Working Paper 538

Why Do Farmers Not Adopt Crop Insurance in India?

Meenakshi Rajeev

Why Do Farmers Not Adopt Crop Insurance in India?

Meenakshi Rajeev

Published and Printed by: Institute for Social and Economic Change
Dr V K R V Rao Road, Nagarabhavi Post,
Bangalore - 560072, Karnataka, India.

ISEC Working Paper No. 538 July 2022

Institute for Social and Economic Change (ISEC) is engaged in interdisciplinary research in analytical and applied areas of the social sciences, encompassing diverse aspects of development. ISEC works with central, state and local governments as well as international agencies by undertaking systematic studies of resource potential, identifying factors influencing growth and examining measures for reducing poverty. The thrust areas of research include state and local economic policies, issues relating to sociological and demographic transition, environmental issues and fiscal, administrative and political decentralization and governance. It pursues fruitful contacts with other institutions and scholars devoted to social science research through collaborative research programmes, seminars, etc.

The Working Paper Series provides an opportunity for ISEC faculty, visiting fellows and PhD scholars to discuss their ideas and research work before publication and to get feedback from their peer group. Papers selected for publication in the series present empirical analyses and generally deal with wider issues of public policy at a sectoral, regional or national level. These working papers undergo external review but typically do not present final research results, and constitute works in progress.

ISEC working papers can be downloaded from the website (www.isec.ac.in).

ISBN 978-93-93879-05-9

Working Paper Series Editor: **M Balasubramanian**

WHY DO FARMERS NOT ADOPT CROP INSURANCE IN INDIA?

Meenakshi Rajeev[1]

Abstract

Climate change, inflation and a plethora of other risk factors tend to make agriculture a risky profession. In a developing country such as India, where a majority of farmers are poor, risk management is crucial to protect incomes. However, formal crop insurance adoption remains low despite its importance, and it is of interest to study the reasons behind this. We construct a theoretical model of farmers' utility when faced with a choice between formal crop insurance and informal borrowing as risk management strategies, in line with empirical observations across the globe, using Bellman's equation in dynamic programming. This model is used to study the impact of informal interest rates and loss assessment mechanisms on crop insurance adoption. The results of this theoretical exercise are tested using an appropriate regression using representative NSSO data of farmers in India in 2013, and are thus verified. The regression exercise reveals a negative relationship between informal interest rates and insurance adoption, in line with theoretical predictions. Further, disparities in adoption of crop insurance is found across economic and social classes, which need to be addressed. Based on the findings, we suggest that the current risk assessment mechanism be overhauled to better identify farmers facing crop losses, and that premiums be varied according to the land cultivated and farmers' social class, to better achieve insurance coverage of crops cultivated in India.

Keywords: Crop Insurance, Agriculture, Informal Credit, India

JEL Classification: Q12, Q14, G52

Introduction

In India, a majority of the populace is reliant on primary cultivation for livelihood, and a considerable percentage (80%) cultivate landholdings less than two hectares in area, leaving them with woefully low incomes. Among such agriculturists, farming is undertaken using traditional, labor-intensive methods (such as rain-fed cultivation) with a low capital base. These cultivation methods leave fields more vulnerable to the natural risks inherent to this class of professions[2]. It is the poor in these regions that are the most vulnerable as they have fewer options to mitigate the risks they face.

Historically, government subsidised formal crop insurance has been provided in India since 1985 (Prabhu and Ramachandran, 1986). However, the reach of formal crop insurance has remained low in India. Though highly subsidised in the country, the adoption rate was only 7% percent during 2012-13, and is more common among richer farmers (Rajeev and Nagendran, 2019). This figure has increased over the years especially after the government initiated a more subsidised scheme with much publicity –The Prime Ministers Fasal Bima Yojana (PMFBY) in 2016. However, the adoption rate still remains lower than what was targeted (Bhati, 2018) with only a quarter of farm area covered by such schemes as of the most recent estimates (Government of India, 2018). In the absence of crop insurance, farmers adopt informal risk mitigation strategies to smoothen consumption during times of distress. These include precautionary savings, informal agreements with other households, and more

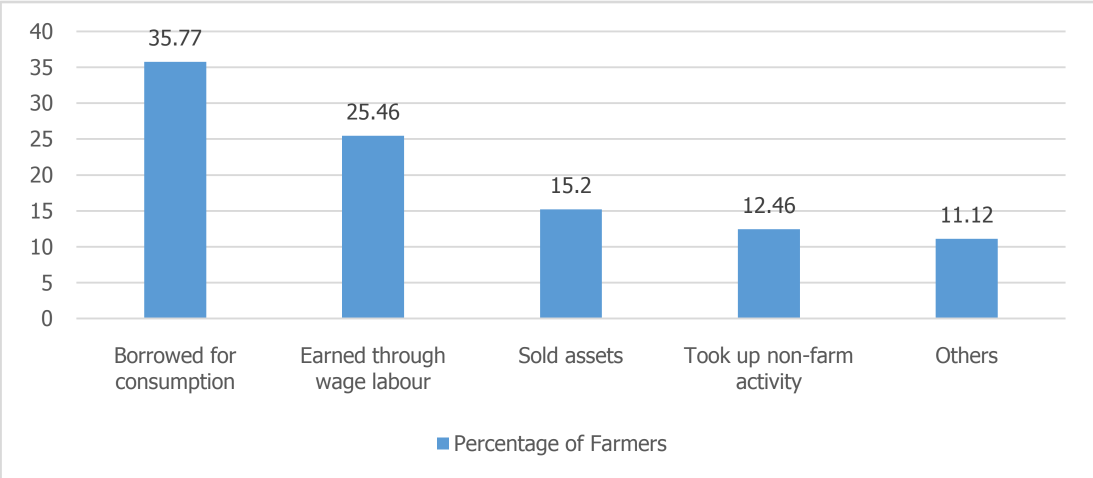
[1] RBI Chair Professor, CESP, ISEC, Bengaluru. E-mail: Meenakshirajeev2020@gmail.com

I thank ICSSR and the RBI for their support to ISEC. I also thank anonymous referees for valuable comments. I am grateful to Mr Pranav Nagendran for invaluable support.

[2] This has been discussed by scholars in the context of Africa (see Cooper *et al*, 2008; Fraiture, Karlberg and Rockstrom, 2009), and we can expect that it holds true for India as well.

importantly, borrowing from the informal market. In a field survey in the state of Karnataka researching how farmers manage essential expenses following crop loss, informal credit was found to be the most common strategy (Rajeev, Bhattacharjee and Vani, 2016). About 36% percent of farmers depended on this source of finance, while others sought employment as a casual labourer (25% percent) to sustain themselves (see Figure 1).

Figure 1: Measures for income stabilization taken after droughts in Karnataka State, India



Source: Rajeev, Bhattacharjee and Vani (2016)

Several studies across the world corroborate this observation, and Udry (1990), commenting on the situation in Zaire, noted that "Wherever insurance markets are incomplete, credit markets are known to play an important role by allowing risks to be pooled over time; households borrow more when they suffer an adverse shock...".

However, in many of these countries, especially in India, formal crop insurance is made widely available by the government, often with subsidised and discounted premiums. This is assumed to be more robust and helpful a support in times of crop distress than informal alternatives. Thus, it is important to understand why informal risk mitigation strategies continue to be prevalent in the presence of formal ones. Since there is a complementary relationship between the two, it is of further interest to understand the impact that changes in an important characteristic of informal lending – the usurious interest rates – have on the adoption of formal crop insurance. Do higher informal interest rates in the region drive farmers toward higher adoption of formal insurance? If this is the case, then there is an indirect positive impact of a high informal interest rate on farmers' welfare. These are critical issues not examined in the literature. This paper uses a theoretical model as well as macro-level data from NSSO (2013) to examine these issues rigorously at the household level to arrive at robust conclusions. This allows us to bring together the relationship between conditions in informal credit markets and formal insurance adoption, which is an unique and important contribution to this area of research.

Our theoretical model based on dynamic optimization shows that if interest rates cross a particular limit, then all farmers adopt crop insurance, thus establishing a critical upper bound on informal rates. These deductions are supported by an empirical analysis, which establishes a positive relationship between informal interest rates in a region and the percentage of farmers adopting crop insurance. This is an important observation as it points to indirect benefits of usurious informal rates that spur adoption of formal crop insurance, which is a departure from the negative impacts often discussed (Bhaduri, 1997). The possibility of such a positive impact has not been studied heretofore. Additionally, the paper also makes an important contribution to the literature by looking at the state of deprivation with respect to crop insurance among minority vulnerable communities in the country, such as those belonging to scheduled castes (SCs), scheduled tribes (STs) and minority religious groups, which are found to be in need of special attention.

In this backdrop, the paper unfolds as follows. Section 2 provides a brief review of literature on risk mitigation strategies and the rationale and importance of insurance in agriculture. A background to crop insurance in India and its salient features are found in Section 3. Based on the features of the Indian crop insurance system, a theoretical model using dynamic programming is constructed in Section 4 to analyse farmer decisions between availing crop insurance versus informal borrowing. The results of the theoretical analysis are then tested in Section 5, followed by a concluding section that summarizes and discusses the results.

Review of Literature

Agriculture is an intrinsically risky industry (Hazell, 1992; Kammar and Siddaya, 2016), and weather represents the major source of uncertainty (Musshoff, Odening and Xu, 2011). As a result, the output of agricultural commodities is prone to fluctuations, which depends on both controlled variables such as the use of fertilizers, irrigation, and pesticides, and uncontrolled variables including climatic factors – rainfall, temperature, etc. (Ray, 1981; Hazell, 1992). These fluctuations make farm income unstable and, especially in the developing world, where poverty is rife in rural areas (Khan, 2001), creates additional burdens for cultivators in the form of risk.

In developing countries, it is often found that agricultural risk management occurs through a variety of informal strategies (Rajeev, Bhattacharjee and Vani, (2016); Mobarak and Rosenzweig (2013)), including, but not limited to: crop diversification, adoption of alternative sources of income, crop sharing agreements, borrowing from informal lenders, sale of assets, and temporary off farm employment among others (Hazell, 1992; Clarke and Dercon, 2009), livestock cultivation (Hanke and Barkmann, 2017), tenancy agreements (Jodha and Walker, 1986), and even marriage agreements in India (Rozenzweig and Stark, 1989). One strategy that is found to have some prominence is the usage of informal loans to finance immediate consumption in times of agricultural distress (as observed by Udry, 1990 in Zaira; Ravago, Roumasset and Jandoc, 2016 in the Philippines; and Rajeev, Bhattacharjee and Vani, 2016 in India). This is a more worrying strategy than the other informal ones described as it is liable to send households into a poverty spiral and debt trap, and is more likely to be used by poorer and marginalized farmers who would not have the social and economic means to access other less harmful risk management strategies.

Given the prominence of informal risk management options and their relative disadvantages, governments across the world, especially in developing countries, have been making efforts to expand formal insurance cover for agriculturists (Barnett, 2014 provides an overview), as it is an important tool to protect farmers' incomes from the several risks inherent to agriculture (Sinha, 2004). However, formal insurance has found considerably more success in developed nations than among developing ones (Mahul and Stutley, 2010; Rajeev and Nagendran, 2019), where it is needed the most. The involvement of the government in this sector is necessitated by high actuarial costs of such programmes that make market determined premiums unaffordable to farmers in many instances (Coble and Knight, 2002). In India, paucity of public funds, the large number of cultivators in operation, along with issues of moral hazard and adverse selection make individual based insurance schemes unfeasible and this has led the government to opt for area based insurance coverage (Dandekar, 1971; Rajeev and Nagendran, 2019). However, this scheme has its own caveat wherein risk reduction is only partial since individual returns are not perfectly correlated with regional returns, and some farmers who faced losses remain uncompensated (Miranda, 1991).

Supply of crop insurance is not sufficient to ensure adoption, and demand for such products is important as well. Several studies have been conducted on this topic, most notably in the USA (recent studies include those of Du, Feng and Hennessy, 2016; and Ramirez and Shonkwiler, 2017), as well as in the Europe Union (see Petri and Sami, 2014; Falco *et al*, 2014; Dragos and Mare, 2014; Santeramo *et al*, 2016; Adam and Pawel, 2018). Among the developing nations, Lyu and Barre (2017) study the determinants of crop insurance participation among maize producers in China, and find that risk aversion plays an important role in farmers' decisions to adopt insurance, while Wang, Ye and Shi (2016) find that community pressure was initially a significant factor in a farmer's decision to adopt crop insurance, and this eventually shifted to factors such as yield volatility and education. The role of advantageous selection in the demand for crop insurance products by farmers in the Philippines has been studied by He *et al* (2018). From a field survey in Ghana, Robert *et al* (2014) find farmer age, education level and land tenure system and to be important determinants in the adoption of crop insurance. In, India, Panda (2013) finds that a lack of awareness and complicated procedures were the major obstacles for the adoption of crop insurance by small and marginal farmers (see also Rajeev, Vani and Bhattacharjee, 2011). Similarly, the influence of socio-economic characteristics on crop insurance adoption is studied by Kumari *et al* (2017) in India, who use discriminant analysis to show that awareness of crop insurance, satisfaction with insurance schemes and access to credit were the major factors that had the greatest effect on crop insurance demand among farmers. Singh, Thakar and Soumya (2018) find that, in Gujarat, India, land holding and social capital are significant determinants of crop insurance adoption. However, it is observed that despite long standing policy support to crop insurance in the country, adoption remains low (Kalavakonda and Mahul, 2003; Vyas and Singh, 2006; Rajeev and Nagendran, 2019). Lack of adoption may be possible because of the existence of alternative risk management mechanisms.

While literature does discuss these mechanisms, there is a lack of studies that look at the choice between formal insurance and informal lending[3].This is an important research gap that this paper looks to fill, as the move to formal strategies will be influenced by the presence of and access to informal ones. We explore the development of crop insurance in India and the possible reasons for this

[3] Though Mobarak and Rosenzweig (2013) discuss insurance and informal linkage among individuals through castes etc., we bring in specifically the terms of informal lending.

lacklustre performance in the next section, and thus construct a theoretical model discussing the choice between formal and informal insurance, and the issue of measurement errors in section 4.Subsequently we empirically study the impact of informal credit market conditionalities on the adoption of crop insurance. The next section provides a background to this analysis by highlighting the development and salient features of the state subsidised crop insurance system in India.

Crop Insurance Scheme in India: Basic Features

In India, government subsidised crop insurance was initially provided under the Comprehensive Crop Insurance Scheme (CCIS) from 1985. Under the CCIS, coverage was provided for farmers cultivating rice, wheat, millets, pulses, and oilseed crops, and compensation was provided for crop failure resulting from natural calamities (Prabhu and Ramachandran, 1986). Uniform premium rates were charged to all farmers. In 1999, the CCIS was superseded by the National Agricultural Insurance Scheme (NAIS) (Venkatesh, 2008). The NAIS differed from the CCIS by making crop insurance mandatory for farmers who took out a loan for Seasonal Agricultural Operations from banks – i.e., a short-term crop loan. The risks covered were further expanded as well to include several other natural causes of crop failure (Venkatesh, 2008). The premium rates were changed to 3.5% of the sum insured for bajra and oilseeds, 2.5% for rabi crops except for wheat, and 1.5% for wheat (Rajeev and Nagendran, 2019). However, despite attractive premium rates, crop insurance adoption stood at just 7% as of 2012-13 and richer farmers were more likely to have adopted it than poorer ones. Lack of awareness and a lack of interest were the major reasons behind these low adoption rates (Rajeev and Nagendran, 2019).

Discussions with farmers in the state of Karnataka shed some light on the reasons for the lack of interest in crop insurance among many farmers. Farmers expressed dissatisfaction with the loss assessment mechanism, which they felt often failed to compensate those who had legitimately faced losses. Losses are assessed through the 'Area Approach' method. This method is undertaken using the national crop cutting surveys, which are conducted annually for the purpose of GDP estimation. Using these figures, the regional average output is estimated. If the estimated output is lower than a certain 'threshold' yield (computed as a function of the yields of the previous seven years), indemnities are paid to farmers. This, however, being a survey, does not cover every plot within a region and can ignore the variability in regional output. Therefore, while some cropped areas may face loss, this may not be reflected through this survey, resulting in *measurement errors* (Rajeev and Nagendran, 2019).

Even the recent PMFBY, which has been much publicized, uses the area approach to loss assessment and has only been able to bring a quarter of the total cultivated area under insurance. As a result, we can see that borrowing from informal sources stands as an alternative to crop insurance, especially when the issue of *measurement errors* remains. In the next section, we construct a theoretical model of farmers' decisions to take up formal crop insurance or borrow from the informal sector when there is a crop loss using dynamic programming and thereby examine this issue further. Such an examination is useful since crop insurance has seen better success in other developing nations such as China, and our theoretical model can help us to understand the factors behind low adoption rates in India.

Adoption of Crop Insurance: A Theoretical Exploration

The theoretical model assumes that all farmers face the same utility functions and exposures to risk, for simplicity. These cultivators have to choose their strategy for mitigating the risk of lost incomes from crop failure. Informal lending at an interest rate 'r' and formal insurance cover at a premium 'm' are the two options available. Crop failure is assumed to be binary, and occurs with a probability of (1-p), where p is the probability of having a good harvest. When there is a good harvest, farmers will earn an income of O_h, which is assumed to be the required consumption of the farm household. Alternatively, under crop loss, farmers will earn O_h, which is insufficient for survival and needs to be augmented by either borrowing or an indemnity pay out. The model follows a dynamic programming approach (using Bellman's equation – Bertsekias, 1995) over several consecutive discounted periods, where the discount factor is 0<β<1. In every period, farmers are assumed to earn a constant amount w from non-farm activities. Under these assumptions, a representative farmer's lifetime expected discounted utility from farming with formal crop insurance is given by:

The value function of a farmer who chooses formal crop insurance:

$$VF_{ins} = u(w) + \beta p\{u(w + O_h - m) + \beta VF_{ins}\} + \beta(1-p)\{u(w + O_l + (O_h - O_l) - m) + \beta VF_{ins}\} \ldots\ldots\ldots (1)$$

In the first period, farmers are assumed to survive on w (even though it is below the minimum required). If there is a good harvest, the high income is earned and m is deducted for premium payments. Alternatively, if there is a bad harvest, the low income is augmented by the insurance company to allow the good harvest level of consumption. Regardless of the world state, the premium 'm' has to be paid. If a bad world state is realized, then insurance compensates the farmer so as to maintain the same level of consumption as in the good world state.

On the other hand, if a farmer opted to mitigate risk through informal borrowing, the value function can be expressed as:

The value function of a farmer who does not adopt formal crop insurance, $VFnins$ is:

$$VFnins = u(w) + \beta p\{u(w + O_h) + \beta VF_{nins}\} + \beta(1-p)\{u\big(w + O_l + (O_h - O_l)\big) - \beta u\big((1+r)(O_h - O_l)\big) + \beta VF_{nins}\} \ldots\ldots\ldots (2)$$

Under this strategy, farmers are exempted from the payment of premiums that would reduce incomes in a good harvest, but are subject to costly borrowing in case of a bad harvest. These loans have to then be repaid out of household assets maintained as collateral, or by additional nonfarm labour work.

Collecting terms and simplifying the two expressions:

$$VF_{ins} = \frac{u(w) + \beta p\{u(w + O_h - m)\} + \beta(1-p)\{u(w + O_h - m)\}}{1-\beta^2} \ldots\ldots\ldots (3)$$

$$VF_{nins} = \frac{u(w) + \beta p\{u(w + O_h)\} + \beta(1-p)\{u(w + O_h) - \beta u\big((1+r)(O_h - O_l)\big)\}}{1-\beta^2} \ldots\ldots\ldots (4)$$

Using the two value functions we arrive at the following results:

Proposition 1: There exists a critical interest rate r* such that if r > r*, then a rational farmer will avail crop insurance.

Proof outline: We define N = VF_{ins}– VF_{nins}, as the net utility gained from choosing formal insurance. The higher is N, the more likely a farmer is to avail crop insurance. In particular, when N>0, a farmer will opt for formal crop insurance over informal loans. We derive conditions under which N>0 using a logarithmic utility function. For details see Appendix A.3. Consequently, we arrive at a critical rate of interest r*, given by:

$$r^* = \frac{1}{O_h - O_l}\left[\left(1 - \frac{m}{w + O_h}\right)\right]^{-\frac{1}{\beta(1-p)}} - 1$$

As m increases, the term on the R.H.S increases, and correspondingly, r* is larger (provided that m < w + O_h). This implies that if premiums are high, informal sector interest rates also have to be correspondingly high to make formal crop insurance an attractive option for farmers. As farmer income (O_h) increases, the R.H.S decreases, and the threshold r* is lower, indicating that large farmers are more likely to take up formal crop insurance than small farmers for the same informal sector interest rate. This is formally derived in Proposition 2.

Corollary 1: As r increases, the net utility N from availing formal insurance cover increases.

Proof: Differentiating N with respect to 'r',

$$\frac{\partial N}{\partial r} = \frac{\beta^2(1-p)(O_h - O_l)u'\big((1+r)(O_h - O_l)\big)}{1-\beta^2} > 0$$

We assume that u'(.) > 0, so, as r increases, the net utility from selecting formal crop insurance cover increases, and this makes farmers more likely to avail formal crop insurance over borrowing from moneylenders in times of distress.

Corollary 2: There exists a critical insurance premium m*(r) such that if m > m*, farmers will not avail formal crop insurance.

Proof: Similar to the Proposition 2, we can continue using the logarithmic utility function, and proceeding as above, we can set N = 0 to obtain:

$$m^* = w + O_h - \frac{w + O_h}{\big((1+r)(O_h - O_l)\big)^{\beta(1-p)}} = (w + O_h)\left(1 - \frac{1}{\big((1+r)(O_h - O_l)\big)^{\beta(1-p)}}\right)$$

We can deduce that as r increases, m* also increases. Therefore, the lower the informal sector interest rate, the lower the critical insurance premium beyond which farmers will not avail formal crop insurance. Further, as O_h increases, the two terms on the RHS increase, and m* also increases. Therefore, the threshold m* is higher for richer farmers than for poorer farmers.

Corollary 3: If there was possibility of a *measurement error* (see Section 3) then given the probability of a farmer **not** getting affected by a measurement error 'q', the higher q is, the higher is the critical insurance premium m*.

We can modify the value function of taking up formal crop insurance in the following way:

$$VF_{ins} = u(w) + \beta p\{u(w + O_h - m) + VF_{ins}\}$$
$$+ \beta(1-p)\big\{q[u(w + O_l + (O_h - O_l) - m)]$$
$$+ (1-q)\big[u(w + O_l + (O_h - O_l) - m) - \beta u\big((1+r)(O_h - O_l)\big)\big] + VF_{ins}\big\}$$

Here, when there is a bad output, the farmer will only receive compensation with a probability of q, and will otherwise have to borrow the shortfall O_h - O_l from the informal sector (as in the case of not having formal crop insurance) for consumption. The value function of a farmer not having formal crop insurance (VF_{nins}) remains the same as before.

Solving the equations by collecting the value terms on the LHS, using the functional form u(x) = ln(x), and by setting the net utility N = 0, we can find m* as:

$$m^* = (w + O_h)\left(1 - \frac{1}{\big((1+r)(O_h - O_l)\big)^{\beta(1-p)q}}\right)$$

This is the same as what was seen in Corollary 2, with the addition of q in the power term on the RHS. As q increases, the RHS increases, and thus, the threshold m* also increases. In particular, when q = 1 (i.e., no possibility of a measurement error) then m* is the same as in Corollary 2.

Proposition 2: For a given 'r', richer farmers have greater net utility from formal crop insurance than poorer farmers.

Proof: Richer farmers have higher consumption, particularly in good periods. Therefore, O_h is higher for a richer farmer than for a poorer farmer. Thus, we need to look at the effect of increasing O_h on N.

$$\frac{\partial N}{\partial O_h} = \frac{1}{1-\beta^2}\big[\{\beta p\{u'(w + O_h - m) - u'(w + O_h)\}$$
$$+ \beta(1-p)\{u'(w + O_h - m) - u'(w + O_h) + \beta(1+r)u'\big((1+r)(O_h - O_l)\big)\}\big]$$

$$=> \frac{\partial N}{\partial O_h} = \frac{1}{1-\beta^2}\Big[\beta\big(u'(w + O_h - m) - u'(w + O_h)\big) + \beta(1-p)(1+r)u'\big((1+r)(O_h - O_l)\big)\Big]$$

We assume that the utility function has the properties $u'(.) > 0$ and $u''(.) < 0$. The second condition implies that if a < b, $u'(a) > u'(b)$. Therefore, $u'(w + O_h - m) > u'(w + O_h)$, and so, $\frac{\partial N}{\partial O_h} > 0$, implying that richer farmers have greater net utility from formal crop insurance than poorer farmers.

Although several discussions on the informal credit market in rural areas focus on the negative effects of usurious interest rates, these can have an indirect effect of promoting adoption of crop insurance, theoretically. These are important results in the case of small and marginal farmers, who are the least likely to be included in insurance cover, since the premium 'm' possibly forms a relatively larger portion of their total consumption 'O_h', thereby decreasing utility significantly.

Identifying the Determinants of Crop Insurance Adoption in India

The theoretical model provides some insights into the functioning of agricultural crop insurance in India, and we test these findings empirically and go on to find other important determinants of crop insurance adoption in the country through a regression analysis.

Data

An important source of socioeconomic data for India is the National Sample Survey Organizations' (NSSO) Surveys, which provide a representative sample of households across the country. For the following empirical exercise, the NSSO's 2013 Survey on the Situation Assessment of Farm Households in India is used. This data set provides information on 35,200 farm households, and includes data pertaining to socioeconomic and demographic composition, agricultural and non-agricultural operations, borrowing, and insurance for crops.

Methodology

A cross-sectional analysis is performed with the data, and robustness of coefficients has been checked by varying the specification of the regression model by selectively excluding groups of variables and observing that signs and significance of covariates remain comparable.

We note that there are two important levels of crop insurance adoption. One – whether a farmer has availed crop insurance (the extensive margin), and two – if it has been availed, the extent to which it is used (the intensive margin). The process that generates the data for these two levels is postulated to be different, and thus requires a bifurcated estimation technique. Given that the extensive margin of crop insurance adoption is a binary variable, a logistic regression is appropriate. In such regressions, the probability response function is an index of the independent regressors x, in the form $P(y=1|\mathbf{x}) = G(\mathbf{x\beta})$ (Wooldridge, 2012). For the log it model, the function G(.) is of the form:

$$G(\mathbf{x\beta}) = \frac{e^{\mathbf{x\beta}}}{1 + e^{\mathbf{x\beta}}} = P(y = 1|\boldsymbol{x}) \dots \dots \dots (1)$$

The coefficients β are derived by maximizing the log likelihood function, which is given by:

$$Log\ L = \sum_{i=1}^{n} y_i \log[G(\boldsymbol{x}_i\boldsymbol{\beta})] + (1 - y_i) \log[1 - G(\boldsymbol{x}_i\boldsymbol{\beta})] \dots \dots \dots (2)$$

For studying the intensive margin of crop insurance adoption, the ratio of area of insured crops cultivated to the total area cultivated by the farm household is studied. This is a continuous variable whose values lie between 0 and 1, known as a fractional response. The logit formulation is used here as well, and the likelihood function remains the same as in (2), which is the Bernoulli log-likelihood function. However, the distinction here is that for each i in (2), y_i takes a value between 0 and 1 so that one of the terms does not disappear as in the logit case. The log likelihood function is a Quasi-Maximum Likelihood estimator, and is consistent. However, the issue of heteroscedasticity exists (Papke and Wooldridge, 1996) since

$$Var(y_i|\boldsymbol{x}_i) = \sigma^2 G(\boldsymbol{x}_i\boldsymbol{\beta})[1 - G(\boldsymbol{x}_i\boldsymbol{\beta})]\ for\ some\ \sigma^2 > 0$$

There exists an inherent heteroscedasticity in the model, which has been corrected for. The procedure followed for the two-part fractional logistic regression estimation has been provided by Oberhofer and Pfaffermeyer (2014). Correspondingly, the Stata logit command is used to estimate the first part. The second part is estimated using the generalized linear model, since the logit function is a part of the linear exponential family. Here, the Stata glm command is used with a logit link function. The estimates of the two regressions are then combined to provide an overall R^2 value for the regression.

Dependent Variables

The binary indicator of whether a farmer adopted crop insurance for any crop for the extensive margin has been constructed using responses to the questions of whether each of the four major crops cultivated during the reference period was insured. If the response was 'true' for any of the crops, then the binary variable takes a value of 1, and it takes 0 otherwise.

The fractional indicator is the of percentage of crops covered under crop insurance schemes at the intensive margin, which has been computed by diving the area in which insured sole and mix-major (in a mixed cropping system) crops are cultivated to the total area of the sole and mix major crops cultivated (including irrigated and non-irrigated land as well as land on which crops that have been sold pre-harvest were cultivated).

Independent Variables

Availing formal crop insurance is a complex outcome that is potentially the result of a variety of factors some of which are discussed below.

1. As discussed in the theoretical section, under certain conditions, the informal sector can act as a substitute for crop insurance, thereby decreasing demand for insurance products. The utility of informal loans (and indirectly, crop insurance) is characterised by the informal sector interest rate, wherein higher rates can reduce the attractiveness of informal loans and incentivize farmers to insure crops instead. To test empirically for this effect, the average regional informal interest rate has been included as an independent regressor.
2. It is notable that informal loans aren't the only risk mitigation strategy available, and several other options exist. Since these have to be adopted before cropping, unlike loans, their effect is ambiguous. They could either act as substitutes for crop insurance, decreasing demand for the latter, or they may be adopted by risk adverse households who pursue as many avenues as possible to reduce risk, thereby leading to these strategies being positively correlated with insurance adoption. To empirically test which of these hypotheses is true, we include variables capturing adoption of certain alternate strategies in the regression. These include: irrigation to reduce dependence on rainfall; and fertilizers to improve soil productivity and increase minimum incomes. The per hectare expenditure on fertilizers and irrigation are included as independent regressors.
3. The possibility of adverse selection can also have an effect on the adoption of crop insurance. Some crops, such as cereals, are more prone to crop failures than others, and farmers may be

more incentivized to avail themselves of crop insurance if they cultivate them. In India, crop insurance is also more geared towards supporting cereal cultivators, which can further make insurance more prominent among these cultivators. Therefore, we have included a binary variable that takes the value of 1 if the farm household cultivated a cereal as a major crop, and 0 otherwise, to capture this effect.

4. Further, the political situation in a state can also influence incentives to avail crop insurance. Loan waivers, which are offered during times of agricultural distress in the country, are one such disincentive. Since crop insurance only covers the loan taken in most cases, if there is a higher chance of a loan waiver in a region, farmers will have lower incentive to take up crop insurance. This is tested by including the region-wise percentage of loan amounts outstanding that were written off as of a reference date.

   Another external influence creating incentives to adopt crop insurance is climate, and variability thereof. If cropping is undertaken in areas with less predictable rainfall, then there are greater risks of crop loss, which would incentivize insurance adoption. To test for this, the absolute percentage deviation from average monsoon rainfall in each district in the year 2012 has been used.

5. Even if a farmer has the incentive to avail crop insurance, s/he may not avail it owing to inability. The premium, although subsidised, continues to be a non-trivial amount. Richer farmers will be more capable of paying premiums than poorer ones, and the influence on economic ability is captured by including the area cultivated as an independent regressor. The possible effect of consumption (indicating income) on insurance adoption was discussed in the theoretical section as well. However, area cultivated does not perfectly capture economic ability since it does not include information on ownership and property rights. Tenant farmers and sharecroppers may be poorer than owner-cultivators, and this effect is controlled for by a variable indicating the share of cultivated land owned by the farm household. Economic ability is also captured through household per-capita consumption expenditure, since the same land area may provide differing incomes owing to factors such as crops cultivated, weather, irrigation and soil quality. However, this cannot be used alone to isolate economic ability since the proportion of income spent on consumption will differ among households.

6. Incomes can also be augmented through livestock rearing, non-farm activity and wage/salaried work. These increased incomes can either act as a risk mitigation strategy for crop incomes, or bolster incomes to better allow payment of premiums, so the effect they exert on insurance adoption remains an empirical question. These effects are tested by including binary variables that take the value of 1 if an activity is carried out, and 0 otherwise.

7. Economic ability is not sufficient to allow for insurance adoption. Information and financial literacy also play a crucial role. Financial literacy, in turn, would depend on education, networking and social capital. The latter two, in turn, vary according to religion and caste, creating drastic variations in ability among farmers. To control for these variations, appropriate binary variables have been used. A binary variable to capture social factors is used which takes the value 1 if the household belongs to a socially deprived caste, and 0 otherwise. Similarly, religion is also a binary variable where the majority religion, namely Hindu, takes the value of 1. For education, we assign

households where at least one member has secondary or higher education the value of 1, and 0 otherwise.

8. Institutional support can play a role in the adoption of crop insurance. Institutional support mechanisms for providing information have been captured by a binary variable which takes the value of 1 if technical advice was accessed from an agricultural extension officer, and 0 otherwise.
9. Having a ration card can provide a source of low-cost food for consumption, which can be an important support in times of crop failure, and such households may have lower rates of crop insurance among them. A binary variable indicating whether at least one household member held a ration card has been included. Geographical diversity can also have a potential impact on insurance adoption owing to differences in customs and institutions affecting outlook on insurance To control for this effect, we have included binary variables for the East, West, South, Central and Northeast zones of the country, taking the North zone as the base category. The variables utilized for finding the determinants are summarized in Table A1 in the appendix.

Measurement errors are an institutional factor that can reduce trust in the insurance mechanism and reduce adoption, but paucity of data precludes inclusion of such a variable in the regression analysis, and thus, it has had to be omitted.

The next sub-section provides and discusses the results of a fractional logistic regression of insurance adoption on incentive, ability, and institutional variables.

Results and Discussion

The coefficients and standard errors of variables in the regression are provided in Table 1 below. Robustness of the regression model has been checked, the details of which are available in Table A.2 in the appendix, where it can be observed that changing model specification by excluding groups of variables did not have an impact on sign or significance of the remaining regressors.

Table 1: Regression Results

Variable	Description	Logit	Fracreg
avginformalrate	Average Informal Interest Rate	0.0059** (0.0030)	-0.0050 (0.0048)
rainmon_mod	Absolute Rainfall Deviation from Average	-0.0004 (0.0016)	-0.0001 (0.0022)
region_cult_wo	Regional Percentage of Loans Waived Off	-15.7934*** (5.2200)	13.4595 (8.6919)
land_total	Total Land Cultivated	0.1607*** (0.0097)	-0.0010 (0.0119)
owned_pc	Percentage of Cultivated Land Owned	0.3905*** (0.1007)	0.2238 (0.1404)
pchhexp	Per Capita Monthly Household Expenditure	0.0000 (0.0000)	0.0000 (0.0000)
irrrigationexp_perha	Per Hectare Expenditure on Irrigation	-0.0000** (0.0000)	-0.0001*** (0.0000)
fertexp_perha	Per Hectare Expenditure on Fertilizers	0.0000*** (0.0000)	0.0000*** (0.0000)
livestock_done	Livestock Activities Undertaken	0.2172*** (0.0583)	-0.1728** (0.0865)
nonagri_done	Non-agricultural Activities Undertaken	0.1434** (0.0657)	0.0090 (0.0909)
wagesal_done	Wage/Salaried Work Undertaken	-0.0047 (0.0501)	0.0987 (0.0697)
accessed_techadv	Accessed Technical Advice	0.6054*** (0.0516)	-0.1875*** (0.0791)
has_ration_card	Household Member Has Ration Card	0.2390*** (0.0858)	-0.0871 (0.1205)
hindu	Hindu	0.7451*** (0.0889)	0.4371*** (0.1285)
Scst	SC/ST	-0.6505*** (0.0636)	0.0431 (0.0917)
secondary	Household Member Has Secondary Education	-0.0736 (0.0504)	-0.0846 (0.0688)
cereals_majorcrop	Cereal is a Major Crop	0.5228*** (0.0712)	-0.5393*** (0.1122)
stateregion = 1	East Zone	0.6391*** (0.0821)	0.2587*** (0.1107)
stateregion = 2	West Zone	0.6749 (0.0839)	-0.1558 (0.1320)
stateregion = 3	South Zone	0.6661*** (0.0815)	-0.3503*** (0.1244)
stateregion = 4	Central Zone	1.4365*** (0.0815)	0.0356 (0.1115)
stateregion = 5	Northeast Zone	-0.8001*** (0.1515)	-0.5613** (0.2356)
Constant	Constant	-5.5480*** (0.1874)	1.3117*** (0.2947)
N		34360	2046
LR χ^2		1760.06	-
Pseudo R^2		0.1124	-
R^2 (Overall)		0.1020	

Source: Authors' Computation from NSSO (2013) Data

Note: *, **, and *** denote that a coefficient is significant at the 10%, 5%, and 1% levels respectively. Figures in parentheses are standard errors

We have included large farmers as they are a small percentage of total farmers and including them sheds light on ability factors more clearly.

The incentive of informal interest rates is confirmed to play a significant role in decisions to adopt crop insurance, as predicted by the theoretical analysis. Farmers in regions with higher informal rates are more likely to avail insurance, after controlling for other relevant factors. The adverse selection also acts as an incentive, and we can see that cereals cultivators are more likely to be insured. We also find that irrigation acts as a disincentive to take up crop insurance, as evidenced by the negative and significant sign of the variable's coefficient in the regression.

Another result derived from our analysis has important policy implications. Indian politicians often waive farmers' loans in the hope of getting votes. However, loan waivers are negatively correlated with insurance adoption, as states with larger portions of loans written off also witness lower insurance adoption as farmers prefer to wait for a loan waiver instead. Thus, loan waiver creates an undesirable habit among the farmers with regards to adoption of crop insurance.

Economic ability, too, influences insurance adoption with richer farmers being more likely to have crop insurance. Property rights were also found to be positively correlated with insurance, further strengthening this observation. This highlights the importance of improving farmer incomes in order to allow them to afford crucial risk mitigation strategies such as crop insurance.

Networking ability and social capital, captured by religion and social group variables, also have an impact and those belonging to majority religious and social communities are also more likely to be insured even when we control for education. Thus the socially deprived castes (schedule caste and Schedule tribes) and religious minorities need the special attention of the policymakers in general and formal financial institutions in particular.

Access to agricultural extension agents positively impacted insurance adoption, and outlines that such support can be useful if expanded. Similarly, households which held a ration card (for accessing subsidized food) were also more likely to be insured. Even after controlling for income and crop patterns, regional differences persisted with farmers in the northern and north-eastern regions being significantly less likely to be insured than those in other areas. Support in the form of institutional infrastructure would be necessary to remove these regional disparities.

The intensive margin of insurance adoption was influenced by institutional and ability factors, but noy by incentive factors, which is in line with expectations. Therefore, we can conclude that while incentives to adopt crop insurance have an effect on extensive decisions, they are less important in intensive decisions such as how much land to insure. Therefore, improving crop insurance adoption requires improving incentives to avail crop insurance to generate more extensive demand, and increasing farmers' ability and bolstering agricultural support institutions, to bring more cropped area under insurance cover.

Conclusions

This paper has theoretically looked at the choice farmers have between formal crop insurance and informal borrowing following crop failure using Bellman's equation of dynamic programming. An empirical exercise has been carried out using large household-level data provided by the NSSO to understand the relation between the two. There is no literature that relates a formal instrument like insurance with the terms and conditions of an informal loan. The usual vices of a high/usurious informal interest rate are stated by many. But it can have an indirect *positive* impact on the adoption of a desirable formal instrument like crop insurance has not been rigorously dealt with in the literature.

Our analysis is useful in providing guidance to policymakers when formulating schemes for these farmers. The theoretical results show a positive relationship between regional informal interest rates and the net utility from adopting formal crop insurance. Measurement errors, which tend to occur when the area yield approach to indemnities is used, reduce the theoretical maximum insurance premium that can be charged so that crop insurance remains attractive in comparison to informal borrowing. Needless to say, an overhaul of this mechanism can have significant positive effects on insurance adoption. In China, for example, the government has instituted a robust system of identifying crop losses by employing a group of stakeholders including farmers, insurance companies, agricultural experts, and village heads to assess indemnity payments (Krychevska, Shynkarenko and Shynkarenko, 2017).This reduces the possibility of a measurement error when compared to reliance on crop cutting surveys. Correspondingly, in China, insurance adoption is far more widespread than in India since more farmers find it beneficial to avail crop insurance at higher premiums there (Krychevska, Shynkarenko and Shynkarenko, 2017). Our regression exercise also reveals that the North and North-eastern regions lagged behind other parts of India in insurance adoption as of 2012. However, when we look at newer data of the adoption of PMFBY (see Rajeev and Nagendran, 2019), many northern states are on par in terms of insurance adoption with Southern and Eastern states, indicating that there has been focused effort to direct support for these areas, which is a positive improvement for farmers in the region, and further outlines the importance of developing institutions to bolster crop insurance.

Given that both theoretically and empirically it was observed that poorer farmers were less likely to adopt insurance compared to richer ones, it is important to vary premiums based on the area cultivated to improve accessibility. Similarly, farmers belonging to socially backward groups and minority religions can benefit from lowered premiums, which would improve insurance adoption across the country. We feel that if some of these lacunas in the current crop insurance programs are addressed, the scheme has the potential to become a useful safety net in stabilizing farm incomes both in India and across the developing world, and will help in achieving the Indian Government’s vision of doubling farmers’ incomes by 2022.

References

Adam, W and Pawel, K (2018). Factors Differentiating the Level of Crop Insurance at Polish Farms. *Agricultural Finance Review*, 78 (2): 209-22.

Barnett, B (2014). Multiple-peril Crop Insurance: Successes and Challenges. *Agricultural Finance Review*, 74 (2): 200-16.

Bertsekas, D P (1995). *Dynamic Programming and Optimal Control*. Belmont, MA: Athena Scientific.

Bhaduri, A (1997). On The Formation of Usurious Interest Rates in Backward Agriculture. *Cambridge Journal of Economics*, 1 (4): 341-52.

Bhati, N (2018). Government May Miss Target of Bringing 50% of GCA under PMFBY in FY19: Coverage Reduced to 24% in FY18. Centre for Monitoring Indian Economy, Available online at:

https://cmie.com/kommon/bin/sr.php?kall=warticle&dt=2018-03-26%2011:23:36&msec=090, Last Visited: 10/9/2019.

Coble, K H and T O Knight (2002). Crop Insurance as a Tool for Price and Yield Risk Management. In Just, R and R Pope (eds), *A Comprehensive Assessment of the Role of Risk in U.S. Agriculture*. Kluwer Publishers.

Cooper, P J M, J Dimes, K P C Rao, B Shapiro, B Shiferaw and S Twomlow (2008). Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: An essential first step in adapting to future climate change?. *Agriculture, Ecosystems and Environment*, 126: 24-35.

Clarke, D and S Dercon (2009). Insurance, Credit and Safety Nets for the Poor in a World of Risk. DESA Working Paper No. 81, United Nations Department of Economic and Social Affairs.

Dandekar (1971). Crop Insurance in India. *Economic and Political Weekly*, 11 (52): 61-80.

Dragos, S L and C Mare (2014). An Econometric Approach to Factors Affecting Crop Insurance in Romania. *E+M*, XVII (1): 93-103. DOI: 10.15240/tul/001/2014-1-008

Du, X, H Feng and D A Hennessy (2016). Rationality of Choices in Subsidized Crop Insurance Markets. *American Journal of Agricultural Economics*, 99 (3): 732-56.

Falco, S Di, Adinolfi, F, Bozzola, M and Capitanio, F (2014). Crop Insurance as a Strategy for Adapting to Climate Change. *Journal of Agricultural Economics*, 65 (2): 485-504.

Fraiture, C de, L Karlberg and J Rockstrom (2009). Can Rainfed Agriculture Feed the World? An Assessment of Potentials and Risk. In Wani, S P, Rockstrom, J and Oweis, T (eds), *Rainfed Agriculture: Unlocking the Potential*. UK: CAB International

Government of India (2018). *Pocket Book of Agricultural Statistics 2018.* Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation and Farmers Welfare, Directorate of Economics and Statistics, New Delhi.

Hanke, H and Barkmann, J (2017). Insurance Function of Livestock, Farmers Coping Capacity with Crop Failure in Southwestern Madagascar. *World Development*, 96: 264-275.

Hazell, P B R (1992). The Appropriate Role of Agricultural Insurance in Developing Countries. *Journal of International Development*, 4 (6): 567-81.

He, J, R Rejesus, X Zheng and J Yorobe Jr (2018). Advantageous Selection in Crop Insurance: Theory and Evidence. *Journal of Agricultural Economics*, 69 (3): 646-68.

Jodha, N S and T S Walker (1986). How Small Farm Households Adapt to Risk. In Hazell, P, Pomareda, C and Valdes, A (eds), *Crop Insurance for Agricultural Development: Issues and Experience.* Baltimore: The John Hopkins University Press.

Kammar, S K and Siddayya (2016). Assessing the Farmers' Attitudes towards Farming, Changes in Agriculture and Risk Management in Agriculture. *Indian Journal of Economics and Development*, 12 (1): 419-26.

Kalavakonda, V and Mahul, O (2005). Crop Insurance in Karnataka. *World Bank Policy Research Working Paper 3654*. Available online at: https://openknowledge.worldbank.org/bitstream/handle/10986/8216/wps3654.pdf;sequence=1, Last Accessed: 9/9/2019

Khan, M H (2001). *Rural Poverty in Developing Countries Implications for Public Policy*. International Monetary Fund. Available online at: https://www.peacewomen.org/assets/file/PWandUN/UNImplementation/SpecializedAgencies/IMF/imf_ruralpoverty_2001.pdf, Last Visited: 9/9/2019.

Krychevska, L, Shynkarenko, I and Shynkarenko, R (2017). *Agricultural Insurance in China: History, Development, and Success Factors*. Agroinsurance International LLC. www.agroinsurance.com.

Kumari, M, Singh, M K, Mishra, R R, Sinha, D K and Ahmad, N (2017). Role of Socio-economic Variables in Adoption of Crop Insurance: A Discriminant Function Approach. *Economic Affairs*, 62 (3): 361-65.

Lyu, K and Barre, T J (2017). Risk Aversion in Crop Insurance Program Purchase Decisions: Evidence from Maize Production Areas in China. *China Agricultural Economic Review*, 9 (1): 62-80.

Mahul, O and Stutley, C J (2010). Government Support to Agricultural Insurance: Challenges and Options for Developing Countries. The International Bank for Reconstruction and Development /The World Bank. ISBN: 978-0-8213-8217-2.

Miranda, M J (1991). Area-Yield Crop Insurance Reconsidered. *American Journal of Agricultural Economics*, 73 (2): 233-42

Mobarak, Ahmed Mushfiq and Mark R Rosenzweig (2013). Informal Risk Sharing, Index Insurance and Risk Taking in Developing Countries. *American Economic Review*, 103 (3): 375-80.

Musshoff, O, Odening, M and Xu, W (2009). Management of Climate Risks in Agriculture – will weather derivatives permeate?. *Applied Economics*, 43 (9): 1067-77.

NSSO (2013). Situation Assessment Survey of Agricultural Households 70th Round. National Sample Survey Office, Ministry of Statistics and Programme Implementation, Government of India.

Oberhofer, H and Pfaffermeyer, M (2014). Two-Part Models for Fractional Responses Defined as Ratios of Integers. *Econometrics*, 2: 123-44.

Panda, A (2013). Climate Variability and the Role of Access to Crop Insurance as a Social-Protection Measure: Insights from India. *Development Policy Review*, 31 (S2): 57-73.

Papke, L E and Wooldridge, J M (1996). Econometric Methods for Fractional Response Variables With an Application to 401 (K) Plan Participation Rates. *Journal of Applied Econometrics*, 11 (6): 619-32.

Petri, L and Sami, M (2014). Willingness to Pay for Agricultural Crop Insurance in the Northern EU. *Agricultural Finance Review*, 74 (4): 539-54.

Prabhu, K S and Ramachandran, S (1986). Crop Credit Insurance: Some Disturbing Features. *Economic and Political Weekly*, 21 (42): 1866-69.

Rajeev, M, Vani, B P and Bhattacharjee, M (2011). Nature and Dimensions of Farmers' Indebtedness in India and Karnataka. *ISEC Working Paper No. 267*. Institute for Social and Economic Change, Bengaluru

Rajeev, M, Bhattacharjee, M and Vani, B P (2016). Climate change and Uncertainty in Agriculture: Does Crop Insurance Help in India?. In Nautiyal, S, Schaldach, R, Raju, K V, Kaechele, H, Pritchard, B and Rao, K S (eds), *Climate Change Challenge (3Cs) and Socio-Economic-Ecological Interface Building*. Springer International Publishing.

Rajeev, M and Nagendran, P (2019). Crop Insurance in India: Where Do We Stand?. *Economic and Political Weekly*, 54 (26&27): 28-35.

Ramirez, O A and Shonkwiler, J S (2017). A Probabilistic Model of the Crop Insurance Purchase Decision. *Journal of Agricultural and Resource Economics*, 42 (1): 10-26.

Ravago, M-L V, Roumasset, J and Jandoc, K (2016). Risk Management and Coping Strategies: Climate Change and Agriculture in the Philippines. *The Philippine Review of Economics*, 53 (2): 66-105.

Ray, S K (1981). Weather, Prices and Fluctuations in Agricultural Production. *Indian Economic Review*, 16 (4): 251-77.

Robert, A, Mensah, J O, Wie, P and Awuyno-vitor, D (2014). Prospects of Crop Insurance as a Risk Management Tool among Arable Crop Farmers in Ghana. *Asian Economic and Financial Review*, 4 (3): 341-54.

Rosenzweig, M R and Stark, O (1989). Consumption Smoothing, Migration and Marriage: Evidence from Rural India. *Journal of Political Economy*, 97 (4): 905-26.

Santeramo, F G, Goodwin, B K, Adinolfi, F and Capitanio, F (2016). Farmer Participation, Entry and Exit Decisions in the Italian Crop Insurance Program. *Journal of Agricultural Economics*, 67 (3): 639-57.

Singh, S R, Thakar, K P and Soumya, C (2018). Status and Determinants of Crop Insurance in Gujarat. *Indian Journal of Economics and Development*, 14 (2): 288-94.

Sinha, S (2004). Agriculture Insurance in India: Scope for Participation of Private Insurers. *Economic and Political Weekly*, 39 (25): 2605-12.

Udry, C (1990). Credit Markets in Northern Nigeria: Credit as Insurance in a Rural Economy. *The World Bank Economic Review*, 4 (3), A Symposium issue on Imperfect Information and Rural Credit Markets. Pp 251-69.

Venkatesh, G (2008). Crop Insurance in India: A Study. *The Journal – January-June 2008*, Pp 15-17. Available online at: https://www.insuranceinstituteofindia.com/downloads/Forms/III/Journal-2008/Journal08_%20pg15-17_crop.pdf. Last Visited: 9/9/2019

Vyas, V S and Singh, S (2006). Crop Insurance in India: Scope for Improvement. In Kapila, R and Kapila, U (eds), *Economic Developments in India: Monthly Update,* 108, *Analysis, Reports, Policy Documents.* New Delhi: Academic Foundation. Pp 83-110.

Wang, M, Ye, T and Shi, P (2016). Factors Affecting Farmers' Crop Insurance Participation in China. *Canadian Journal of Agricultural Economics*, 64: 479-92.

Wooldridge (2012). *Introductory Econometrics: A Modern Approach*, 5th ed., Mason, USA: Cengage Learning.

Appendix

Table A1: Descriptions and Descriptive Statistics of Variables Used

Variable	Description	Mean	S.D
majorcrop_insured	= 1 if the household had at least one major crop cultivated insured during the reference period (July 2012 – June 2013), 0 otherwise	0.0626	0.2422
pctai	Area cultivated for insured sole and mix major crops / Total area cultivated for sole and mix major crops	0.0496	0.1981
avginformalrate	Average regional interest rate for informal loans	19.4324	10.5197
land_total	Total area (in ha) cultivated by the household	1.5022	1.8565
owned_pc	Percentage of cultivated area owned by the household	0.8962	0.2639
rainmon_mod	Absolute percentage deviation from average rainfall in district	19.3706	14.7675
region_cult_wo	Percentage of loan amount waived off in NSS region	0.0036	0.0047
pchhexp	Per-capita household monthly expenditure in rupees	1519.22	2071.08
irrigationexp_perha	Per hectare expenditure on irrigation in rupees during reference period	1220.79	11233.14
fertexp_perha	Per hectare expenditure on fertilizers in rupees during reference period	5640.86	34992.02
ppcexp_perha	Per hectare expenditure on plant protection chemicals in rupees during reference period	1650.21	17009
livestock_done	= 1 if the household cultivated livestock during reference period, 0 otherwise	0.7256	0.4462
nonagri_done	= 1 if the household engaged in non-agricultural activities during the reference period, 0 otherwise	0.1513	0.3584
wagesal_done	= 1 if the household engaged in wage/salaried work during reference period, 0 otherwise	0.4864	0.4998
accessed_techadv	= 1 if the household accessed technical advice from an agricultural extension officer during the reference period, 0 otherwise	0.4672	0.4989
has_ration_card	= 1 if one household member or more has a ration card, 0 otherwise	0.8868	0.318
majorcrop_sold_ msp_agency	= 1 if the household sold a majorcrop to an MSP agency during the reference period, 0 otherwise	0.0824	0.2750
hindu	= 1 if the household belongs to the majority religious group (Hindu), 0 otherwise	0.7964	0.4027
SC/ST	= 1 if the household belongs to any of the scheduled castes or scheduled tribes as per the government order, 0 otherwise	0.3220	0.4672
secondary	= 1 if at least one member of the household has completed their secondary level of education (10th grade) or better, 0 otherwise	0.5540	0.4971
cereals_major crop	= 1 if cereals are a major crop cultivated by the household, 0 otherwise	0.7641	0.4246
state region	= 0 if household is in the North region (including the states of Jammu & Kashmir, Himachal Pradesh, Punjab, Uttarakhand, Uttar Pradesh, Haryana, Delhi, and Chandigarh), 1 if household is in the East region (including Bihar, Orissa, Jharkhand, West Bengal, and the Andaman and Nicobar Islands), = 2 if household is in the West region (Rajasthan, Gujarat, Goa, Maharashtra, Dadra & Nagar Haveli, and Daman & Diu), = 3 if household is in the South region (Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Telangana, Pondicherry, and Lakshadweep), = 4 if household is in the central region (Madhya Pradesh and Chhattisgarh), and = 5 if household is in the North-East region (Assam, Sikkim, Nagaland, Meghalaya, Manipur, Mizoram, Tripura, and Arunachal Pradesh)	-	-

Table A2: Robustness Test of Regression Results

Variable	Reg 1		Reg 2		Reg 3		All Variables Incl.	
	Logit	Fracreg	Logit	Fracreg	Logit	Fracreg	Logit	Fracreg
Average Informal Interest Rate (avginformalrate)	0.1932*** (0.0022)	-0.0067* (0.0038)					0.0059** (0.0030)	-0.0050 (0.0048)
Absolute Monsoon Rainfall Deviation (rainmon_mod)	-0.0012 (0.0154)	-0.0003 (0.0021)					-0.0004 (0.0016)	-0.0001 (0.0022)
Percentage of Loans Waived Off (region_cult_wo)	-12.4802** (5.1028)	10.1183 (8.3342)					-15.7934*** (5.2200)	13.4595 (8.6919)
Total Land Cultivated (land_total)	0.2093*** (0.0092)	-0.0064 (0.0111)					0.1607*** (0.0097)	-0.0010 (0.0119)
Percentage of Cultivated Land Owned (owned_pc)	0.4052*** (0.9723)	0.2757** (0.1337)					0.3905*** (0.1007)	0.2238 (0.1404)
Per Capita Monthly Household Expenditure (pchhexp)	-0.0000 (0.0000)	-0.0000 (0.0000)					0.0000 (0.0000)	0.0000 (0.0000)
Per Hectare Expenditure on Irrigation (irrrigationexp_perha)			-0.0000*** (0.0000)	-0.0000*** (0.0000)			-0.0000** (0.0000)	-0.0001*** (0.0000)
Per Hectare Expenditure on Fertilizers (fertexp_perha)			0.0000*** (0.0000)	0.0000*** (0.0000)			0.0000*** (0.0000)	0.0000*** (0.0000)
Livestock Activities Undertaken (livestock_done)			0.2554*** (0.0533)	-0.1284* (0.0773)			0.2172*** (0.0583)	-0.1728** (0.0865)
Non-agricultural Activities Undertaken (nonagri_done)			0.0085 (0.0613)	0.0377 (0.0878)			0.1434** (0.0657)	0.0090 (0.0909)
Wage/Salaried Work Undertaken (wagesal_done)			-0.1937*** (0.0452)	0.0518 (0.0644)			-0.0047 (0.0501)	0.0987 (0.0697)
Accessed Technical Advice (accessed_techadv)			0.8349*** (0.0470)	-0.2211*** (0.0696)			0.6054*** (0.0516)	-0.1875*** (0.0791)
Household Member Has Ration Card (has_ration_card)			0.3234*** (0.0818)	-0.0944 (0.1106)			0.2390*** (0.0858)	-0.0871 (0.1205)
Hindu (hindu)					0.6700*** (0.0839)	0.4684*** (0.1203)	0.7451*** (0.0889)	0.4371*** (0.1285)
SC/ST (scst)					-0.7266*** (0.5856)	0.1529* (0.0838)	-0.6505*** (0.0636)	0.0431 (0.0917)
Household Member Has Secondary Education (secondary)					0.1290*** (0.0467)	-0.0642 (0.0649)	-0.0736 (0.0504)	-0.0846 (0.0688)
Cereals is a Major Crop (cereals_majorcrop)					0.7282*** (0.0643)	-0.5919*** (0.1025)	0.5228*** (0.0712)	-0.5393*** (0.1122)
East Zone (stateregion = 1)					0.5035*** (0.0706)	0.1753* (0.0985)	0.6391*** (0.0821)	0.2587*** (0.1107)
West Zone (stateregion = 2)					0.7148*** (0.7978)	-0.0642 (0.1176)	0.6749 (0.0839)	-0.1558 (0.1320)
South Zone (stateregion = 3)					0.9743*** (0.0698)	-0.2842*** (0.1000)	0.6661*** (0.0815)	-0.3503*** (0.1244)
Central Zone (stateregion = 4)					1.5585*** (0.0773)	0.1138 (0.1032)	1.4365*** (0.0815)	0.0356 (0.1115)
Northeast Zone (stateregion = 5)					-1.0009*** (0.1497)	-0.4041* (0.2259)	-0.8001*** (0.1515)	-0.5613** (0.2356)
Constant	-3.8108*** (0.1154)	0.9059*** (0.1714)	-3.5521*** (0.0955)	1.2694*** (0.1323)	-4.3024*** (0.1078)	1.0800*** (0.1673)	-5.5480*** (0.1874)	1.3117*** (0.2947)
N	34406	2047	35124	2173	35200	2174	34360	2046

Source: Authors' Computation from NSSO (2013)

Note: *, **, and *** denote that a coefficient is significant at the 10%, 5%, and 1% levels respectively.

Appendix A3: Proof of Proposition 1

Using equations (3) and (4), we have:

$$N = \beta p\{u(w + O_h - m) - u(w + O_h)\} + \frac{\beta(1-p)\{[u(w + O_h - m) - u(w + O_h)] + \beta u((1+r)(O_h - O_l))\}}{1-\beta^2} \quad (5)$$

We set u(x) = ln(x), which has the properties $u^{/}(x) > 0$ and $u^{//}(x) < 0$ for x > 0. From (5), we get: $N(1-\beta^2) = \beta p\{\ln(w + O_h - m) - \ln(w + O_h)\} + \beta(1-p)\{\ln(w + O_h - m) - \ln(w + O_h) + \beta \ln((1+r)(O_h - O_l))\}$
Using the properties of the natural logarithm function, we obtain:

$$N = \frac{1}{1-\beta^2} \ln\left[\left(\frac{w + O_h - m}{w + O_h}\right)^{\beta} \left((1+r)(O_h - O_l)\right)^{\beta^2(1-p)}\right] \ldots\ldots\ldots (6)$$

A rational farmer will opt for formal crop insurance when there is a positive net benefit from doing so. That is, when N > 0, the farmer will take up crop insurance, and when N < 0, informal insurance agreements will be preferred. When N = 0, the farmer will be indifferent between crop insurance and borrowing from moneylenders. The rate of interest at which N = 0 is r^*. Solving for r when N = 0:

$$\left(\frac{w + O_h - m}{w + O_h}\right)^{\beta} \left((1+r)(O_h - O_l)\right)^{\beta^2(1-p)} = 1$$

$$[(1+r)(O_h - O_l)]^{\beta^2(1-p)} = \left(\frac{w + O_h}{w + O_h - m}\right)^{\beta}$$

$$1 + r = \frac{1}{O_h - O_l}\left[\left(\frac{w + O_h}{w + O_h - m}\right)^{\beta}\right]^{\frac{1}{\beta^2(1-p)}}$$

$$r^* = \frac{1}{O_h - O_l}\left[\left(1 - \frac{m}{w + O_h}\right)\right]^{-\frac{1}{\beta(1-p)}} - 1$$

Recent Working Papers

515 Effects of Covid-19 Pandemic on the Rural Non-farm Self-employed in India: Does Skill Make a Difference?
Indrajit Bairagya

516 Promoting Green Buildings towards Achieving Sustainable Development Goals: A Review
S Manasi, Hema Nagaraj, Channamma Kambara, N Latha, O K Remadevi and K H Vinaykumar

517 Indian Civil Aviation Industry: Analysing the Trend and Impact of FDI Inflow
Priyanka Saharia and Krishna Raj

518 Biodiversity and Ecosystem Governance in Indian Protected Areas: A Case Study from Manas in Assam
Michael Islary and Sunil Nautiyal

519 Coresidence of Older Persons in India: Who Receive Support and What are the Levels of Familial Support?
Kinkar Mandal and Lekha Subaiya

520 India's Trade in Dirty Products
Malini L Tantri and Varadurga Bhat

521 Education and Nutrition among the Migrant Construction Workers' Children – A Case Study of Bengaluru City
Channamma Kambara, Malini L Tantri, S Manasi and N Latha

522 Performance of Piety: Lived Experiences of Muslim Women
Romica Vasudev and Anand Inbanathan

523 Changing Forest Land Use for Agriculture and Livelihood in North East India
Reimeingam Marchang

524 Fiscal Federalism: Transfer Dependency and Its Determinants Among Select Indian States
J S Darshini and and K Gayithri

525 Essentiality of Package of Practices (PoPs) of Tomato Cultivation in Semi-arid Region of Karnataka – A Bird's Eye View
M Govindappa

526 Job-Seeking Behaviour, Employment, Labour Employability Skills, Dissatisfaction and Job Mobility: A Study of North-East Migrant Workers in Bengaluru
Reimeingam Marchang

527 Socio-Economic Characteristics and Land Particulars of Ginger Farmers in Karnataka
Pesala Peter and I Maruthi

528 How Civic Groups are Meeting the Challenges of Saving Bengaluru Lakes: A Study
Dipak Mandal and S Manasi

529 Revisiting India's SEZs Policy
Malini L Tantri

530 TATA Motors Singur: Narratives of Development Projects, Politics and Land Acquisition in West Bengal
Pallav Karmakar and V Anil Kumar

531 Migration, Reverse Migration, Employment and Unemployment Crises During the First Wave of COVID-19 Pandemic in India
Reimeingam Marchang

532 Women, Employment and Stigma of Crime: Narratives of Former Female Convicts From West Bengal
Shreejata Niyogi

533 Cost Benefit Analysis of System of Wheat Intensification Method of Cultivation Vis-à-Vis the Traditional Method: A Case Study of Gaya, Bihar
Shikha Pandey

534 Did Skill Development Policies Promote Participation in and Benefits from Skill Education? Evidence from a Nation-wide Survey
Andrea Vincent and D Rajasekhar

535 Implications of Infrastructure on Human Development in North East India: A Review
T Thangjahao Haokip and Reimeingam Marchang

536 Domestic Violence Against Women – A Case Study and the Role of Civil Societies from the Sundarbans Region of West Bengal
Anamika Das and C M Lakshmana

537 Impact of Skill Development Infrastructures: A Study of Manipur
T Thangjahao Haokip and Reimeingam Marchang

Price: ` 30.00

ISBN 978-93-93879-05-9

INSTITUTE FOR SOCIAL AND ECONOMIC CHANGE
(ISEC is an ICSSR Research Institute, Government of India
and the Grant-in-Aid Institute, Government of Karnataka)
Dr V K R V Rao Road, Nagarabhavi P.O., Bangalore - 560 072, India
Phone: 0091-80-23215468, 23215519, 23215592; Fax: 0091-80-23217008
E-mail: balasubramanian@isec.ac.in; Web: www.isec.ac.in