causes a significant increase in suicide rates among females. Yang also finds that unemployment only seems to cause a significant increase in suicide rates among white males and that female labor participation decreases suicide rates among females. The only variable with a homogenous effect on all groups was the divorce rate. Yang (1992) served as a model for subsequent research in the area in that it emphasized how simply examining overall suicide rates is insufficient and that suicide rates of different groups respond differently to economic and social factors. (Yang, 1992)

Inspired by the Yang model, Chuang and Huang use a cross-sectional heteroskedastic and time-wise autoregressive method to examine pooled suicide rates of cities and counties in Taiwan from 1983 to 1993. Like Yang, they found that both economic and social factors impact suicide rates. Overall they find that economic variables seem to have a greater impact than sociological variables on regional suicide rates, particularly increases in income per capita of a region were closely associated with decreases in suicide rates. (Chuang et.al., 1997) Using a fixed effects panel estimation technique, Chen et. al. come to a similar conclusion in their study of suicide rates in OECD countries. Economic variables such as the real GDP per capita and the Gini index have a greater impact on suicide rates than sociological factors such as the divorce rate. In specific relation to Japan, the researchers find that socioeconomic variables show a higher correlation with suicide rates than in other countries and that the effect of the Gini index coincides with assumptions that individuals tend to be averse to individual inequality and relative deprivation. There are a number of other studies which conduct similar empirical work looking at general suicide rates: using a cross-section of 30 countries Jungeilges and Kirchgassner (2002) find that increases in real income and the growth rate of real income correspond with higher suicide rates, Chuang and Huang (2003) find that both economic factors such as income, inflation and consumption and social factors such as age and religion contribute to changes in the suicide rates. Altinanahtar & Halicioglu (2009) investigate suicide rates in Turkey using the time-series data from 1974-2007. Applying the Auto-Regressive Distributed Lag model and they find that among per capita real income, divorce rates, urbanization and liquidation, urbanization has the strongest positive effect on suicides rates. They argue that the precarious shanty districts and towns which result from unplanned urbanization contribute significantly to the hardships associated with city-dwelling. (Altinanahtar & Halicioglu , 2009) In a study specific to India, Pandey & Kaur (2009) use the Auto-Regressive Distributed Lag model to assess the impact of inflation, real GDP per capita, industrial growth and household consumption

on all-India suicide rates. Their findings are based on time-series data of suicide deaths from 1967 to 2006 and conform to expectations: the real GDP per capita, industrial growth and inflation increase suicide rates while increases in household consumption decreases the suicide rate. Their findings reinforce the notion that relative income matters as well as absolute income; holding personal income (i.e. household consumption) constant, increases in real GDP results in an increase in the suicide rates.To date, this is the only economic study that has examined suicides rates and economic determinants in at the all-India level. (Pandey et.al., 2009)

As useful as these papers are for gaining general intuition on factors that may impact suicide rates, they do not provide insight into how to approach occupation-specific suicide rates. Hamermesh & Soss (1974) present a summary of sociological studies conducted in cities in the US which presented suicide rates among different occupations. The general conclusions they make is that suicide rates in occupations where income levels are higher, though they caution the sample size is too small to make any concrete conclusions. Beyond this style of analysis, little economic literature exists that investigates the relationship between specific occupations and suicide rates.

Stack (2002) uses a multivariate model to investigate the relationship between suicide and 32 occupational groups for a cross section of the US working age population in 1990. The researcher conducts two sets of regressions to come up with odds ratios for each profession: the first is a simple bivariate regression while the second is multivariate and includes demographic variables. After removing the marginal effects of demographic factors on suicide rate, only eight occupation groups are found to exhibit a significant effect on likelihood of committing suicide. Of these, the highest likelihood to commit suicide is found in the medical profession. This finding is explained by the fact that occupational stress tends to be higher in this area and that the occupation is heavily client dependent. Interestingly enough, farm workers are found to have a lower likelihood of

committing suicides than people in other occupations. Their work suggests that much of the perceived association between suicides and occupation may have less to do with specific occupational stressors and more to do with associations between demographic variables and suicides. (Stack, 2002)

In Nishimura et.al. (2003), the researchers look at the correlation of suicide rates in Japan by region with the percent of workers employed in primary, secondary or tertiary industries. Primary includes farmers, fisherman and forest workers; secondary includes construction workers, and miners; and tertiary includes only indoor workers. Panel regression analysis reveals that suicide rates are positively and significantly associated with the percent of workers employed in what they define to be primary industries. Percent employed in secondary and tertiary industries did not have a significant impact on the general suicide rate of the region. Next, the run a regression with suicide rate as the dependent variable and primary industry percentage, annual total sunshine, annual individual income, mean age and sex ratio as the dependent variables. Primary industry percentage is still positive and statistically significant and the only other significant variable is annual total sunshine which is found to have a negative effect on suicide rate. In studying farmer suicides in Scotland, Stark (2006) find that access to firearms had a significant impact on the suicide rate. Their research shows that farmers in areas where farming is less common are more likely to die by suicide rather than any other means. In fact, differences in the percent of the population in farming described most of the differences in suicide rates among areas. The importance of this factor in the case of Indian agricultural suicides will also be examined in this paper.

The literature which addresses farmer suicides in India is focused mostly on listing socioeconomic causes and state-level policy recommendations rather than addressing the mechanisms behind the rise in suicides. (Bose, 2000; Parthasarathy, 1998; Revathi, 1998). Among

the causes mentioned are inadequate rainfall, low yields, falling commodity prices, lack of institutional credit, bad quality of inputs and increased reliance on informal moneylenders. All of which, incidentally, are also sources of problems in Indian agriculture at large. Of these, moneylenders are widely vilified as being the primary stressor pushing already over-burdened farmers to take their own lives. In a discussion of how American Boll worms have ruined cotton crop yields in Punjab and presumably contributing to farmer suicides in the state, Bose does not highlight seed quality, rainfall or lack of pesticides as primary causes. Instead, the author concludes that indebtedness is the problem and associates the increase of indebtedness among farmers in the area with the increase in the occurrence of farmer suicides. (Bose, 2000)

Parthasarthy et. al. reach a similar conclusion in their study of suicides in the Warangal district of Andhra Pradesh. They provide statistics on a range of factors (including rainfall, crop yield, pesticide use and access to banks) and while conceding that each factor could work towards the farmer's disadvantage, they contend that growing indebtedness to moneylenders is the main cause. Such a relationship is difficult to prove without personal interviews with each of the victims' families, which was not done in this survey. The researchers concede that there are social conditions and personal factors which lead to the alienation of the individual farmer from society and influence the decision to commit suicide, but these are beyond the scope of this study. (Parthasarthy, 1998). In response to this survey, Revathi presents some issues that have not been addressed by Parthasarthy et. al., namely the contributory role of irrigation projects to farmer debt. Although the author presents evidence that a proportion of the debt held by many deceased farmers in the sample was tied up in irrigation projects, the issue of presupposing indebtedness to be the major cause of suicide is still not addressed. Case studies presented in Vidyasagar (2004) and Meeta et.al. (2006) echo similar sentiments and emphasize the location specific nature of the issue of agricultural suicides.

While helpful in presenting the myriad of issues facing the Indian farmer and identifying where blame is currently being placed, these surveys do not present robust analysis. Also, they do not present these suicides and possible causes within a framework which demonstrates how they relate. This is one way in which this paper hopes to improve upon previous work.

III. Suicides Among Farmers: Theoretical Framework

In this section, I outline the theoretical foundations for the empirical work that is presented later on in the paper. I start with the utility maximization approach to suicide which was first presented in Hamermesh & Soss (1974). Here, the language used by Hamermash and Soss is revised to define cohorts not by age group, but by occupation: agriculture and non-agricultural. In this section, I will focus on individuals employed in agriculture, but similar logic may be employed for individuals not employed in agriculture.

Using the Hamermesh & Soss framework, we assume that individuals commit suicide when the present discounted value of expected lifetime utility falls below a certain threshold. This threshold is defined as the individual's taste for living (or conversely, their dislike for suicide) which they express as a random variable *b*. Let $W_A(YP,X)$ represent the expected value of discounted lifetime utility of an individual employed in agriculture, with a utility function defined by $U_A(YP,X)$, with a permanent income of YP and a set of other characteristics defined by X. Next, individual suicidal behavior is extrapolated to the agricultural population at large. We find that the fraction of individuals employed in agriculture who commit suicide may be defined by the expression:

$$S_A = f[W_A(YP,X)] \qquad (1)$$

Where *f*( ) is the cumulative distribution function of *b*. Differentiating equation (1), yields the result that agricultural suicides should decrease as agricultural income increases. This prediction is based on the assumption that increased income increases expected lifetime utility and by extension, decreases the perceived benefits of committing suicide.It follows then that increases in agricultural income would increase the expected utility of living for individuals employed in agriculture and decrease the agricultural suicide rate.

Subsequent studies have tried to reform the Hamermesh model to account for a wider range of economic realities such as unemployment, income uncertainty and income inequality. Most relevant here are the studies that deal with the effects of income inequality on suicide rates. A substantial body of literature has indicated that subjective well-being depends to a large degree on relative income and not absolute income alone. Researchers in the field agree that individuals tend to be averse to inequality and relative deprivation. Thus, it is entirely plausible that increases in agricultural income would coincide with an increase in the agricultural suicide rate if the income of the rest of the population has increased by a greater amount. In light of this, current decision models of suicide include measures of inequality in the individual's utility function along with measures of income. Following the framework presented in Chen et.al. (2008), I introduce income inequality into the utility function by including it in the vector X. The assumption is that individuals not only derive utility from having more income, but also have more than other groups in the population. Conversely, as the relative deprivation of the group of interests increases we would expect that the stress levels of individuals in the group to increase and also their purchasing power to decrease. Thus, holding real agricultural income constant, an increase in the general income level of the population would be expected to increase the prevalence of suicides among agricultural workers.

Rainfall enters into this theoretical model of suicide as a significant determinant of agricultural income. Viewed within this framework, the effect of lower amounts of rainfall extends beyond directly decreasing productivity and income to indirectly causing the individual agricultural worker to revise their expected utility from living downwards. In the aggregate, this means that we should expect increases in the agricultural suicide rate during years where there has been low rainfall.

Social cohesion is another factor that enters in to the utility function under the vector X. Studies in social psychiatry have found that when individuals have access to extensive social networks and are surrounded by others who are exposed to similar environmental stressors, they are less likely to commit suicide. (Stark et al. , 2006) When individuals feel less isolated, they are better able to weather adverse economic conditions because social interaction serves to mitigate mental stress. In most empirical studies, the social cohesion hypothesis has been tested by looking at the effects of marital status and family structure on the incidence of suicides. In this study, I look at the percent of the population employed in agriculture. The hypothesis is that agricultural workers in states with a lower percentage of workers employed in agriculture are more isolated than those who live in states where agriculture is more prevalent and are more likely to see suicide as a viable option. Thus, as the percentage of workers employed in agriculture decreases, the agricultural suicide rate should increase. It is possible that a state would have a small percent of farmers who all live in the same region which would negate the isolation effects explained here, which is an issue that will be further addressed in the discussion.

IV. Data

The timeframe of inquiry is 1995 to 2008 and the panel constructed to conduct this research consists of data from 25 Indian states and 1 union territory. The excluded areas are: Andaman & Nicobar Islands, Arunchal Pradesh, Dadra& Nagar Haveli, Pondicherry Lakshadweep, Daman &

Dui, Chandigarh, Jammu & Kashmir, Uttaranchal, Uttar Pradesh (prior to 2001) and Himachal Pradesh. These states were excluded due a combination of factors: unavailability of rainfall and other explanatory data, low prevalence of agriculture in the economy and near zero agricultural suicide rates which persist over the entire period combined with a negligible percent of the population employed in agriculture. The majority of time and effort on this project was spent in the data collection, input and cleaning process. Thus, in this section I endeavor to describe the methods used to generate the variables which were used in the regressions.

Suicides

Suicide data used in this paper comes "Accidental Deaths and Suicides in India" ; an annual publication released by the National Crime Records Bureau (NCRB). [2]The NCRB pools information on suicides reported from the Crime Bureau of each state and union territory. The first issue was published in 1967 and the latest issue available comes from 2007. Responding to the Right to Information Act enacted by the government of India in 2005, the NCRB has recently made electronic copies of all issues available on their website. The evolving nature of the data played an integral part in the selection of timeframe for the study: documentation of professional status only begins in 1995.

Data on the cause of suicide along age distribution is consistently available from 1984 at the state-level. The causes listed are failure in examination, quarrel with parents-in-law, quarrel with married partner, poverty, love affairs, insanity, dispute over property, despair over dreadful diseases, bankruptcy or sudden change in economic position, unemployment, death of dear persons, fall in social reputation and other causes. Initially, the possibility of using one or more of these causes (such as poverty or change in economic status) as a generalized proxy for farmer suicides had been

[2] Full reports available online: http://ncrb.nic.in/accdeaths.htm.

considered because professional status only started to be recorded by the NCRB in 1995. But, upon reading the survey literature, this does not seem to be a feasible option. In many cases documented, it was family issues and not economic issues that pushed the particular farmer towards suicide. Another observation that has led to the discrediting of this approach is that on the all-India level, around fifty percent of suicides reported fall under the "other causes" category which indicates that the existing categories do not capture the full spectrum of issues. (Accidental Deaths and Suicide in India)

Thus, professional status was settled on as the best way to separate agricultural from non-agriculturally related suicides. The different professional status classifications used by the report are: housewife, service (government, private), public sector undertaking, student, unemployed, self-employed (business activity, professional activity, farming/agriculture, other), retired person and other. In this paper, agricultural suicide rate is calculated by dividing the number of suicide victims classified as working in farming/agriculture by the estimated mid-year population in millions which is available from the Registrar General of India. Non-agricultural suicides are defined as total suicides minus number of suicides by people employed in agriculture divided by the estimated mid-year population (in millions).

There are a few points of concern relating this data. For one, there is no information about how the data is actually collected by the state agencies. If methods differ according to state, this would introduce systematic bias into the estimation. The fact that this data source is widely used and cited in the literature and by news agencies suggests that it's the most reliable source to be using. In addition, there is no specific description on what professions are included under each category. For instance, it is unclear whether the farming/agriculture category includes only farmers or whether it includes farmers and agricultural laborers as well. This designation would be of interest because we would expect that suicidal behavior among farmers would be more sensitive to fluctuations in

rainfall. Not only is their entire income dependent on their crops, but farmers also have a higher debt burden because they must make capital investments (irrigation, bullock carts, seed) to increase the productivity of their operations. Thus, if their crops fail because of bad rainfall, not only have they lost their source of income, but also their ability to pay back these debts. Agricultural laborers are partially insulated from the effects of rain by minimum wage standards. Moreover, the debt burden of agricultural capital investment does not fall on them. Despite the fact that agricultural laborers are one degree removed from agriculture, the research presented in Jayachandran (2006) suggests that agricultural wages do still depend upon rainfall to a certain extent. [3]

Systematic underreporting of suicides throughout India is another issue which is endogenous to the data and is an issue that has been widely noted. (Sainath, 2004; Vidyasagar, 2004; Meeta et. al. 2006; Pandey, 2009) The primary reason for this issue is mainly that societal stigma against suicide still persists throughout much of India. In addition, a number of suicides go unreported due to the rural isolation of the victims or other circumstances that prevent access to the authorities.

GDSP per capita

The statewise real gross domestic product per capita was calculated using data from the Central Statistical Organization and the Census of India. In reality, GDSP data encompasses production during the fiscal year which is from April 1st to March 31st of the following year. When entered into the panel, GDSP data for the 2007-08 fiscal year was coded as GDSP for 2008. Originally, the data came from two different series; the first from 1993-94 to 2000-01 in constant 1993-94 dollars and the second from 1999-00 to 2007-08. The second series was deflated to constant 1993-94 prices by a state-specific conversion factor obtained by dividing the 1999-00 figures from the two series. These GDSP figures were then divided by the estimated mid-year population (available thought the

[3] Refer to Jayachandran(2006) for methodology and full results.

Registrar General of India) to obtain real GDSP per capita at 1993-94 prices to come up with the real GDSP per capita. GDSP data was not available for all states in each year which partially accounts for the decreased number of observations in regressions which include economic variables.

Percent of Workers in Agriculture

The state wise number of agricultural workers for each year was estimated using employment data from the 1991 and 2001 Census of India. The percent of workers in agriculture was linearly interpolated and the actual number of total and agricultural workers was derived.[4] A slightly more complicated procedure was adopted for Jharkhand, Chhattisgarh, Bihar and Madhya Pradesh because the former two states succeeded from the latter two in 2001. Thus, for the sake of estimating, it was assumed that succession did not occur. For example, the 2001 number of workers (both total and agricultural) in Jharkhand was added to the 2001 number of workers for Bihar. An exponential curve was then fitted through the 1991 and combined 2001 data points to come up with estimates for the number of workers in non-census years. Next, the post 2001 worker totals had to be separated into workers belonging to Bihar and those belonging to Jharkhand. As a best approximation of this separation factor, the proportion of workers in Jharkhand divided by the combined total of workers in Jharkhand and workers in Bihar as of the 2001 census was used. The same methodology was employed to derive the estimated number of workers post-2001 in Madhya Pradesh and Chhattisgarh.

[4] Although more sophisticated models exist for this kind of estimation, this method was deemed sufficient for providing an estimate of agricultural output per worker.

Value of Agricultural Output per Worker [5]

A similar methodology was adopted in the estimation of agricultural output per worker. Data on state wise total value of output from agriculture was compiled from the Central Statistical Organization (CSO), Ministry of Statistics and Program Implementation and the Department of Agriculture and Cooperation. Data from 1995-2006 was taken from the Central Statistical Organization estimates and deflated to 1993-94 prices. Estimates for 2007 and 2008, which have yet to be published by the CSO, were found in the 2007 and 2008 issues of Agricultural Statistics at a Glance, a publication released by the Department of Agriculture and Cooperation. After being standardized to 1993-94 prices, the output data divided by the number of workers to come up with the estimated value of agricultural output per worker.

Rainfall

Rainfall data comes from the Indian Institute for Tropical Meteorology which has a publically accessible set providing monthly rainfall data for the period between 1871 and 2008. The IITM dataset is organized into 31 subdivisions in order to maximize homogeneity of rainfall within each subdivision and all values are in millimeters. The data set was constructed with a conscious effort to have one representative and reliable rain gauge station for each district. The result was the use of a network of 306 uniformly distributed rain gauge stations. In compiling the monthly data for each district to create subdivisional data, each district's reading was weighted by the geographical area they occupy. The areas that have not been including into the data set include four meteorological subdivisions in the hilly areas parallel to the Himalayas (due to a sparse rain-gauge

[5] Originally average yield for major crops was going to be included as a measure of agricultural productivity. After a significant time searching for data from various sources, it became apparent that methods of calculating average yield differ widely and that finding a single reliable source for all states and years included in the panel would be difficult.

network and negligible readings) and two island subdivisions. Thus, the contiguous area covered by this data set is 2,880,000 square kilometers which is about 90% of the total area of the nation.

Some subdivisions coincide perfectly with state boundaries and thus required no manipulation. In certain instances, such as Karnataka and Madhya Pradesh, there are multiple subdivisions within a state. In these cases, an area-weighted mean of the rainfall values for all relevant subdivisions was taken in order to create a single dataset for the particular state. In other instances, such as Assam and Meghalaya, two states have been put together in one subdivision because of the similarity of their rainfall patterns. In these cases, the dataset for both states are identical. Bihar and Madhya Pradesh required two data sets each, one for before 2001 and another for after 2001 when parts of the states succeeded. For instance, values in the pre-2001 dataset were weighted means of the Bihar rainfall values and the Jharkhand rainfall values, while values in the post-2001 set included rainfall from only the Bihar subdivision.

Table 1: Summary Statistics

Variable	Units	Mean	Std. Deviation	Minimum	Maximum
Agricultural Suicide Rate	Suicides per 1,000,000 population	14.98	17.76	0	100
Non-Agricultural Suicide Rate	Suicides per 1,000,000 population	98.66	70.48	3.71	378.33
Total Annual Rainfall	Meters	14.71	7.20	2.18	34.40
Monsoon Rainfall	Meters	10.76	5.38	1.77	29.45
Real GDSP per capital	Rupees	12666.36	6438.80	2248.48	39404.72
Real value of Agricultural Output per worker	Rupees	14782.05	12700.28	2544.74	72399.23
Percent of Total Workers in Agriculture	NA	52.83	18.20	0.62	81.75

Note: Panel excludes Arunchal Pradesh, Chandigarh, Dadra & Nagar Haveli, Daman & Dui, Himachal Pradesh, Jammu & Kashmir, Lakshadweep, Pondicherry and Uttaranchal.

The mean of the non-agricultural suicide rate is expected to be substantially higher than the agricultural suicide rate because it includes suicides of all occupational categories besides farming/agriculture. The means for rainfall highlight the importance of the monsoon season as an important source of rain: at the mean, monsoon rain accounts for almost three-quarters of annual rainfall. Another statistic worth noting is the standard deviation of agricultural output per worker which is almost twice as large in magnitude as the standard deviation in GDSP. This statistic speaks to the fact that the value of agricultural output is more volatile than overall output and that in general the decisions of people working in agriculture might be more driven by income uncertainty than the decisions of individuals not employed in agriculture.

V. Empirical Methodology

A fixed effects estimation model was used to conduct all of the empirical work presented in this study. The empirical strategy is separated into three distinct stages. In the first, I present the relationship between suicide rates and rainfall, both monsoon and annual. In the second, I isolate the impact of rainfall on the value of agricultural output per worker and on gross domestic state product per capita. In the last stage, the economic theory is tested by regressing GDSP per capita, agricultural output per worker and percent of the population employed in agriculture against agricultural suicide rates. Where appropriate, I compare the results for agricultural suicide rates to results found for non-agricultural suicide rates to highlight where and why suicide responses differ between the two groups.

Table 1 shows the trends in both the agricultural suicide rate and the non-agricultural suicide rate by state along with the mean suicide rate. State names in bold are states where the sign of the trend coefficient coincides for both types of suicides rate. In half of the cases, the trends do not

coincide suggesting that there are a particular set of circumstances which selectively operate to change suicide rates in agriculture. Additionally, in only four states are the trend coefficients the same and statistically significant.

Table 2: Statewise Trend in Suicide Rates (1995-2008)

State/ Union Territory	Agricultural Suicide Rate		Non-Agricultural Suicide Rate	
	Trend Coefficient	Mean	Trend Coefficient	Mean
Andhra Pradesh	0.7787 (2.53)*	24.17	5.4879 (11.91)**	119.30
Assam	0.4052 (2.58)**	7.41	-0.2040 (-0.31)	92.69
Bihar	-0.0457 (-2.27)**	0.79	-0.3904 (-1.46)	8.92
Chhattisgarh	1.5400 (1.36)	63.72	1.8505 (1.39)	135.62
Delhi (UT)	-0.0888 (-1.91)+	1.27	0.2730 (0.61)	79.58
Goa	-0.6747 (-2.11)*	7.63	-4.2790 (-1.03)	193.24
Gujarat	-0.3615 (-3.63)**	10.92	0.7687 (1.53)	83.46
Haryana	-0.0632 (-0.35)	7.65	1.3530 (1.70)+	89.33
Jharkhand	0.4346 (2.37)*	2.15	4.1575 (4.95)**	19.63
Karnataka	-1.0053 (-2.42)*	40.77	1.0379 (1.24)	177.96
Kerala	-0.8483 (-1.80)+	37.73	-0.1871 (-0.19)	241.86
Madhya Pradesh	-0.6157 (-1.80)+	24.25	-0.0235 (-0.03)	81.71
Maharashtra	1.8448 (6.26)**	32.34	-1.8077 (-4.45)**	112.00
Manipur	0.0392 (1.12)	0.43	0.3473 (1.76)+	11.82
Meghalaya	0.0229 (0.16)	2.99	0.0717 (0.17)	26.48
Mizoram	-0.0833 (-0.68)	1.10	0.4068 (0.30)	52.59
Nagaland	-0.2323 (-2.50)*	1.00	-0.3547 (-0.84)	15.07
Orissa	-0.1767	8.02	2.2242	97.37

	(-1.47)		(4.79)**	
Punjab	-0.2303	3.25	0.0646	26.00
	(-3.03)**		(0.17)	
Rajasthan	0.1052	10.06	0.7277	54.06
	(0.41)		(1.46)	
Sikkim	5.1157	42.34	8.9140	151.55
	(3.84)**		(2.11)*	
Tamil Nadu	-0.4435	15.04	4.5637	168.03
	(-1.06)		(5.68)**	
Tripura	-4.8831	22.31	6.5449	199.49
	(-3.49)**		(2.24)*	
Uttar Pradesh	-0.0504	2.97	-0.3506	17.70
	(-0.43)		(-1.09)	
West Bengal	-0.8525	15.44	-0.2692	158.39
	(-5.53)**		(-0.50)	
All-India (actual)	.1575	16.97	-5.2143	120.13
	(0.50)		(-1.39)	

t statistics in parentheses
$^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$
[*] Suicide rate is measured as suicides per 1,000,000 population
Note: Trend coefficient estimation based on 14 observations for most states. For Chhattisgarh and Jharkhand the number of observations was 8.

Rainfall and Suicide Rates

I first examine the predictions made relating to rainfall on its effects on agricultural suicide rates. In light of the fact that the Indian government has created a wide range of policy interventions aimed at improving the situation of people employed in agriculture, it would seem to be a worthwhile question to ask if rainfall still matters. And if so, to what extent? Equation (2) relates the agricultural suicide rate to annual rainfall:

$$ASR_{jt} = \beta_1\, Annual_{jt} + \beta_2 Annual_{jt} * AShock_{j\,t-1} + \delta_j + \alpha_t + \varepsilon_{jt} \qquad (2)$$

The agricultural suicide rate is represents the number of people employed in agriculture per million total state population. [6] Annual is the total annual rainfall in meters, δ_j are state fixed effects, α_t are time- fixed effects and ε_{jt} is the error term. AShock is a dummy variable constructed using the full

[6] In other literature, suicide rate is typically per 100,000 population. This definition has been revised here because of the relative scarcity of agricultural suicides.

138 years of the rainfall dataset. First, the annual rainfall values for the panel period were normalized by the 138 year mean and standard deviation of rainfall for each state. The dummy AShock was then defined as equal to one if rainfall in the past period was more than one standard deviation below the mean (a year of "bad rainfall"), and zero otherwise. By interacting the AShock dummy variable relating to the previous year with the current year's rainfall, I hope to capture the compounding effect that continually unfavorable rainfall might have on agricultural suicide rates. State fixed effects are in place to account for any unobserved interstate differences (such as differences in state compensation policy towards farmer suicides) which may cause variation in suicide rates, and time fixed effects are included to rule out mutual variation as a source of correlation between the two variables. Table 3 shows the results of equation (2).

Table 3: Response of Agricultural Suicide Rate to Annual Rainfall

	(1)	(2)	(3)	(4)
Annual Rain (t)	-0.6633	-0.6678	-0.6525	-0.6974
	(-2.49)*	(-2.53)*	(-2.46)*	(-2.60)**
Annual Rain (t-1)		-0.5314	-0.5318	-0.5131
		(-2.04)*	(-2.04)*	(-1.96)*
Annual Rain (t-2)			-0.1740	
			(-0.68)	
Annual Rain (t) *				0.0692
AShock (t-1)				(0.68)
N	332	332	332	332
Adj. R^2	.7165	.7195	.7190	.7190

t statistics in parentheses
$^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$
Note: Coefficients estimated using the *areg* command in Stata absorbing *state* as the indicator and including separate time dummies. R^2 estimation allows groupwise heteroskedasticity to influence calculation of the fit of the model.
* Suicide rate is measured as suicides per 1,000,000 population

Lagged rainfall has also been included to account for the fact that bad rainfall in the previous year or two, irrespective of the current year's rainfall, has long-term implications for agricultural livelihoods. The effect of a lower rainfall on the agricultural suicide rate is prolonged by the burden of indebtedness. The more drought-like conditions become, the greater the burden as farmers struggle in non-drought years to make up losses which they incur in drought years. For instance, farmers often take out loans during planting season in order to pay for capital to prepare their lands such as seed, bullock carts (oxen driven tractors) and irrigation. These loans are taken out with the expectation that they will be paid off during the harvesting season. If crops fail, farmers are unable to pay off their loans and must wait until the next crop cycle. But in order to prepare for the next crop cycle, farmers must again take out loans to buy new seed. Often loans are taken out from the same moneylender who will charge a higher rate of interest than before. The cycle continues until the farmer has a successful harvest and is able to begin to pay back what they owe. (Vidyasagar, 2004; Meeta, 2006)

What is readily apparent is that both the current and previous year's rainfall has the expected sign and is quite a significant predictor of agricultural suicide rates. Evaluated at the mean of the agricultural suicide rate (14.98 per million), a one meter increase in the current year's rainfall would correspond with a .66 decrease in the suicide rate. This is almost a 5% percent decrease in the agricultural suicide. One meter may seem like an unlikely increase in rainfall, but for the average annual rainfall over this period (14.71 meters) a one meter increase corresponds to less than a 7 percent increase in rainfall. Independent of current rainfall, the previous year's rainfall has almost as economically and statistically significant impact on agricultural suicide rates in each of the specifications. According to these results, a one meter increase in the previous year's rainfall would translate to over a 3 percent decrease in the mean agricultural suicide rate. This finding provides a

good reason why attention should be given to farmer suicides not just during drought years, but also in at least the year afterwards.

Expectedly, the coefficient for the two-year lagged rainfall is much less significant than the others with a magnitude that is three times smaller than the current year's rain coefficient. Holding current and previous year's rainfall constant, crop failure or a debt burden incurred two years ago would have a weaker impact on suicide rates because most farmers have had an opportunity to recover from their losses without incurring more in the interim. What effect that is caused by two-year lagged rainfall may likely be attributed to the least well-off farmers who required more than two years to recover from their losses. The coefficient obtained for the Annual*AShock interaction term, on the other hand, appear counterintuitive. Given "bad rain" in the previous year, the results suggest that an increase in the current year's rainfall would actually increase agricultural suicide rates. Granted, the coefficient the small in magnitude and not statistically significant, but the result is still intriguing. What the mechanism driving this result could be is unclear.

Table 4 compares the results of specification (3) the results that are obtained when non-agricultural suicide rate is taken as the dependent variable. The means of the dependent variables are displayed in order to put the coefficients into perspective:

Table 4:

	Dependent Variable	
	Agricultural Suicide Rate	Non-Agricultural Suicide Rate
Annual Rain (t)	-0.6525 (-2.46)*	0.0330 (0.05)
Annual Rain (t-1)	-0.5318 (-2.04)*	-1.6432 (-2.43)*
Annual Rain (t-2)	-0.1740 (-0.68)	-0.4465 (-0.67)
Mean of Dependent Variable	14.98	98.66
N	332	332
Adj. R^2	.7190	.8799

t statistics in parentheses
$^{+}p< 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$
Note: Coefficients estimated using the *areg* command in Stata absorbing *state* as the indicator and including separate time dummies. R^2 estimation allows groupwise heteroskedasticity to influence the calculation of the fit of the model.
* Suicide rate is measured as suicides per 1,000,000 population

The most interesting result here is insignificance of current year's rainfall and the significance of previous year's rainfall as a determinant of the current year's non-agricultural suicide rate. Again, evaluated at the mean of non-agricultural suicide rate (98.66per million) an increase in the previous year's rainfall by one meter results in a decrease in the non-agricultural suicide rate by 1.64: almost a 2 percent decrease. The actual relative impact of rainfall on suicide rates is half as small in the non-agricultural case supporting the argument that rainfall more has a greater effect on agriculture suicides than non-agricultural suicides. Another notable point is that while current year's rainfall is the most significant in the agricultural case, rainfall in the previous year is more significant in the non-agricultural case. The fact that rainfall has any substantial impact on non-agricultural suicides at all speaks to how important the agricultural sector is in the Indian economy. Although the fate of

the overall economy is greatly influenced by agriculture, the non-agricultural sector is still one degree removed from agriculture. Thus, any shock that may impact the agricultural sector by increasing or decreasing output would take time to trickle into the non-agricultural sector and impact non-agricultural livelihoods through increases food prices.

The next regression deals with monsoon rainfall and its impact on suicide rates. Equation (3) relates agricultural suicides rates to monsoon rainfall, which is specified as the rainfall from June to September for most states. [7] Like annual rainfall, monsoon rainfall is measured in meters. Also state and time fixed effects are still included for the same reasons mentioned above. MShock is defined identically to AShock except that normalized monsoon rainfall is used instead of annual rainfall.

$$ASR_{jt} = \beta_1 Monsoon_{jt} + \beta_2 Monsoon_{jt} * MShock_{j\ t-1}\ \delta j + \alpha_t + \varepsilon_{jt} \quad (3)$$

Results for equation (3) are displayed in the Table below:

[7] For Tamil Nadu the specification if from October to December since the Northwest monsoon much more important for agriculture than the Southwest Monsoon.

Table 5: Response of Agricultural Suicide Rate to Monsoon Rainfall

	(5)	(6)	(7)	(8)
Monsoon Rain (t)	-0.6911	-0.6949	-0.6830	-0.6707
	(-2.37)*	(-2.40)*	(-2.32)*	(-2.32)*
Monsoon Rain (t-1)		-0.4885	-0.4896	-0.9652
		$(-1.74)^{+}$	$(-1.75)^{+}$	(-2.56)*
Monsoon Rain (t-2)			-0.0775	
			(-0.27)	
Monsoon (t) *				-0.2804
Shock (t-1)				$(-1.88)^{+}$
N	332	332	332	332
Adj. R^2	.7159	.7170	.7170	.7203

t statistics in parentheses
$^{+}p< 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$
Note: Coefficients estimated using the *areg* command in Stata absorbing *state* as the indicator and including separate time dummies. R^2 estimation allows groupwise heteroskedasticity to influence the calculation of the fit of the model.
[*] Suicide rate is measured as suicides per 1,000,000 population

Worth noting is the fact that the coefficients for monsoon rain and annual rain in the current year are almost identical (slightly below -0.7 in all cases). Also, similar to the annual rainfall case, the current year's monsoon rainfall is the most significant determinant of suicide rates, both in magnitude and statistical significance. A one meter increase in monsoon rainfall would decrease the agricultural suicide rate by nearly 5%. [8] The one exception is specification (8) where the previous year's rainfall exhibits the highest magnitude and statistical significance. That the previous year's monsoon rainfall could matter more than the previous year's total rainfall possibly points to the fact that previous monsoon rainfall plays a more important role in shaping agricultural expectations in the current term than total rainfall. Note that the most curious difference between the annual rainfall results and the monsoon results is that the interaction variable is both significant at the 10% level and negative. Given that monsoon rainfall in the previous year was more than one standard

[8] For monsoon rainfall, one meter represents almost a 10% increase.

deviation below average, increases in current monsoon rainfall will decrease the agricultural suicide rate.

Table 6 shows a comparison between the results obtained in specification (8) and the same regression but with non-agricultural suicide rate as the dependent variable.

Table 6:

	Dependent Variable	
	Agricultural Suicide Rate	Non-Agricultural Suicide Rate
Monsoon Rain (t)	-0.6707 (-2.32)*	-0.0086 (0.01)
Monsoon Rain (t-1)	-0.9652 (-2.56)*	-1.0663 (-1.08)
Monsoon * Shock(t-1)	-0.2804 (-1.88)$^{+}$	0.2036 (0.52)
Mean of Dependent Variable	14.98	98.66
N	332	332
Adj. R^2	.7203	.8789

t statistics in parentheses
$^{+} p < 0.10$, $^{*} p < 0.05$, $^{**} p < 0.01$
Note: Coefficients estimated using the *areg* command in Stata absorbing *state* as the indicator and including separate time dummies. R^2 estimation allows groupwise heteroskedasticity to influence the calculation of the fit of the model.
* Suicide rate is measured as suicides per 1,000,000 population

Firstly, the current and previous year's monsoon rainfall is less significant than annual rainfall as a correlate of nonagricultural suicide rates supporting the hypothesis that fluctuations in monsoon rainfall during the current year might be an occupation-specific stressor. Similar to the annual rainfall case, lagged monsoon rainfall has a more significant influence on nonagricultural suicide rate than the current year's monsoon rainfall. This is mostly likely due to delayed food price

effects caused by decreased production during years of lower monsoon rainfall. Also, the interaction term is no longer significant in either statistical or economic terms. Again, this is reflective of the special importance of monsoon rainfall to the agricultural sector.

Rainfall and Economic Indicators

Equation (4) relates annual rainfall to the log of the value of real agricultural output per worker. Annual rainfall is measured in meters, state and time fixed effects have again been included.

$$\log(\text{AgricOut})_{jt} = \beta_1 \text{Annual}_{jt} + \delta_j + \alpha_t + \varepsilon_{jt} \qquad (4)$$

Table 6: Impact of Annual Rainfall on Value of Agricultural Output per Worker

	(9)	(10)	(11)
Annual Rain (t)	0.00166 (0.71)	0.00164 (0.70)	0.00163 (0.71)
Annual Rain (t-1)		0.00627 (2.82)**	0.00627 (2.81)**
Annual Rain (t-2)			-0.00274 (-0.12)
N	328	328	342
Adj. R^2	.9209	.9228	.9225

t statistics in parentheses
$^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$
Note: Coefficients estimated using the *areg* command in Stata absorbing *state* as the indicator and including separate time dummies. R^2 estimation allows groupwise heteroskedasticity to influence the calculation of the fit of the model.
[*] Suicide rate is measured as suicides per 1,000,000 population

Equation (5) is identical to equation (4) except that log of real GDSP is now the dependent variable:

$$\log\text{GDSPcap}_{jt} = \beta_1 \text{Annual}_{jt} + \delta_j + \alpha_t + \varepsilon_{jt} \qquad (5)$$

Table 7: Impact of Annual Rainfall on Value Gross Domestic State Product per Capita

	(12)	(13)	(14)
Annual Rain (t)	0.00275	0.00275	0.00261
	(1.85)	(1.84)	(1.75)$^{+}$
Annual Rain (t-1)		0.000073	0.00016
		(0.05)	(0.11)
Annual Rain (t-2)			0.00173
			(1.14)
N	317	317	317
Adj. R^2	.9410	.9408	.9409

t statistics in parentheses
$^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$
Note: Coefficients estimated using the *areg* command in Stata absorbing *state* as the indicator and including separate time dummies. R^2 estimation allows groupwise heteroskedasticity to influence the calculation of the fit of the model.
[*] Suicide rate is measured as suicides per 1,000,000 population

What is evident in these results is that annual rain does have an impact on both agricultural output and gross output. The higher statistical and economic significant of lagged rainfall in the case of agricultural output per capita is mostly likely attributed to the fact that it takes some time for rainfall to translate into crops and for these crops to be sold and recorded as agricultural output. Another contributory factor is that agricultural output, along with GDSP, is calculated with respect to the fiscal year (April to March) and not the calendar year. In reality, agricultural output for 2005 corresponds to agricultural for April 2004 to March 2005 while current year's annual rainfall aggregates rainfall from January 2005 to December 2005. Thus, only the first three months of annual rain in *t* can potentially impact agricultural output. Lagged rainfall in this example aggregates rainfall from January 2004 to December 2004 which means that it impacts agricultural output for a full eight months which explains its greater statistical and economic significance. The result for GDSP per capita is harder to explain. Intuitively, changes in rainfall should have a more immediate impact on the value of agricultural output than on the gross domestic product. One possible cause could have to do with the measurement of these two economic indicators. GDSP estimates are generally

released well before estimates for agricultural output and so the information that the GDSP figure contains is probably more reflective of the current economic environment than agricultural output. This explanation does not seem sufficient to explain what is happening here, thus only further research will shed more light on these results.

Focusing on the lagged rainfall coefficients in the agricultural output case, evaluation at the mean of agricultural output per worker dependent variables of a 1 meter increase in annual rainfall results in an 89 rupee increase agricultural output per worker. Once converted 89 rupees translates into 2 dollars which may seem incredibly insignificant. Putting this value into perspective, if we consider that in 1995 the rural poverty line was set at approximately 356 rupees per month, a 89 rupee increase would be about a two percent increase in income. (World Bank) This analysis assumes that value of agriculture output translates directly into income, which is obviously not the case, but still demonstrates that the impact of rainfall on the real value of output is not negligible. As would be expected, both the economic and statistical significance of rainfall decrease when GDSP per capita is taken as the dependent variable. Many other industries aside from agriculture contribute to the value of GDSP per capita, thus the importance of rainfall as a determinant is expectedly diluted with an increase in annual rainfall by 1 meter corresponding to a 35 rupee increase in GDSP per capita. Thus, the results in these regression tables confirm that there is a significant relationship between rainfall and economic factors, despite improvements in agricultural technology and government price and subsidy support programs. Therefore, some of the impact of rainfall and suicide rates which was investigated in the first part of the empirical section is very likely due to rainfall's impact on these economic indicators. The economic theory of suicide supports the idea that general economic indicators can have an impact on suicide rates. The extent to which this is true in the case of agricultural suicides is investigated in the next section.

Suicide rates and economic/demographic factors

In this section, I return to the economic theory of suicide and empirically test the income and social cohesion hypotheses made in the theoretical section of the paper. The aim is to ascertain whether the behavior of the agricultural suicide rate conforms to prevailing economic theory.

In equation (6), ASR represents the agricultural suicide rate in a given state and year, and percagric represents the percent of the working population employed in agriculture. State and time fixed effects have been included. Results of this equation (6) are displayed.

$$ASR_{jt} = \beta_1 \log GDSP_{jt} + \beta_2 \log AgriOut_{jt} + \beta_3 PercAgric_{jt} + \delta_j + \alpha_t + \varepsilon_{jt} \quad (6)$$

Table 8: Variation of Agricultural Suicides due to Economic/Demographic Factors

	(15)	(16)
log GDSP per capita (t)	-12.2056 (-1.00)	-4.1801 (-0.33)
log GDSP per capita (t-1)		-25.9839 (-1.24)
log Agric Output per capita (t)	-3.6078 (-0.48)	4.8143 (0.56)
log Agric Output per capita (t-1)		-1.9648 (-0.24)
Percent of Workers in Agriculture	0.00078 (0.00)	-0.3419 (-0.13)
N	316	291
Adj. R^2	.6983	.7393

t statistics in parentheses

$^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$

Note: Coefficients estimated using the *areg* command in Stata absorbing *state* as the indicator and including separate time dummies. R^2 estimation allows groupwise heteroskedasticity to influence the calculation of the fit of the model. Reduction in the amount of observations from specification 15 to 16 due to insufficient data…

* Suicide rate is measured as suicides per 1,000,000 population

As was the case with annual rainfall, the economic variables and the suicide rates pertain to slightly different time periods. Because their overlap is greater, the lagged economic variables are of most interest. The signs for GDSP per capita do not conform to expectations in either specification. The literature on subjective well being asserted that relative deprivation is an important determinant of suicide rates. Here theory predicted that, holding agricultural output per worker constant, an increase in the general income of society should have coincided with an increase in the agricultural suicide rate because the relative economic position of the individual in agriculture has worsened. Instead, a one percent increase in the previous year's GDSP at the mean results in a 175% decrease in the agricultural suicide rate. This result, along with the insignificance of the agricultural output per worker coefficient, is likely an indicator that agricultural output per worker is not the optimal way to define the income of agricultural suicide victims. In the absence of data beyond the professional status of the suicide victims, using agricultural output per worker was the best way to try to control for agricultural income without making assumptions about the profiles of the suicide victims. Converse to the social cohesion hypothesis put forth by other literature, percent of workers in agriculture is not significant in either case. One would expect that being surrounded by other agricultural workers who are in the same position might make a farmer more able to weather misfortune. This is a belief that is driving the Self Help Group movement in rural India. (Dev, 2008) Another possibility is that where there are a greater proportion of agricultural workers, there is also more developed support system in place to provide assistance. The finding that this variable is not at all significant is most likely due to the fact that there are states with a high percent of people employed in agriculture coupled with insufficient infrastructure, as well as states with a low percent of people employed in agriculture who are geographically concentrated (and thus not isolated). An interesting question for more in-depth research might look at whether prevalence of Self Help

Groups is actually associated with declines in suicide rates, if so, it would show that the social cohesion theory does have traction in the field of agricultural suicides.

To summarize the findings in this section: both rainfall in the current and the previous year is significantly associated with agricultural suicide rates. Fluctuations in monsoon rainfall seem to operate selectively on agricultural suicide rates with a magnitude comparable to fluctuations in annual rainfall. Most importantly, these results showed that agricultural suicides are not only an issue during drought years, but also in the years following drought years. While the predictions of economic theory were confirmed in the case of rainfall and agricultural suicide rates, this was not the case with the economic and demographic variables. The relatively high significance of rainfall's association with suicides rates and economic variables combined with inconclusive evidence regarding the relationship between economic variables and agricultural suicides rates suggest that the mechanism by which rainfall operates is more complicated than the one suggested by the empirical narrative of this research. It undoubtedly includes the cycle of indebtedness as a contributory component, but without more specific data about the victims, it would be difficult to push the analysis any further.

VI. Conclusion & Suggestions for Further Research

This research has endeavored to place the phenomenon of farmer suicides within the context of economic theory. Current discussions, though well-meaning, have made it seem as though farmer suicides in each state occur for completely unique reasons instead of viewing the issue within the context of the nation as a whole. An ideal study on the subject would integrate sub-state level data on rainfall and crop revenue/yield into the analysis to better isolate the impact of rainfall and other crucial factors such as indebtedness. In addition, specific data on the onset of the monsoon along with monthly data on suicide deaths would allow for a more refined analysis. Due to

data constraints, this type of analysis was not possible in this paper. While the results presented are far from conclusive, they do provide evidence that economic thinking can be effectively applied to the case of agricultural suicides. Although the economic and demographic variables which were emphasized in the literature did not behave in the way expected, these results are still instructive in that they demonstrated the inadequacies of these measures as explanatory factors for farmer suicides.

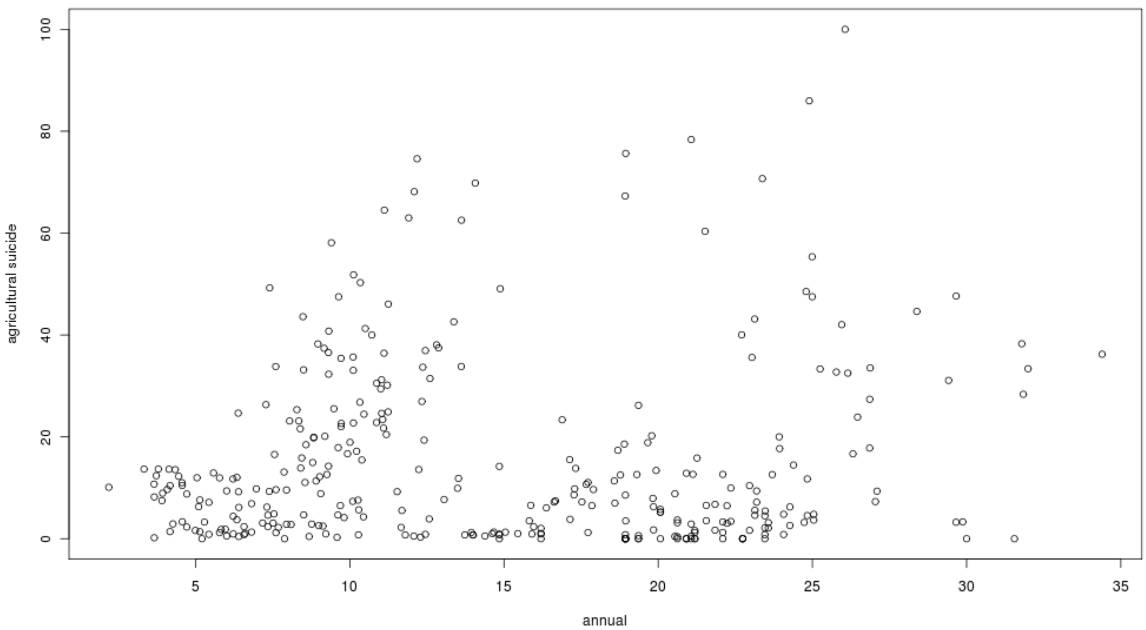
Like the "Matrix of Agrarian Distress" shown in the introduction, most current studies on farmer suicides in India list all of the problems facing farmers along with all of the possible policy recommendations. While each point is valid, such an approach does not lend itself to an understanding of the situation which . More importantly, for a government trying to determine the most efficient way to spend their limited funds, a large matrix of policy recommendations is more daunting than helpful.

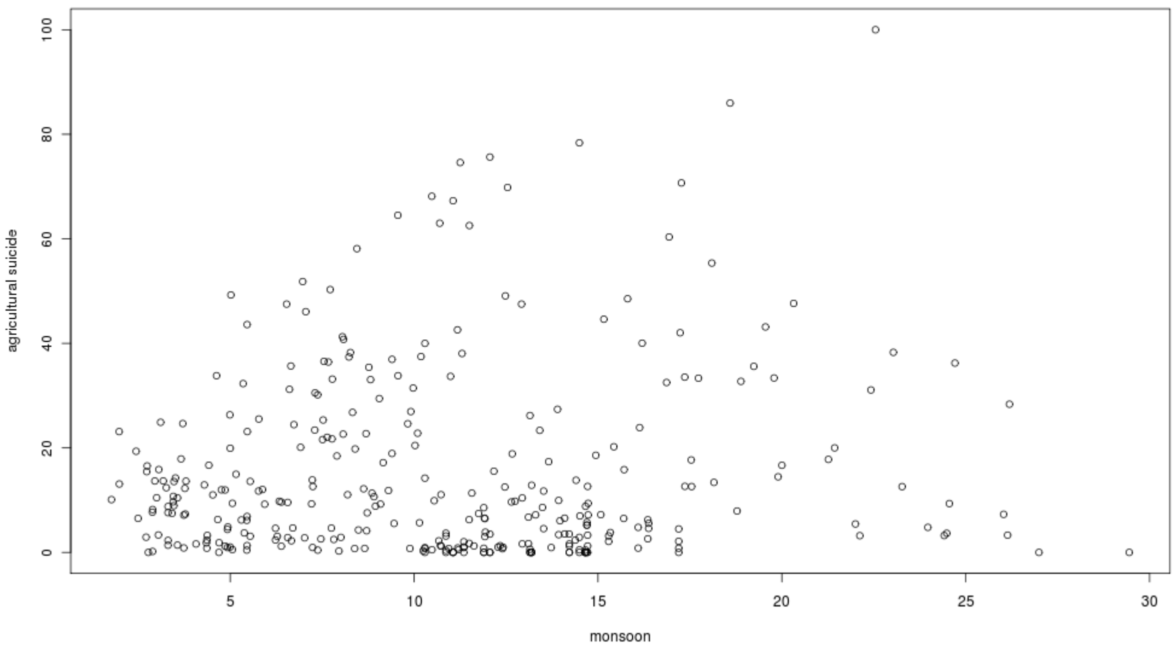
By relating rainfall to the value of agricultural output per worker and to GDSP per capita, I demonstrated that despite widespread use of high-yielding varieties of seed and extensive government intervention in agriculture through controlled food distribution and minimum support prices, rainfall still matters as a determinant of agricultural and overall income. Thus, one possible policy implication is that increased government intervention in rainfall water management might help alleviate some of the distress experienced by farmers. Relative to other policy options, rainfall collection is an inexpensive option which is relatively to implement and maintain on a large scale. Of course, in areas where water scarcity is an issue year round, such an intervention may not prove to be incredibly helpful. Yet studies have shown that watershed projects and rainfall insurance schemes, in addition to being cost-effective, have also proven to be effective means of improving the productivity of small –scale rural farmers (Gine, 2008 ; Raju, 2008; Ratna,2004)

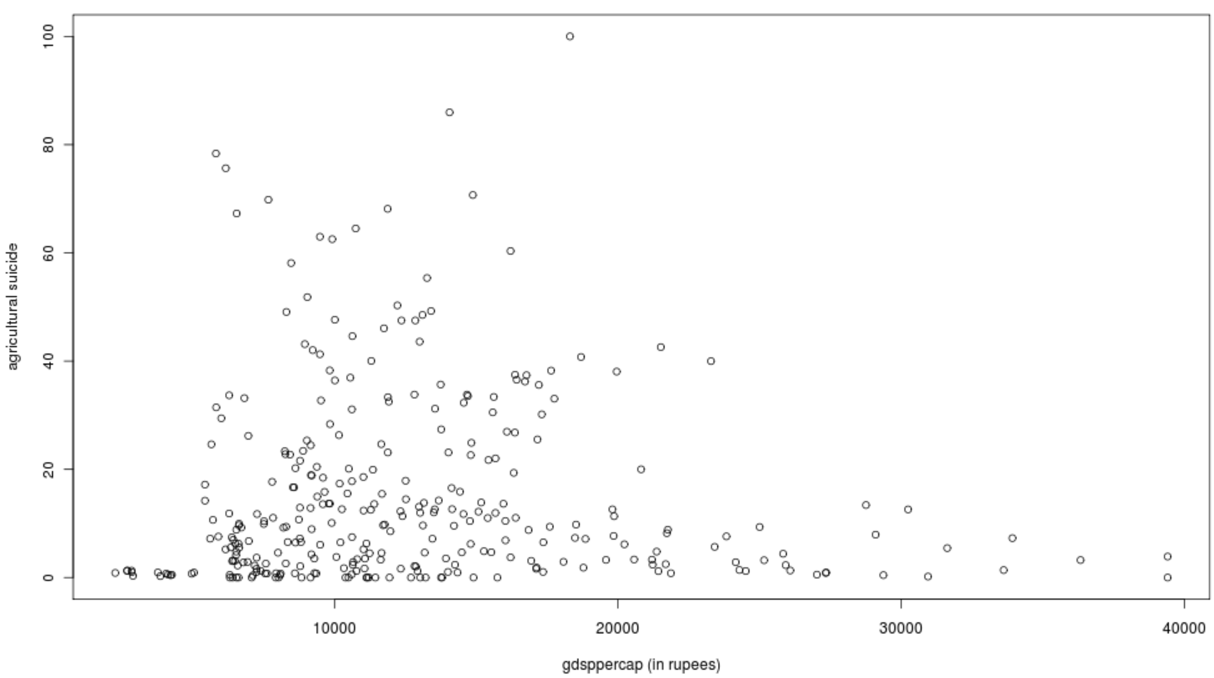
The fact that agricultural conditions are so unfavorable that over 200,000 agricultural workers have taken their own lives in the past 13 years is enough to make anyone eager to find all of the answers. The hope is that the model and the empirical work presented in this study might inspire other researchers to approach farmer suicide and agrarian distress from a different perspective. Although location and situation specific considerations are crucial, examining the issue from the perspective of the nation as a whole has the potential to provide viable solutions.

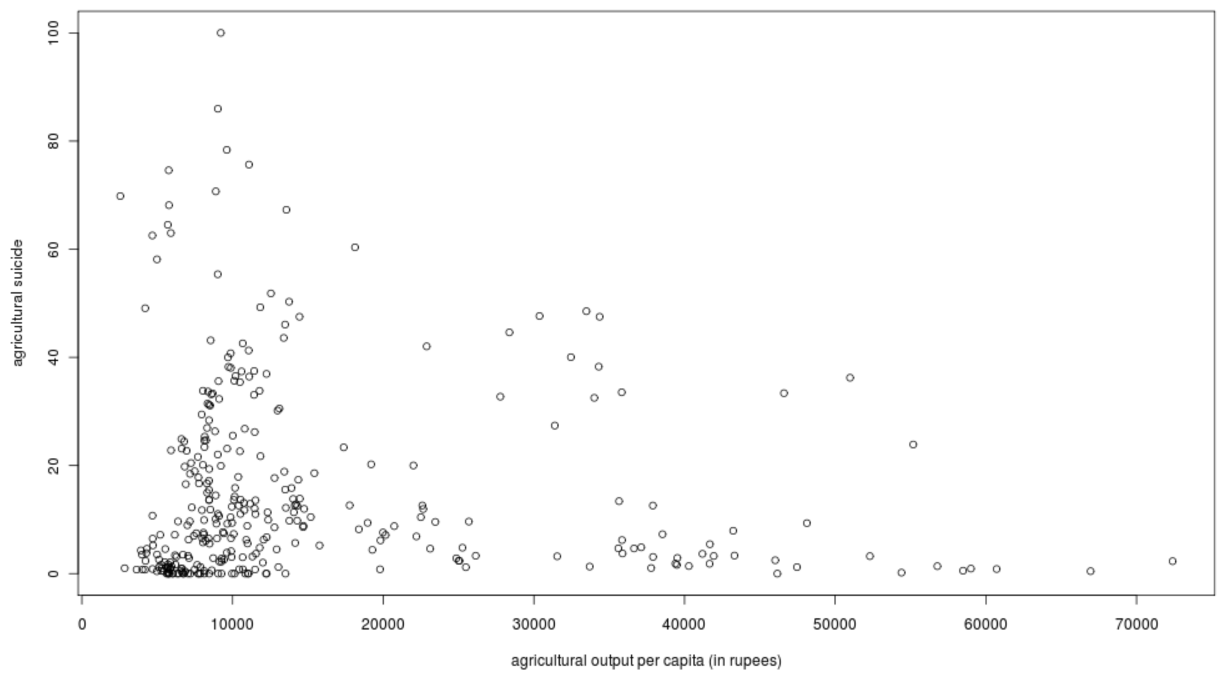
Appendix:

Pairwise Graphs of Suicide Rate and Select Independent Variables.

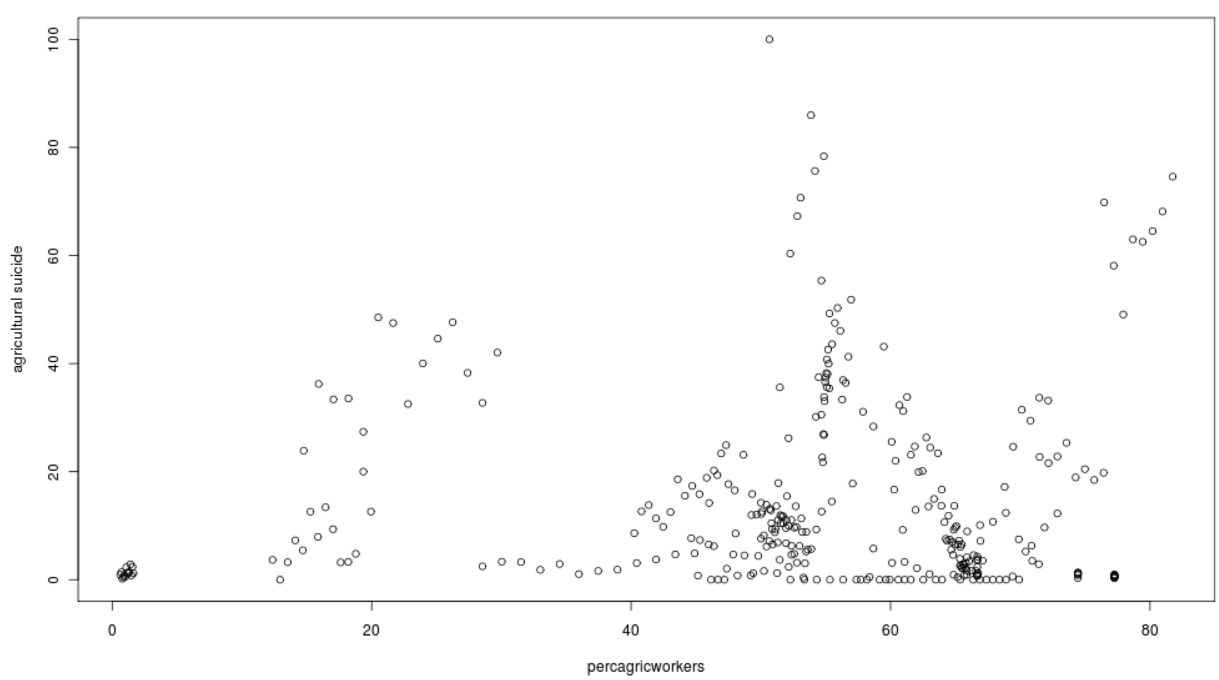



agricultural suicide
0
20
40
60
80
100
5
10
15
20
25
30
monsoon


agricultural suicide
0
20
40
60
80
100
10000
20000
30000
40000
gdsppercap (in rupees)



agricultural suicide
agricultural output per capita (in rupees)



agricultural suicide
percagricworkers

References

"Accidental Deaths and Suicides in India," National Crime Records Bureau. Various Issues. Available: http://ncrb.nic.in/accdeaths.htm.

Bose, Ashish. 2000. " From Population to Pests in Punjab: American Boll Worm and Suicides in Cotton Belt". *Economic and Political Weekly*. 35 (38): 3375-3378.

Census of India. 2001. Ministry of Home Affairs, Government of India. Available: http://www.censusindia.net/

Chen, J., Choi,Y., Sawada,Y. 2008. "How is Suicide Different in Japan?". CIRJE Discussion Papers. Available: http://www.e.u-tokyo.ac.jp/cirje/research/03research02dp.html

Chuang, W. L., and W. C. Huang (1997): Economic and Social Correlates of Regional Suicide Rates: A pooled Cross-section and Time-series Analysis, *Journal of Socio-Economics*, 26(3), 277-289.

Dev, S. Mahendra. 2002. "Bold Initiatives Needed on Agriculture and Rural Employment". *Economic and Political Weekly*. 37(12): 1088-1091

Dev, S. Mahendra. 2008. *Inclusive Growth in India*. Delhi: Oxford University Press.

Gine, Xavier, Robert Townsend, and James Vickery. 2008. "Patterns of Rainfall Insurance Participation in Rural India." *The World Bank Economic Review*. 22(3): 539–566

Hamermesh, Daniel S., Neal M. Soss. 1974. "An Economic Theory of Suicide." *Journal of Polictical Economy*. 83(1): 83-98

Kaur, Charanjit, Manoj K. Pandey. 2009. "Investigating Suicidal Trend and its Economic Determinants: Evidence from India." *ASARC Working Paper.*

Koo, JAHYEONG, Michael Cox. 2008. "An Economic Interpretation of Suicide in Japan." *Contemporary Economic Policy.* 26(1): 162-174.

Meeta, Rajivlochan. 2006. *Farmer Suicide: Facts and Possible Policy Interventions.* Government of Maharashtra: Pune.

Mooley, D.A., Parthasarathy, B.,Kumar,K. Rupa. "IITM Indian regional/subdivisional Monthly Rainfall data set". Indian Institute of Tropical Meteorology (IITM). Available: http://www.tropmet.res.in/static_page.php?page_id=53.

Nishimura, M., Terao, T. 2004. "Suicide and occupation : further supportive evidence for their relevance". *Progess in Neuro-Psychopharmacology and Biological Psychiatry.* 28(1): 83-87

Parthasarathy, G., Shameem. 1998. " Suicides of Cotton Farmers in Andhra Pradesh: An Exploratory Study". *Economic and Political Weekly.* 33(13): 720-726.

Reddy, V. Ratna, M. Gopinath Reddy, S. Galab, John Soussan, Oliver Springate-Baginski. 2004." Participatory Watershed Development in India: Can it Sustain Rural Livelihoods?" *Development and Change* 35(2): 297–326

Raju, K. V., Paramesha, J.H. 2008. "Hirehalla Watershed Project in Shimoga: A Concurrent Evaluation." in *Glimpses of Indian Agriculture* Vol. 2.

Revathi, E. 1998. "Farmers' Suicide: Missing Issues". *Economic and Political Weekly.* 33(20): 1207.

Stark C, Gibbs D, Hopkins P, Belbin A, Hay A, Selvaraj S. Suicide in farmers in Scotland. *Rural and Remote Health* 6 (online), 2006: 509. Available from: http://www.rrh.org.au

"State-wise per-capita net gross domestic product at factor cost (at constant prices) in India 1980-81 to 2008-09" Parts 1-3. Data set available: indiastat.com.

Suzuki, Tomoya. 2008. "Economic Modeling of Suicide Under Income Uncertainty". *Australian Eocnomic Papers.*

Thapliyal, B.K. 2004. *Managing Droughts…Rapid Interactive Research Study on Management of Drought 2002.* National Institute of Rural Development: Hyderabad.

Vidyasagar, R., K. Suman Chandra. 2004. Farmers' Suicides in Andhra Pradesh and Karnataka. *National Institute of Rural Development.*