SUICIDE LIKELIHOOD AMONG FARMERS IN PUNJAB

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Economics

Abstract

This study focuses on the problem of agrarian suicide in the Punjab region of India using individual level survey data. Previous research on North Indian farmer suicides has focused solely on economic and climate related causes, and ignored familial and personal characteristics of these victims almost entirely. This study fills this gap using a Logit model to analyze how different social, as well as financial and agricultural factors increase or decrease suicide likelihood among farmers in northern India. Then it further breaks down the financial components using a Tobit Regression to model how various aspects, such as education, affect farmer debt. The findings confirm previous aggregate studies of suicide showing education and marriage to be negative correlates and decreased crop profits and debt to be positive correlates of suicide; however, it also finds the coefficients of the social factors to be much larger than those of the financial and agricultural variables. This suggests that social factors, and not debt and crop failure, may be the most important keys to preventing Indian farmer suicide. The combination of these findings helps identify Indian agrarian workers who are most prone to suicide as well as provide direction for potential policy solutions to the suicide epidemic.

KEYWORDS: Farmer Suicide, Debt, Social Integration
JEL CODES: F60, I20, Q15, R20, Z13

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ON MY HONOR, I HAVE NEITHER GIVEN NOR RECEIVED UNAUTHORIZED AID ON THIS THESIS

Jacob Lauer

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Introduction

Since the early 1990's, over 300,000 Indian agricultural workers have committed suicide, taking their own lives at a rate that is 47% higher than the national average (National Crime Records Bureau, 2015). This dramatic spike in Indian farmer suicides is an epidemic that has not gone un-researched. There are many theories as to why this sudden increase occurred, ranging from the adoption of genetically modified crops (Malone, 2008), to market imperfections and small farmers' lack of competitiveness in the global agricultural market (Bandyopadhyay, 2004; Mishra, 2006; Mitra & Schroff, 2007). However, most previous academic studies point to more obvious causes such as crop loss and indebtedness, citing these stress-inducing elements as the reasons farmers are committing suicide (Assadi, 2000; Bandyopadhyay, 2004; Jeromi, 2007; Mishra, 2006; Mohanty & Shroff, 2004; National Crime Records Bureau 2015). Unfortunately, many of these financially and agriculturally focused studies do not touch on social integration: one of the most researched aspects of suicide in the last century. This study aims to combine all of these factors: social, agricultural, and financial, into a comprehensive econometric study that not only helps explain the phenomena of farmer suicides in northern India but also adds to the existing literature on suicide as a whole. It seeks to do so by using two econometric models: a logistic model that explores how individual and family, agricultural, and financial characteristics affect suicide likelihood, and a Tobit model that examines various factors that make a farmer more debt prone. The paper is laid out as follows: first a literature review that covers the relevant research on suicide as a whole and suicide specific to Indian farmers in order to demonstrate the gap that this current study fills. Immediately following are data and methodology sections that explain how and why these specific models were crafted. Finally, the results are presented and discussed with the limitations and implications for future research.

Literature Review

Social factors are far and away the most investigated aspect of suicide, stemming back to the research of sociologist Emile Durkheim (1897). The most lasting and studied portion of his theory is the concept of egoistic suicide. Durkheim argued that the lack of family connection, social ties, and community roles, drives a person to commit egoistic suicide. Subsequent research on egoistic suicide has overwhelmingly confirmed many of Durkheim's propositions by focusing on the family characteristics of the theory. Danigelis and Pope (1979), Denney, Rogers, Krueger, & Wadsworth (2009), Mohanty and Schroff (2004), and Stack (1997) all found that marriage was highly negatively correlated with suicide; that is, married persons are much less likely to commit suicide than unmarried persons. This is because married individuals have additional social support from their partners that unmarried people do not have. Mohanty and Schroff (2004), Breault and Barkey (1982), and Denney et al. (2009) all found that family size is linearly and negatively correlated with suicide, while Ellner (1997), Conklin and Simpson (1987), and Danigelis and Pope (1979) found that having children also decreased suicide confirming Durkheim's theory that more family provides more support and thus decreases suicide likelihood.

However, research also suggests that not only is family size important in dealing with suicide probability, but so is the gender composition of families. Mishra (2006) found that gender composition of a family is significant in dealing with suicide specifically among Indian farmers. He concludes that having more females in a family actually increases suicide likelihood because of marriage burdens in traditional Indian households. Having to marry off a sister or a daughter can be very stressful financially with expensive weddings and dowries driving up debt. In the midst of crop failure, it can be a driving factor in farmer suicide. Conklin and Simpson (1987)

also found that family gender is important, finding that men whose wives work outside the house rather than at home are more prone to suicide. Conklin and Simpson hypothesized that this is because it represents a departure from traditional family values and breaks down family bonds to a certain extent, thus decreasing the family support system that Durkheim argues is so important. This present study looks at all of these factors to see how marriage, family size, family gender composition, and family employment affect farmer suicide in North India.

Other social aspects frequently cited as correlates of suicide are gender, age, and education. Males have consistently been proven to be statistically more likely to commit suicide than females (Danigelis & Pope, 1979; Denney et al., 2009; Mayer & Ziaian, 2002) and this appears to remain true for rural Indian farmers as the proportion of male farmer suicides to all farmer suicides has hovered between 80% and 90% in the last several decades, reaching 91.4% in 2014 (National Crime Records Bureau, 2015). Age is generally thought to increase suicide risk as well. Conklin and Simpson (1987) found that age is a positive correlate of suicide; however, there are some studies that suggest this is not entirely true for economically developed countries. Girard (1993) found that suicide and age, while most of the time positively correlated, sometimes have a concave relationship in developed economies. He theorized that this is due to achievement driven success, meaning that the stress that drives people to commit suicide increases with age until a person reaches the height of their career, after which it subsides. The present study aims to further the discussion on age and suicide by analyzing them as independent variables that affect Indian farmer suicide.

Education is usually found to be negatively correlated with suicide, so that the more educated a person is, the less likely they are to commit suicide (Denney et al., 2009; Ellner, 1997; Mäki, 2008) except in rare cases. In his 1998 study, Stack found that education normally is negatively

correlated with suicide except in the case of black Americans. He hypothesized that this was because, unlike their white counterparts, black workers were not financially compensated appropriately for their increased education leading to discontent and eventual suicide. Stack also suggested that receiving higher education separated blacks in the U.S from their families and relatives who had less education resulting in social de-integration. In the case of Indian farmers, Mohanty and Schroff (2004) drew a similar conclusion to Stack (1998), noting that in some cases, Indian farmers who were more educated were more likely to commit suicide because they originally wanted to work outside of agriculture but failed to do so. Thus, they became discontent and distanced themselves from other farmers. However, exceptions like the ones listed above are few and far between. This present study will look at education as a driver of suicide to examine whether or not education among Indian famers reduces or increases suicide likelihood.

As far as literature specific to Indian farmer suicide goes, researchers cite agricultural factors far more than social causes. Jeromi (2007) found that crop failure and decreasing crop yields are primary indicators of farmer suicide in India. He cites the switch to mono-cropping and decreased soil fertility as the causes for the yield crisis. Mishra (2006) also supported the proposition that crop failure is a primary cause and his theory is further reinforced by the farmers themselves. In a "seed tribunal" held in 2000, several years after the suicide crisis had begun, Indian farmers testified the reasons for their struggles, claiming that crop failure and the ensuing debt was the primary cause (Assadi, 2000). Other studies claim that irrigation is also a major problem for these farmers. Revathi (1998) claimed that the depletion of groundwater paired with the major expense of deepening existing wells or digging new ones has proven to be a very large burden for Indian farmers. Vaidyanathan (2006) also concluded that irrigation expenses played a key role in farmer suicides in his examination of the crisis. However, neither irrigation or mono-

cropping has been shown to econometrically impact suicide likelihood. This study helps fill the gap by looking both irrigation and mono-cropping as causes of suicide using econometric analysis.

The final category of causes is financial factors. The National Crime Records Bureau (2015) has pointed to debt and financial problems as one of the leading causes of Indian farmer suicide. This claim is supported both by financial and survey data (Assadi, 2000; Bandyopadhyay, 2004). However, because debt has been so indisputably linked to these suicides, the more pertinent question is what has caused these farmers to take on so much of it. Many scholars point to the internationalization of India's agricultural economy in the 1990s as a cause (Assadi, 2000; Bandyopadhyay, 2004; Mishra, 2006; Mitra & Shroff, 2007). When the economy opened up, many of India's small farmers switched from traditional multi-crop strategies to mono-cropping in order to take advantage of high global prices for cash crops like cotton (Bandyopadhyay, 2004). However, these farmers' input prices also rose as multinational seed companies like Monsanto entered and began aggressively selling expensive, supposedly higher quality seeds that also required expensive fertilizers and pesticides (Assadi, 2000; Mohanty & Schroff, 2014; Vaidyanathan, 2006). Not only do these seeds have higher input costs but many of them require more irrigation (Vaidyanathan, 2006) and the cost of deepening wells or digging new ones is very high and the result is not always successful (Revathi, 1998). In order to pay for these increasing expenses, small farmers who were unqualified for bank lending had to take out loans from middlemen at rates far above their institutional counterparts (Assadi, 2000; Mishra, 2006; Mohanty & Schroff, 2014; Revathi, 1998). When crops failed, prices often did not increase to offset farmer losses because global production either remained unchanged or in some cases increased, magnifying the losses of small farmers and leaving them with an insurmountable debt

(Vaidyanathan, 2006). This study focuses on the narrative laid out above by looking at the impact of debt interest rates, seed and pesticide/fertilizer expenses, as well as irrigation on total debt held by Indian farmers.

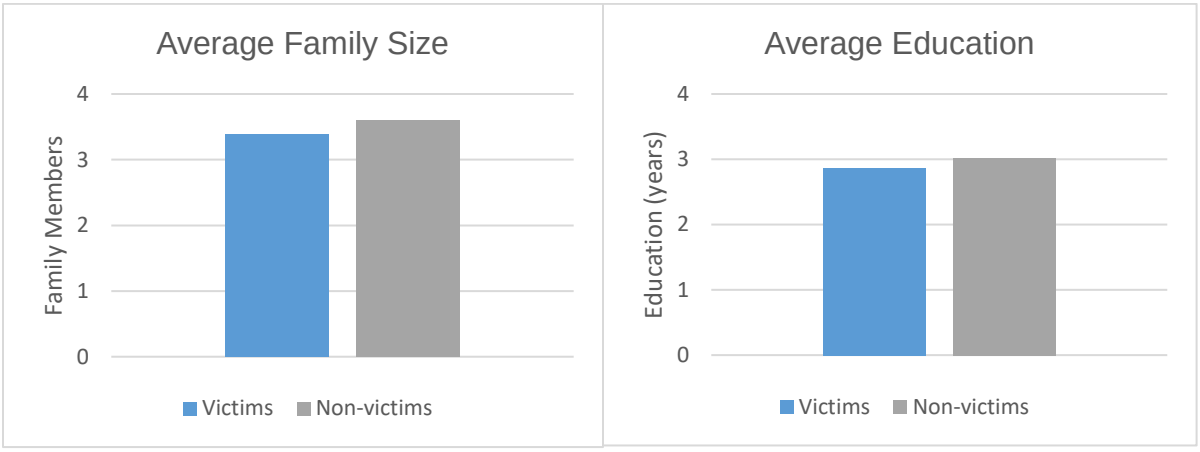
The picture painted by the literature on Indian farmer suicide is by no means simple. There are many possible explanations for the spike in agrarian suicides in North India, but this study aims to bring together as many of these causes as possible together in single econometric study using individual level suicide data. It does so by looking at the social, agricultural, and financial factors impacting the farmers. Then, it seeks to explain how the financial troubles (debt) facing these farmers are acquired.

Data

The dataset is made up of survey responses from 1,393 rural households in three North Indian districts: Bathinda, Mansa, and Sangrur. The data was gathered by Lakhwinder Singh, Kesar Bhangoo, and Rakesh Sharma for their book: *Agrarian Distress and Farmer Suicides in North India* (2016). The survey contains responses regarding almost all aspects of life for both suicide victims and comparable non-victims including: family members, education, employment, land, income, crop data, debt, gender, age, and more. In addition to being split up by district, the responses were also organized into four categories: victim farmers, non-victim farmers, victim laborers, and non-victim laborers. For the purposes of this study, all 372 laborers were removed from the data, isolating the farmer responses. After removing an additional 77 responses due to missing family and financial data, the final observation count was 944, of which 477 were victims and 467 were non-victims.

Some of the social aspects collected were family size and farmer education. Figure 1.1 shows that the average family size of victims was 3.39 members, while the average family size for non-victims was 3.60. This falls in line with the hypothesis that having a larger family decreases suicide likelihood. Figure 1.1 also shows the difference in average education between victims and non-victims, with victims having on average only .15 years less schooling than non-victims. In addition, there was no difference in literacy between farmers who committed suicide and those who did not as the proportion of illiterate to non-illiterate observations was 56% to 44% for both victims and non-victims. Therefore, on its own, the demographic data seems to suggest that in the case of North Indian farmers, education does not play a large role in suicide probability.

Figure 1.1. Average Family Size & Farmer Education



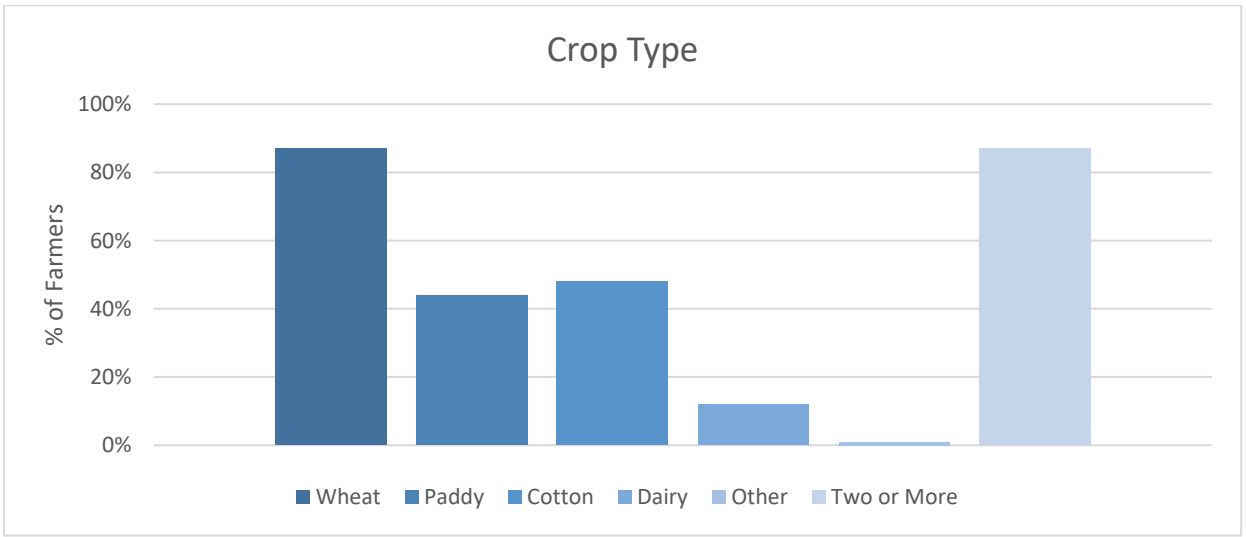
Other notable social statistics in the data set were differences in marriage, children, and age between victims and non-victims. On average, farmers who committed suicide were married 75% of the time, and 21% had one or more young children. Whereas non-victim farmers were married 94% of the time, but only 17.5% had young kids. This seems to suggest that while marriage appears to decrease suicide likelihood, having children may have the opposite effect. However, this lack of children among non-victims might be explained by the average age difference between victims and non-victims. The mean age of victims at the time of death was 36, but for non-victims that number rose to 47 at the time of survey. This eleven-year difference pointed to age being negatively correlated with suicide likelihood, but also raised concern that any affect having children had on suicide was actually being caused by age. This issue is addressed in the results section.

The agricultural data gathered from the survey ranged from land owned and irrigated, to the yield and income generated by each crop farmers cultivated. Unfortunately, agricultural factors had the most missing information in the entire data set. When it came to irrigation, the

only response that was not missing a significant amount of data was the number of wells owned, which was used as a proxy for irrigation. The crop-specific income and yield data were even more incomplete. All responses had the total agricultural income from all crops combined; however, many responses were missing the specific income breakdown crop to crop, making the crop specific incomes useless for this study. The crop yields were also missing hundreds of responses; in order to include these variables in the model, more data must be collected.

Despite much of the agricultural data being compromised, it was still possible to identify which crops a farmer cultivated through the acres of land dedicated to each crop. Using this data, Bernoulli variables were created for each crop as well as an additional variable that equaled "1" if a farmer had two or more crops, and "0" if they only farmed one crop (mono-cropping). Figure 1.2 illustrates the proportion of farmers that cultivate each crop. Dairy was included as crop because a large proportion of farmers listed a substantial yearly dairy income. "Other" is defined as either paddy, oilseed, vegetable, or sugarcane production.

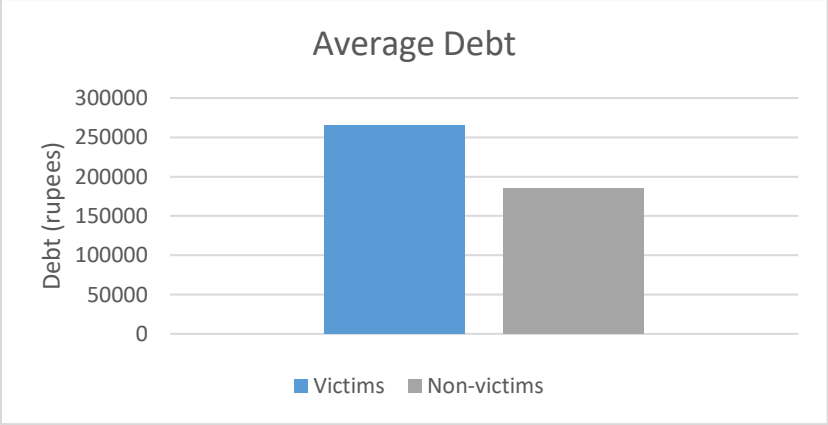
Figure 1.2. Farmer Crop Types



The most common crop in this dataset was wheat with 87% of all respondents farming this crop. The next most popular was cotton at 48%, followed by paddy and dairy at 44% and 12% respectively. Less than 1% cultivated a different crop and 87% farmed two or more crops.

The financial aspects of the data were far more complete than agricultural factors. Included were (1) total, agricultural, and other income, (2) total, private, family, institutional, cooperative, and other debt as well as the interest rates on each of these totals, (3) the yearly spending on health, education, marriages, electricity, and more, and (4) the expenses on seeds, pesticides, fertilizer, transportation, and more. The focus of this study concentrates primarily on the debt statistics and relevant farming expenses. Looking solely at the raw data seems to confirm that debt is positively correlated with suicide. Figure 1.3 shows that the average debt for non-victims was more than 80,000 rupees less than their victim counterparts.

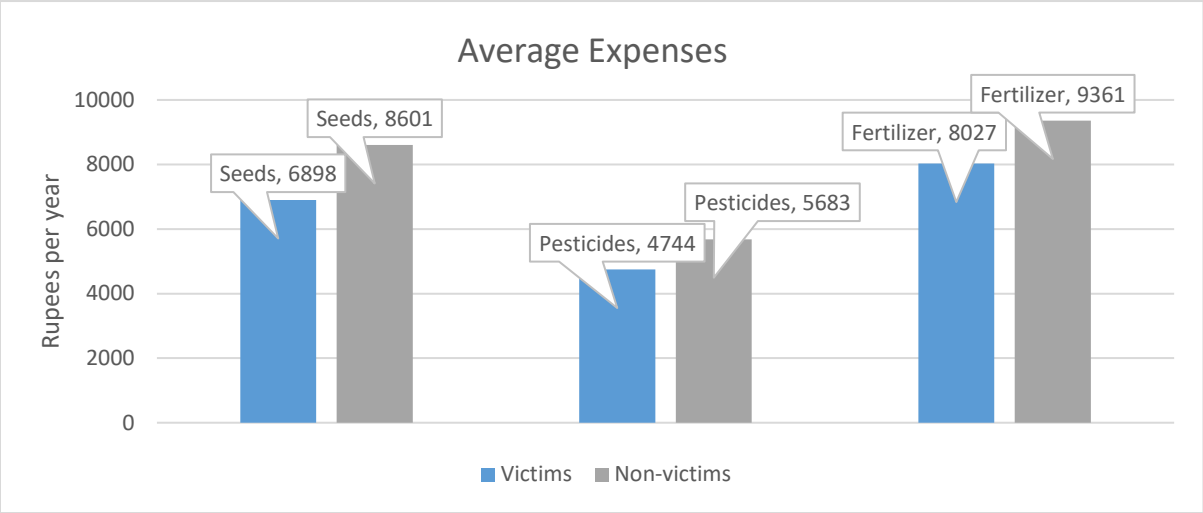
Figure 1.3. Average Farmer Debt



Furthermore, the weighted-average interest rate on that debt was more than 2% lower for non-victims than it was for their victim counterparts. This supports the claim that farmers who were ineligible for institutional lending, and therefore had to borrow at higher rates, were more likely to commit suicide. The yearly expenditures on seeds, pesticides, and fertilizer were also of

interest due to their potential impact on a farmer's debt. Figure 1.4 shows that average yearly expense on all of these items for non-victim farmers was between 900 and 1,700 rupees more than the average yearly expense for victim farmers.

Figure 1.4. Average Crop Expenses



This is an interesting finding, considering that the overall debt for non-victim farmers was significantly lower than victim farmers, because it appears that spending more on seeds, pesticides, and fertilizer might actually decrease debt. These expenses are analyzed as factors that affect total debt to see if this finding holds true.

Of the over 500 coded variables, only a handful were pertinent to this study. The important social factors were: family size and gender composition, farmer age and education, and family employment. The usable agricultural factors were: crop type, wells owned as a proxy for irrigation, and agricultural income year-to-year as a proxy for yields (this is discussed in further detail in the next section). The relevant financial factors were: debt, interest rate on debt, and the yearly expenses on seeds, pesticides, and fertilizer. The next section lays out how these variables were modelled.

Methodology

This study is split into two separate models, one that looks at the impact of social, agricultural, and financial factors on suicide likelihood, and another that analyzes the effect of expenses, income, irrigation, and education on total debt.

Model 1

The first model uses a logistic regression where the dependent binary variable is whether or not the farmer committed suicide.

$$Victim = \beta_0 + \beta_1 married + \beta_2 education + \beta_3 age + \beta_4 family\_male + \beta_5 family\_female + \beta_6 family\_child\_female + \beta_7 family\_child\_male + \beta_8 family\_occup\_house\_female + \beta_9 2ormorecrops + \beta_{10} wells\_total + \beta_{11} agincome\_difference + \beta_{12} total\_debt + \beta_{13} average\_interest\_debt \quad (2.1)$$

β_1 is a Bernoulli variable that is equal to "1" if the farmer is married and "0" if they are unmarried. Marriage is one of the most frequently cited buffers against suicide (Danigelis & Pope, 1979; Denney et al., 2009; Mohanty & Schroff, 2004; Stack, 1997) and this study hypothesizes that the results will confirm this finding with marriage decreasing suicide likelihood among Indian farmers. β_2 is a measure of farmer education in years measured from 0-14: "0" meaning the farmer has no formal education and is illiterate, and 12 or more years meaning high school graduation plus two or more years of specialized schooling. As mentioned earlier, most previous literature finds that education is negatively correlated with suicide, that is, the more years of schooling a person has the less likely they are to commit suicide (Denney et al., 2009; Ellner, 1997; Mäki, 2008). This study sides with the majority and hypothesizes that education is significant and negatively correlated with suicide. β_3 is the farmers' age defined as age at the time of death for victims and the age at the time of survey for non-victims. Most

previous literature on suicide finds that age is positively correlated with suicide except for several select cases (Conklin & Simpson, 1987). Based on the raw data mentioned earlier, this study is expected to produce results that defy the majority and find that age is negatively correlated with suicide.

Not included in this study is the gender of farmers. Only 33 of the 944 observations in this study were female and the National Crime Records Bureau notes that between 80-90% of Indian farmer suicides are male. There is an obvious tendency for male farmers to commit suicide at a higher rate than their female counterparts but this difference is one that should be explored in a different study as there are simply not enough female observations in this dataset to produce meaningful results.

β_4 through β_7 are measures of family composition: the total number of males and females as well as the total number of male and female children in the farmer's family. By including the total number of male and female family members, this model tests to see not only if family size affects suicide likelihood, but also how the gender of additional members added makes a difference. Similarly, the model tests to see how number and gender of children affect suicide likelihood. While most literature finds that family size is negatively correlated with suicide, Mishra (2006) suggested that in the case of Indian farmers, having more females in the family actually increases suicide likelihood. This study sides with Mishra and theorizes that having more males and male children in the family will decrease suicide likelihood and having more females and female children will increase it. β_8 measures female employment within the home as a proxy for traditional family values. Conklin and Simpson (1987) found that female family members working outside the home increased likelihood of suicide; they hypothesized that this was because it represented a move away from traditional family values. β_8 was included based

on Conklin and Simpson's hypothesis, so it is expected that having more females working in the house will decrease suicide likelihood.

β_9 through β_{11} are agricultural factors. β_9 is a Bernoulli variable representing mono-cropping versus multi-cropping that equals 1 if the farmer cultivates more than one type of crop and equals 0 if the farmer only specializes in one crop. It is expected that farmers who utilize a multi-crop approach will be less likely to commit suicide confirming Jeromi's (2007) proposition that mono-cropping provides less insulation from crop failure and price fluctuation. β_{10} counts the total number of wells owned by a farmer as a proxy for irrigation, hypothesizing that the more wells farmers have, the better protected from droughts and crop failure they are and thus the less likely they are to commit suicide. β_{11} is a proxy for crop yields that subtracts farmers' total agricultural income in 2006 (non-victims) or pre-suicide year (victims) from their total agricultural income in 2007 (non-victims) or suicide year (victims). A positive or zero balance represents an increased or unchanged crop yield and a negative balance represents decreased yield or crop failure. Using agricultural income as a proxy for yield allows comparison across different crops and also makes up for inconsistencies and missing information in the data that made econometrically analyzing the yield statistics impossible. It is expected that the higher the difference between year two and year one agricultural incomes, the less likely it is that the farmer will commit suicide.

β_{12} and β_{13} represent the hypothesized financial drivers of suicide by measuring total debt and the weighted average interest on that debt. Not only is debt cited as a major cause of suicide among farmers but also the type the debt (Assadi, 2000; Bandyopadhyay, 2004; Mishra, 2006; Mohanty & Schroff, 2014; Revathi, 1998). As mentioned in the literature review, many small farmers who are ineligible for commercial bank loans resort to taking loans from informal

sources of credit at very high interest rates that they end up being unable to repay. Thus, this study hypothesizes that suicide likelihood will increase not only with every dollar of added debt but also with higher interest rates on that debt.

Model 2

The second model in this study is a Tobit regression with a lower limit of zero where the dependent variable is the farmer's total debt amount.

$$\begin{aligned} Total\ Debt = {} & \beta_0 + \beta_1 expense\_pesticide + \beta_2 Average\_interest\_debt + \\ & \beta_3 total\_income\_year2 + \beta_4 education + \\ & \beta_5 spending\_ceremonies + \beta_6 wellstotal \end{aligned} \tag{2.2}$$

β_1 is the farmers' yearly expense on pesticides. As mentioned in the data section, the average expenses for seeds, pesticides, and fertilizer items were higher for non-victim farmers, who have on average substantially less debt than victim farmers. The resulting implication is that having more seed/pesticide/fertilizer expenses actually decreases debt among Indian farmers. However, based on previous research citing increased seed and pesticide expenditures as drivers of debt and suicide (Assadi, 2000; Mohanty & Schroff, 2014; Vaidyanathan, 2006), this study hypothesizes that all three would be positively correlated with total debt. For this study, only pesticide expense is modelled due to the extremely high correlation between seed, pesticide, and fertilizer expenses. β_2 is the weighted average interest rate on farmers' debt and it is expected that it will also be positively correlated with total debt due to interest accruing at a faster rate with each percentage point added. β_3 is the total income of the farmer in year 2 which is defined as the sum of agricultural and non-agricultural income in 2007 for non-victim farmers and in the suicide year for victim farmers. This study projects that income is a positive correlate of debt because with a higher income, comes a greater ability to borrow. However, it is expected that the

increase in debt per dollar increase in income will be much smaller than the increase in debt per dollar increase in expenditures.

β_4 is the farmer's education level measured in years. This study hypothesizes that education is a negative correlate of debt, suggesting that more years of education increases farmers' ability to make smart financial decisions and avoid accumulating overwhelming debt. β_5 is money spent on family marriage ceremonies. As briefly mentioned in the literature review, Indian farmers are often responsible for paying for their daughters' weddings as well as providing dowries, expenses that can be quite costly (Mishra, 2006). This study expects to find that wedding ceremony expenses will a be large and significant positive correlate of debt. Finally, β_6 is the total number of wells a farmer owns. Because wells are very expensive to dig and because new wells are not always successful as an irrigation solution providing little return on investment (Revathi, 1998), it is expected that the number of wells owned will be a positive correlate of debt. This study's hypotheses are summarized in the next section.

Hypotheses

Model 1:

Positive Correlates with Suicide:

- Female Family Members (family_female)
- Total Debt (total_debt)
- Debt Interest Rate (average_interest_debt)
- Female Children in Family (family_child_female)

Negative Correlates with Suicide:

- Farmer is Married (married)
- Years of Education (education)
- Male Family Members (family_male)
- Male Children in Family (family_child_male)
- Female Family Members Working in the House (family_occup_house_female)
- Multi-cropping (twoormore_crops)
- Total Wells Owned (wells_total)
- Total Income Gained or Lost from Year 1 to Year 2 (agincome_difference)

Model 2:

Positive Correlates with Debt:

- Seed Expense (expense_seeds)
- Fertilizer Expense (expense_fertilizer)
- Pesticide Expense (expense _pesticides)
- Debt Interest Rate (average_interest_debt)
- Spending on Marriages (spending_ceremonies)
- Total Wells Owned (wells_total)

Negative Correlates with Debt:

- Years of Education (education)
- Total Income (total_income_year2

Results/Analysis

Model 1

Model 1 was significant and had a pseudo R^2 of .1971. Eight of the thirteen independent variables were significant at the 95% confidence interval in impacting Indian farmers' suicide likelihood. Table 3.1 shows the table of results from the logistic regression and table 3.2 lays out the marginal effects of each variable on suicide probability.

Table 3.1. Model 1 Results

Regression results, logit
Dependent variable: Suicide y/n

Variable	dy/dx	Variable	dy/dx
married	-0.951***	family_occup_house_female	-0.370**
	(-3.76)		(-3.15)
education	-0.0550**	2_or_more_crops	-0.287
	(-2.78)		(-1.24)
age	-0.0600***	wells_total	-0.109
	(-9.00)		(-0.80)
family_male	-0.0522	agincome_difference	-0.0000132**
	(-0.66)		(-3.20)
family_female	0.0803	total_debt	0.00000144***
	(0.95)		(4.85)
family_child_female	-0.132	average_interest_debt	0.0190*
	(-0.56)		(2.00)
family_child_male	0.486*	_cons	3.659***
	(2.38)		(8.88)
N	**944**		
LR chi2(13)	**257.92**		

Standard errors are reported in the parentheses
*Significant at $\alpha<0.10$
**Significant at $\alpha<0.05$
***Significant at $\alpha<0.01$

Table 3.2. Model 1 mfx
Marginal effects after logit
Dependent variable: Suicide (y/n)

Variable	dy/dx	Variable	dy/dx
married	-0.226*** (-4.15)	occup_house_female	-0.093*** (-3.15)
education	-0.014*** (7.98)	2_or_more_crops	-0.071 (-1.25)
age	-0.015*** (-9.00)	wells_total	-0.027 (-0.80)
family_male	-0.013 (-0.66)	agincome_difference	-3.30e06*** (-3.20)
family_female	0.080 (0.95)	total_debt	3.60e-07*** (4.85)
family_child_female	-0.033 (-0.56)	average_interest_debt	0.005** (2.00)
family_child_male	0.122** (2.38)		
N	**944**		

Standard errors are reported in the parentheses
*Significant at $\alpha<0.10$
**Significant at $\alpha<0.05$
***Significant at $\alpha<0.01$

Marriage, education, age, females working in the house, and the difference between agricultural incomes in year 1 and year 2 all came out as significant and negatively correlated with suicide, confirming this study's hypotheses on these variables. Marriage resulted in being the most impactful factor, decreasing suicide likelihood by almost 23% confirming the findings of Danigelis and Pope (1979), Denney et al. (2009), Mohanty and Schroff (2004), and Stack (1997). Education also confirmed previous findings documented in the literature review with each additional year of education decreasing suicide likelihood by approximately 1.4%. This meant that a farmer that had completed high school was 14% less likely to commit suicide than an illiterate farmer with no formal education. Age had roughly the same impact on suicide as education, decreasing suicide likelihood by 1.5% with each additional year; however, the negative correlation with suicide contradicts all previous literature. There are a variety of

potential explanations for this difference. It is possible that older more experienced farmers were better able to adapt to and manage the stresses caused by crop failure and debt. It is also possible that older farmers were more well-integrated into their farming communities and therefore had a stronger social support system than their younger counterparts. Regardless of the reasoning, more data should be collected and analyzed in order to confirm this study's finding as it does contradict all other suicide literature.

Females working in the home was another significant negative correlate with suicide with each additional female family member working in the home decreasing suicide likelihood by nearly 10%. This aligns with the findings of Conklin and Simpson (1987) and suggests that females working within the home strengthen family bonds, and therefore provide a stronger buffer against Durkheim's egoistic suicide (1897). The final negative correlate significant at the 95% confidence interval was the difference in agricultural income between year 1 and year 2 which served as a proxy for crop yields by measuring profits and losses from year to year. The model found that for every additional rupee earned in year 2, a farmer's suicide likelihood decreased by 3.30e-06%. The average yearly agricultural income for farmers in this dataset was roughly ₹73,300, so a 10%, ₹7,300 increase in agricultural income in year 2 would make a farmer 2.4% less likely to commit suicide than a farmer whose agricultural income remained unchanged from year 1 to year 2. Likewise, if a farmer were to only make half as much from agriculture in year 2 as he did in year 1, he would be more than 12% more likely to commit suicide than a farmer whose income remained unchanged.

The significant negative correlates help paint a clear picture of the suicide-preventing factors among North Indian farmers. The summation of all the significant negative correlates of suicide propose that older, married, well-educated farmers who have female family members

working at home, and have an increased agricultural income from the previous year are much less likely to commit suicide than young, single, illiterate farmers who have decreased agricultural income from the previous year.

The significant positive correlates of suicide found in this model were debt, debt interest rate, and male children in the family. Debt was expected to be significantly positively correlated with suicide, not only based on previous literature (Assadi, 2000; Bandyopadhyay, 2004), but also based on the demographic data which found that victim farmers had on average ₹80,000 more in debt than non-victims. Though the coefficient for debt was positive, the value of 3.60e-07 was much smaller than expected. An additional ₹80,000 of debt only results in a 2.88% increase in suicide likelihood, a much smaller impact than some of the social factors such as marriage and education. Likewise, the coefficient on debt interest rate was smaller than expected, coming in at .0047. On average, the weighted average debt interest rate for victims was about 2.5% higher than non-victims, but this only results in a 1.2% increase in suicide likelihood. This suggests that while debt and debt interest rates undoubtedly play a significant role in suicide likelihood, Durkheim's (1897) proposed factors of social integration may play more important roles in the case of Indian farmers.

The number of male children in the family was the only significant family composition related variable. The coefficient proposes that every additional male child in a farmer's family increases suicide probability by 12.2%. This contradicts this study's hypothesis and the findings of Ellner (1997), Conklin and Simpson (1987), and Danigelis and Pope (1979) who claimed that children, regardless of gender, decreased suicide likelihood. Initially, this finding was thought to be a result of the age difference between victims and non-victims as the older non-victims would naturally have less children but upon checking the correlations between farmer age and male,

female, and total children, the theory was discarded as the highest correlation was only .13. A theory as to why having children would increase suicide likelihood is that having dependents who can do little to help around the farm increases both financial and physical stress for farmers thereby making them more likely to commit suicide. However, there is no obvious answer for why only additional male children increased suicide likelihood and why additional female children was insignificant. More data is needed to confirm this finding, so research can begin to answer why male children specifically might increase suicide likelihood among North Indian farmers.

The rest of the family composition variables: male family members, female family members, female children, were insignificant. As a result, a second model was run that replaced male/female family members and male/female children with total family members and total children to see if removing gender increased significance. The marginal effects of this modified model are shown in table 3.3.

Table 3.3. Model 1b mfx
Marginal effect after logit
Dependent variable: Suicide y/n

Variable	dy/dx	Variable	dy/dx
married	-0.220*** (-2.72)	2_or_more_crops	-0.075 (-1.32)
education	-0.013*** (-2.72)	wells_total	-0.027 (-0.79)
age	-0.015*** (-9.25)	agincome_difference	-3.24e-06*** (-3.14)
family_members_total	-0.002 (-0.14)	total_debt	3.57e-07*** (4.85)
family_child_total	0.055* (1.68)	average_interest_debt	.005** (1.96)
family_occup_house_female	-0.080*** (-2.88)		
N	944		
LR chi2(13)	**257.92**		

Standard errors are reported in the parentheses
*Significant at $\alpha<0.10$
**Significant at $\alpha<0.05$
***Significant at $\alpha<0.01$

Making this change did nothing to change the significance of the other modelled variables and neither total family members nor total children ended up being significant. This suggests that in the case of Indian farmers, the only important family composition factor is the number of male children in the family, though as mentioned earlier more data is needed to confirm this result.

The other two insignificant variables in Model 1 were the Bernoulli variable for multi-cropping and total wells. The multi-cropping variable (labelled as "2 or more crops") did have the hypothesized negative coefficient but was only significant at around an 80% confidence interval. This could be due to such a large portion (87%) of the respondents farming multiple crops. Therefore, a broader sample of farmers is needed to confirm this result. The total number of wells also had the hypothesized negative coefficient meaning that additional wells decrease suicide probability; however, it was one of the least significant variables in the model rendering the coefficient meaningless.

Overall, Model 1 found that marriage was far and away the most significant variable that decreases suicide likelihood, followed by females working in the house, education, age, and income difference from year one to year two. The variables that increased suicide likelihood were debt, debt interest rate, and male children in the family with the coefficients on debts and debt interest rates being surprisingly low and the impact of male children contradicting previous research on how children affect suicide probability (Conklin & Simpson, 1987; Danigelis & Pope, 1979; Ellner, 1997).

Model 2

Model 2 produced significant results and four of the six independent variables were significant at the 95% confidence interval. Table 3.4 shows the results of the Tobit regression.

Table 3.4. Model 2 Results
Regression results, Tobit, lower limit (0)
Dependent variable: Total Debt

Variable	Regression Coefficient	Variable	Regression Coefficient
expense_pesticide	5.676*** (4.77)	spending_ceremonies	1.669 (0.76)
average_interest_debt	10622.3*** (7.98)	wells_total	49603.1* (2.52)
total_income_year2	0.384** (3.22)	_cons	-16962.9 (-0.69)
education	-1060.8 (-0.38)		
N	**944**		
LR chi2 (6)	**126.63**		

Standard errors are reported in the parentheses
*Significant at $\alpha<0.10$
**Significant at $\alpha<0.05$
***Significant at $\alpha<0.01$

Yearly pesticide expenses, year 2 income, weighted average debt interest, and total wells were significant and positively correlated with total debt, all confirming this study's hypotheses. Pesticide expense had the highest impact on debt per rupee added with every rupee expended on pesticides adding 5.67 rupees of debt. This confirmed literature pointing to increased pesticide and seed costs stemming from the arrival of multi-national seed corporations as drivers of debt and suicide (Assadi, 2000; Mohanty & Schroff, 2014; Vaidyanathan, 2006). Total income was also positively correlated with total debt, but as expected, the coefficient was much smaller than that of pesticide expenses with each additional rupee of income only adding .38 additional rupees of debt. This makes sense because with increased income comes increased capacity to borrow, but also greater ability to make purchases without borrowing.

Weighted average debt interest produced very large results, with every percentage point added increasing total debt by 10,622.34 rupees. Even more impactful on debt was the effect of adding additional wells. One additional well added 49,603.13 rupees of debt confirming the

hypothesis that the high costs of digging new wells would increase debt. This large and significant finding could also explain why wells showed up as insignificant in Model 1 which hypothesized that wells would decrease suicide likelihood. While better irrigation may in fact decrease suicide probability, using wells to measure irrigation is not the best selection as any positive effect of an additional well on suicide is likely offset by the increased debt that accompanies it.

Only two variables came up as insignificant in Model 2: spending on marriage ceremonies, and education. Spending on marriage did come up as a positive correlate of debt, however its insignificance suggests that marriage burdens do not have enough of an impact to include in the discussion of Indian farmer debt. Likewise, education also aligned with this study's hypothesis, coming up as negatively correlated with debt but its insignificance proposes that more education does not provide farmers with the extra skills to avoid falling into debt.

Overall, Model 2 found four positive significant correlates of debt, all of which confirmed previous literature as well as this study's hypotheses. Adding additional wells, increasing debt interest rate, and increasing yearly pesticide expenses all dramatically increase Indian farmer debt, and while increased income increases debt, it is at a far smaller rate than the previously listed variables.

Regression Diagnostics

While both models did produce meaningful results, they unfortunately were not without econometric errors. Model 1 did not have issues with heteroscedasticity or autocorrelation due to it being a logit model without time series data. Likewise, Model 2 did not use time series data and the estimators were within the parameters of maximum likelihood estimation and thus did

not have heteroscedasticity or autocorrelation. Nor did either model have multicollinearity, as the highest correlation between independent variables in either model was only .40 between marriage and age which is unsurprising and understandable. The next highest correlation was .36 between female family members and female children in the family which was also explainable. However, Jarque-Bera normality tests found that both models did have non-normality of errors. In addition, Ramsey Regression Equation Specification Error Tests also revealed that both models had omitted variable bias. Ideally, with more time, more data would be collected in an attempt to solve these problems, but that will have to be a future study. The next section lays out the conclusions and implications of this study relating to potential policy changes and actions that could help mitigate the Indian farmer suicide crisis based on the findings of this study.

Discussion

Farmer suicide in North India has been an epidemic for nearly the last two decades and only recently has the Modi government begun to take clear and effective action to protect these farmers. This study confirmed previous research citing debt and crop failure as major causes of farmer suicide and these financial and agricultural factors are what the government has decided to act on first. They have done so in multitude of ways. To help with debt accumulation, they have enforced a 70% cut in Monsanto royalties which decreased the cost of GMO seeds for farmers. In addition, they also created new crop insurance and input subsidy schemes. The crop insurance is now only a 2% premium rate of the sum insured with a 50% cover versus the old 4-15% rate for a 23% cover. The input subsidy can be used by any farmer who had 33% of more of their crop damaged (Kapor, 2016). These new policies help farmers not only stay out of debt but also decrease the debt impact of crop failure. In the future, making institutional loans more accessible to farmers and creating regulations to protect farmers from predatory lending would be great additional programs that offer financially focused relief as they could help mitigate the issue of high debt interests illustrated in model 2.

To help with agricultural factors like irrigation and inefficient input use, the Modi government has issued soil cards that contain crop-specific input recommendations for how to most efficiently cultivate harvests. In addition, in 2016 they implanted the Pradhan Mantri Krishi Sinchai Yojana (PMKSY) to improve water use and conservation throughout the country by way of micro-irrigation projects over the next five years (Kapor 2016). These agricultural techniques aim to prevent future crop-loss and failure which also may contribute to debt alleviation. The combination of these financial and agricultural policies are major steps in mitigating farmer suicide in India and they do address several of the key suicide factors laid out in this study;

however, they do not address any of the social factors that are increasing suicide likelihood. Considering that this study found that it was the social factors that had the highest coefficients, focusing on social support and education should be the next step the Modi Government takes in preventing farmer suicides.

Taking into account only the social factors, this study found that unmarried, undereducated, young farmers without family taking care of the house were most susceptible to suicide. The Center for Disease Control (2016) cites social support systems and connectedness as well as problem solving skills as buffers against suicide. Using this as a frame work, the Modi government could launch a campaign encouraging farming communities to support and connect with each other so that young fringe farmers with little to no support can develop mentoring relationships within their community of agricultural workers. In addition, while education might not be attainable for many farmers and their families due to intensive work requirements, continuing to provide farming specific educational packets is a good first step. Adding farming workshops or consultation services might be another way to increase farmer education and equip them with not only the problem solving skills required to produce a good yield, but also provide them with an outside resource and tools to recognize and navigate the warning signs associated with suicide.

While this study is the first to econometrically combine and analyze financial, agricultural, and social factors affecting suicide likelihood in North India, there is still much room for improvement, starting with gathering more data. More data might help eliminate the non-normality of errors and omitted variable bias found in the regression diagnostics. Ideally, this new data would have complete crop yield information from a larger and more diverse array of crops so that actual yield data could be modelled instead of a financial proxy. Another

potential avenue for improvement would be collecting yield data across time, from the year of the earliest suicide in the data set, to the latest. This would allow for time to be modelled and any potential seasonal effects to be controlled. Without a doubt, there is still much to be done on this topic, though this study has provided a unique contribution to the literature by econometrically identifying a wide array factors that affect farmer suicide likelihood in India as well as factors that make these farmers more susceptible to debt.

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