Demand and Impact of Crop Microinsurance in India

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SUMMARY

This thesis presents an analysis of the demand and impact of crop microinsurance in India. The study is based on extensive fieldwork and primary data collection from two field sites in India.

The first empirical chapter examines the impact of crop microinsurance on output. Accounting for the endogeneity of insurance investment, this chapter uses a two-step instrumental variables approach to assess the impact of insurance on yield for two varieties of paddy. The assessment is based on secondary district level data and primary household survey data. The findings indicate that impact of insurance on yield is not homogeneous across crops. It is based on the flexibility of the crop's input requirement structure.

The second chapter explores the impact of crop insurance on the use of inputs such as seeds, fertilizers, pesticides, irrigation and labour for paddy varieties. This chapter is a significant addition to the existing small pool of literature on the impacts of crop insurance on a range of inputs. Since both insurance and input decisions are *ex-ante*, a simultaneous equations model is employed to assess impacts. Results show that the impact of crop microinsurance varies based on the type of input, crop under consideration and its significance in the income portfolio of a farmer.

The final chapter assesses the demand for crop microinsurance using a contingent valuation experiment on turmeric farmers. This is a first of its kind attempt to delineate the *willingness to join* (WTJ) from the amount of *willingness to pay* (WTP) for crop insurance policies. Results based on a Heckman selection model, indicate that while the WTJ is influenced by risk attitudes and product literacy, the amount of WTP is driven by a careful assessment of the other risk coping avenues available to a household. Only the 'residual' risk is passed on to insurance

Acknowledgements

I arrived in the UK with a mind full of ideas and a mixed bag of emotions – the excitement of living in a new country, the anticipation of new friendships, an anxiety of the unknown and fear that things may not work out. It is time now to reflect on the last four years and express my gratitude to those individuals who have been instrumental in making this journey the most meaningful experience of my life.

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This thesis is founded on primary data collected over a period of eight months in India. The fieldwork at Erode and Howrah was possible only due to the support of the several individuals and institutions that contributed to the data collection process. I express my heartfelt thanks to Dr. Rabindran Ramalingam, Registrar at the Tamil Nadu Agricultural University (TNAU), India. The Erode survey would not have been possible without his support and encouragement. I am thankful to Dr. Alagesan at Myrada for providing a sound base for data collection in Erode and employing able enumerators, who executed the survey with great care. I also duly acknowledge the role played by Arindom Baidya in developing the hypothetical insurance policy for the study.

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List of Abbreviations

AFC	Agriculture Finance Corporation
AIC	Agriculture Insurance Company of India
AP	Andhra Pradesh
CCIS	Comprehensive Crop Insurance Scheme
CIRM	Centre for Insurance and Risk Management
CVM	Contingent Valuation Model
DBDC	Double Bounded Dictomous Choice
ECIS	Experimental Crop Insurance Scheme
FGD	Focussed Group Discussion
GDP	Gross Domestic Product
GIC	General Insurance Company of India
GMM	Generalised Method of Moments
GUJ	Gujarat
HYV	High Yielding Variety
IISS	Indian Institute of Soil Sciences
ILO	International Labour Organisation
IMD	Indian Meteorological Department
INR	Indian rupee
IRDA	Insurance Regulatory and Development Authority
IV	Instrumental Variables
K	Potassium
KVK	Krishi Vigyan Kendra
MFI	Microfinance Institutions
MIS	Management Information Systems
mm	millimeter
MNAIS	Modified National Agricultural Insurance Scheme
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Scheme
MSP	Minimum Support Price
N	Nitrogen
NAIS	National Agricultural Insurance Scheme
NFSM	National Food Security Mission
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Cooperation and Development
OLS	Ordinary Least Squares
P	Phosphorous
PCIS	Pilot Crop Insurance Scheme
RKBY	Rashtriya Krishi Bima Yojana
SHG	Self-Help Groups
TN	Tamil Nadu
TNAU	Tamil Nadu Agricultural University
WBCIS	Weather Based Crop Insurance Scheme
WRMS	Weather Risk Management Services
WTJ	Willingness to Join
WTP	Willingness to pay

Chapter I

Agricultural risk management in India

1. Introduction

Jitu Bagdi, a farmer from West Bengal, India killed himself on 23 August 2010. Hounded by moneylenders, he drank poison after his crop failed because of the drought, says his widow, Rupa Bagdi.[1]

Adroa Kabumba, a small farmer lives in a remote village in Uganda. His family consisting of himself, his wife and three children consume most of his cultivation. His wife works as a domestic help to earn additional income. The family barely manages to save money every month and only one of their three children goes to school. Last year, there was a flood in the district and Rehaman's crop suffered. Left without income, the family had to starve; one of the children fell ill and could not be treated in time. The family lost a member.

The risks and uncertainty faced by farmers such as Jitu and Adroa are experienced by low-income households across developing countries on a regular basis. While households use several coping mechanisms such as savings, borrowings, income and crop diversification etc. to deal with such risks, there is a debate on the effectiveness of these measures in catering to catastrophic shocks that affect all households in a community.

Markets have the potential to pool risks across geographies and create strong portfolios that do not fail in the event of huge calamities that affect all households in a given area. They can also respond relatively quickly in the event of small-scale shocks that affect some households within a community. Microinsurance is a potential market based intervention that can help low income households cope with shocks effectively.

[1]Source: http://www.investingcontrarian.com/index.php/india-investing/drought-affected-west-bengal-hit-by-lack-of-farm-investment/

Microinsurance is defined as the protection of low-income people against specific perils in exchange for regular premium payments proportionate to the likelihood and cost of the risk involved (Churchill, 2006, pp. 12-13). Apart from providing a hedge against crop risks, microinsurance also covers risks relating to life, health, livestock and property. The fact that microinsurance is an *ex-ante* means of risk management also provides an opportunity to strengthen the risk coping framework of the household in a comprehensive manner. Rather than being reactive, microinsurance is a proactive measure that can eliminate the anxiety faced by households on a daily basis.

Though microinsurance is a useful risk coping technique, this sector has been little explored in literature. Research on the working and dynamics of microinsurance is fairly recent. This thesis aims to contribute to the slow growing literature by examining the demand and impact of crop microinsurance in India.

While community based insurance groups have existed for several years, the growth of market-based microinsurance is fairly recent. It is only in the last decade that Governments and private sectors have recognised the potential of formal microinsurance solutions in catering to shocks and losses. The microinsurance sector has grown exponentially from 78 million insured in 2006, 135 million insured in 2009 to almost 500 million insured in 2011 across developing countries (Churchill and McCord, 2012). The estimated continent-wise outreach of microinsurance is provided in Table 1.1

Table 1.1: Estimated outreach of microinsurance in the world (in million)			
Year	**Asia**	**Africa**	**Latin America**
2006	66	4.5	8
2011	350-400	18-24	45-50

Source: Churchill and McCord (2012)

As evident in Table 1.1, the development of microinsurance is concentrated in Asia. The major contributing countries are India, China, Philippines, Bangladesh and Pakistan. Of these countries, India has made the most significant progress in microinsurance in terms of product design and outreach. It is estimated that nearly 60 percent of the total individuals covered by microinsurance live in India.

Around 11.8 percent of the 1.3 billion population in India fall below the *international poverty line*[2] (World Bank, 2014). Several microinsurance products are offered to low-income households in India including life, health, agriculture, livestock and property microinsurance. At least 163 million low-income individuals have had some kind of microinsurance coverage in the country as of 2010. This figure excludes public-sponsored health microinsurance schemes that are estimated to have covered over 300 million low-income individuals across the country (Ruchismita and Churchill, 2012).

India is one of the first countries that formally regulated its microinsurance sector. The Insurance Regulatory and Development Authority (IRDA) Regulations that oversee insurance operations in the country were amended in 2005 to incorporate microinsurance schemes. Under this amendment, it is mandatory for all insurance companies to ensure that at least five percent of their gross annual premium comes from microinsurance products and businesses.

Crop microinsurance is an important component in the Indian Government's Risk Management portfolio. Several schemes have been offered to protect the yields of farmers since the 1960s. Insurance subsidies are also offered to small and marginal farmers in the country.[3] The Indian crop insurance programme is considered the world's largest with over 25 million farmers insured under various crop insurance schemes. The current crop microinsurance penetration in India stands at 25 percent (AFC, 2013).

A unique feature of the Indian crop insurance programme is that it is bundled with credit on a mandatory basis for farmers who avail crop loans from public sector banks. The few other countries where insurance is mandatorily bundled with credit are Ecuador, Honduras, Morocco, Philippines, Nepal and Pakistan (Mahul and Stutley, 2010). In all these countries, insurance is also offered on a voluntary basis to farmers who do not avail loans.[4]

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[2] The international poverty line is set at USD 1.25 at 2005 purchasing power parity (World Bank, 2008)

[3] The Indian Government defines marginal farmers as those cultivating agricultural land up to 1 hectare (or 2.5 acres). A small farmer is defined as cultivating between 1 hectare and 2 hectares (as defined in the Financial Budget of 2008). In most Indian states, the small and marginal farmers account for between 70 to 94 per cent of total farmers.

[4] Agriculture insurance is also compulsory in countries such as China, Cyprus, Japan, Kazakhstan, Mauritius, the Netherlands, Switzerland, and the Windward Islands. However, the compulsory aspect is limited to certain crops and risk types only. They are not bundled with credit.

The distinct features of the Indian microinsurance industry include Government regulation, public-private partnerships and regular investments in understanding the specific needs of farm communities to provide meaningful insurance covers that respond to the actual risk needs at the local level.

The rest of this section provides a brief understanding of risks and traditional coping mechanisms available to households and the potential role of crop microinsurance in facilitating safety nets.

1.1 Risks and coping strategies

The risks faced in agriculture could stem from weather vagaries, pest attacks, price fluctuations and other farm specific causes. These shocks vary across regions, climatic zones and crops and can be categorised as systemic or idiosyncratic. Systemic shocks refer to large-scale shocks such as floods, drought etc. that affects all households in a given region or community. Idiosyncratic shocks are individual specific shocks such as pest attacks, illness/injury of farmer etc. that affect a particular farm.

There are several consequences of shocks, ranging from increase in child mortality rates due to negative rainfall shocks (Rose, 1999), children dropping out from school to start working (Pizarro, 2001 as cited in Dercon, 2005) and heavy *ex-post* borrowings at high rates of interest to make ends meet. Farmers are, thus, forced to constantly battle against mounting debts and crop failures pushing them into a vicious cycle of poverty that they are sometimes unable to recover from even after decades.

Farm households tap into a variety of *ex-ante* and *ex-post* resources to deal with shocks. Such strategies could be formal or informal sources of risk management. World Development Report (20001) defines informal strategies as ‘arrangements that involve individuals or households or such groups as communities or villages,’ while formal arrangements are ‘market-based activities and publicly provided mechanisms.’ World Bank (2011) classifies the various agricultural risk coping mechanisms available to a farmer as listed in Table 1.2.

Table 1.2: Potential risk management mechanisms			
Severity of risk	**Informal measures**	**Formal measures**	
	Household level	**Markets**	**Governments**
Non-specific	Sharecropping SHGs Water resource management	New technology Improved seeds	Irrigation infrastructure Extension services Agriculture research Weather data systems
Low	Crop diversification Livestock savings Buffer stocks	Formal savings	-
Moderate	Labour diversification Risk pooling Money lenders	Formal lending Formal risk sharing via insurance	State sponsored lending
High/Catastrophic	Sale of assets Migration	Formal insurance	Disaster relief State sponsored insurance

Source: World Bank (2011)

Households prefer to tap into informal risk coping measures such as personal savings, borrowings, crop diversification etc. to deal with shocks. There is greater dependence on informal mechanisms as they are easily available within the community. The most common informal tool used is informal borrowing. While loans immediately respond to the financial needs of affected households, they could lead to prolonged debt and poverty traps.

These informal measures also tend to fail in the event of systemic shocks that affect the entire area. Czukas et al. (1998) find evidence that non-farm income is positively correlated with shocks affecting crop income. This means that a large-scale event such as drought adversely affects not only crop income but also non-farm income. They refer to Sen's analysis of famine – crop failure leads to a collapse of the demand for local services and crafts, limiting the use of diversification to handle risk' (cited in Dercon 2002).

Government support and relief is mandated in the national risk management strategies of most developing countries. However, these incentives are made available only in the event of catastrophic shocks. Often, the financial relief packages either fail to reach affected households or there are huge delays due to bureaucracy and red tape.

There is a need for formal, market based risk management solutions to facilitate poor households cope with both idiosyncratic and systemic shocks efficiently. Such formal risk management strategies include formal credit or microfinance and microinsurance.

The microfinance movement has gained substantial scale in the last few decades attracting academicians, governments, multi-lateral agencies and philanthropists across the globe. However, microfinance is an *ex-post* risk coping measure.

Microinsurance is a useful *ex-ante* risk coping strategy that can help poor households counter poverty traps. A description of how microinsurance works and why it provides a comprehensive risk management framework is discussed in the next sub-section.

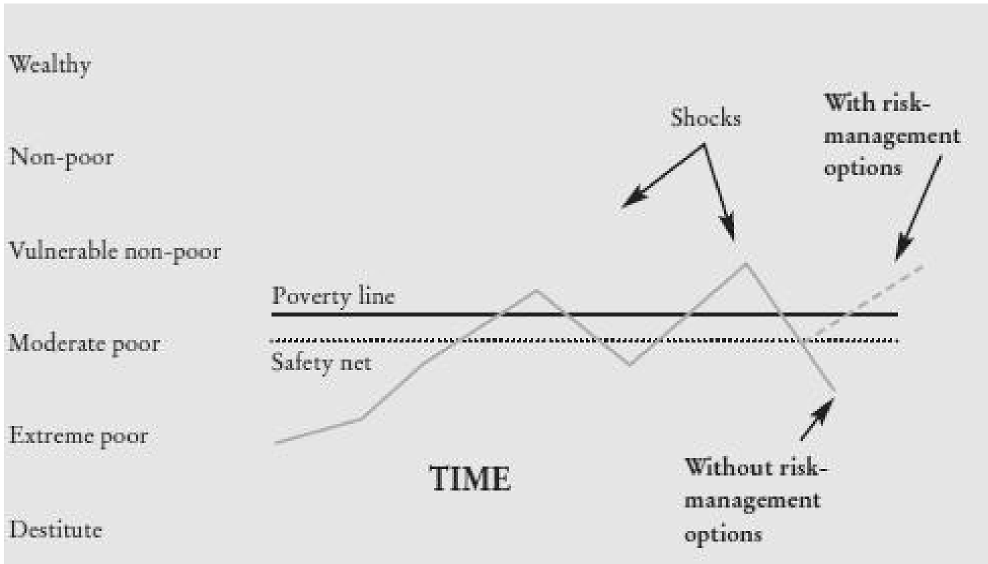
1.2 Microinsurance as a source of risk management

Microinsurance is a proactive, *ex-ante* investment that can be made by households to cope with risk and uncertainty. Microinsurance involves pooling of risks across different local units to create diversified portfolios that can cater to both idiosyncratic and systemic shocks effectively.

Market participation also ensures that claims are disbursed immediately to the affected households in the event of a risk that is covered under the microinsurance policy, helping them recover from the event at a faster pace. Aggregating risks portfolios across local units allows more flexibility and immediate availability of funds even in case of systemic shocks.

This means that investing in *ex-ante* formal microinsurance provides the much-needed safety nets for low-income households. It ensures that their consumption does not drop below subsistence levels and provides a valuable cushion against debt and poverty traps as illustrated in Figure 1.1.

Figure 1.1: Role of formal microinsurance in shock management



Source: McCord (2005)

Microinsurance products are generally marketed through local institutions such as self-help groups (SHGs), non-governmental organisations (NGOs) or microfinance institutions (MFIs).

Despite these numbers, households tend to prefer microfinance to microinsurance. In the former, money is offered first and the onus of ensuring repayment lies with the lenders. In microinsurance, clients pay a fee (premium) upfront for a shock that may or may not occur. Lenders have to trust borrowers; while insurers have to be trusted by clients (Dercon et al., 2008).

This does not necessarily mean that microinsurance is readily available to those households who are willing to pay premiums. Access to formal insurance is low in most countries. There is limited knowledge at the provider end resulting in poor product design and outreach models. The requirement of more individual, institutional and financial resources is imperative in understanding the needs of the sector, designing appropriate products, developing robust outreach channels and engaging in better microinsurance education and marketing endeavours.

It is also important to note that the microinsurance sector has not been studied extensively in academia. While there is a significant amount of literature in this space, there is a need for more involved research to understand the different facets of this sector- demand, role of regulation and subsidies and the impacts of insurance on agriculture and other occupational/non-occupational aspects of low-income households in developing countries.

This Chapter is organised as follows: Section 2 elaborates on the importance of agriculture in the Indian economy and the significance of effective *ex-ante* crop microinsurance in this context. This section also elaborates on the existing crop microinsurance schemes in the country. Section 3 describes the specific research questions identified by this thesis. It also sets the framework for the rest of the dissertation as outlined in Chapters II-VI.

2. Agricultural insurance in India

Agriculture has traditionally been an important occupation in the Indian economy even before its independence in 1947. It has been the main source of income for rural households, who constitute 70 percent of the total poor in the country. Around 75 percent of the Indian labour force is employed in agriculture. Major crops cultivated include food crop such as rice and wheat apart from a range of pulses, oilseeds and spices. [5]

However, the contribution of Agriculture to the nation's GDP has been constantly declining from 51.9 percent in 1950-51 to 13.7 percent in 2012-13 at 2004-05 prices.

Indian farmers constantly battle against the twin problems of crop failures and mounting debts. These consequences range from shift to non-farm activities, lower labour availability for agriculture, increase in rural school drop-out rates, rural-urban migration

[5] There are two major cropping seasons in India – autumn or Kharif season and winter or Rabi season. The specific months covering each season vary across crops though typically Kharif could stretc.h from May-January and Rabi is from November to April. The rest of this thesis uses the words Kharif and Rabi to denote the autumn and winter cropping seasons in India respectively.

to even farmer suicides. As per the 2011 census, farmers commit suicide at a rate of 16.3 per 100,000 farmers

There is a definite need for effective risk management solutions in the country. This section elaborates on the role of Government in providing *ex-ante* risk hedge solutions and describes the currently operational crop microinsurance schemes in the country.

2.1 Role of the Government

As an institutional response to address agricultural shocks, the Government of India has introduced several insurance schemes starting October 1965. These schemes have been offered to farmers in India through General Insurance Company of India (GIC), a public sector undertaking that operated through various subsidiaries located in different parts of the country.

In the traditional insurance schemes, claims were made by individually assessing the losses of the farmers. Most of the traditional crop insurance schemes such as Pilot Crop Insurance Scheme (PCIS), Comprehensive Crop Insurance Scheme (CCIS) and Experimental Crop Insurance Scheme (ECIS) incurred huge administrative expenses and experienced a high degree of adverse selection and moral hazard. Most of these schemes were subsequently removed from operations.

In 2002, the existing subsidiaries of GIC that offered crop insurance products were made independent units that no longer offered crop insurance. The Agriculture Insurance Company of India (AIC) was formed in this year. The AIC was mandated as the ‘implementing agency’ for crop microinsurance products in India. However, in 2007, the Government allowed select private insurance companies to offer crop microinsurance to farmers in the country. This move has been instrumental in the rapid growth of the sector in the last few years leading to a marked improvement in insurance product design and coverage.

It must be noted here that while insurance companies, both public and private, are allowed to design insurance products for local units, the broad profile of the schemes under which products can be offered are provided by the Department of Agriculture &

Cooperation, Government of India. This means that the broad nature of the crop microinsurance schemes, the types of risks covered under each scheme, the processes under which claims are assessed, the manner in which subsidies are disbursed to small and marginal farmers etc. are clearly specified by the Government. These operational guidelines are to be followed by AIC and private insurance players in offering crop microinsurance products to farmers in the country.

The currently operational schemes, launched by Department of Agriculture & Cooperation, Government of India are the National Agricultural Insurance Scheme (NAIS), the Weather Based Crop Insurance Scheme (WBCIS) and the Modified National Agricultural Insurance Scheme (MNAIS). A detailed description of each scheme is provided in the next sub-section.

The State Governments may choose to adopt either one insurance scheme or a combination of insurance schemes for their districts. Typically, the State Governments provide a list of the crops to be covered under each insurance scheme before each cropping season and products are designed accordingly. However, only one scheme can be made available per crop in a given district in each season. To elaborate, assume that potato insurance is provided under NAIS and WBCIS in autumn season for State M. Now, M may choose to provide potato insurance under NAIS for districts A, B and C and potato insurance under WBCIS for districts D and E. It cannot offer potato insurance under both NAIS and WBCIS in all five districts.

State Governments are also allowed to choose the insurance provider, public or private for their districts. Here again, a single insurance company is allowed per crop/scheme in a district. This means that if Insurer X provides potato insurance under WBCIS in district A, Insurer Y cannot offer potato insurance under WBCIS in this particular district. However, this rule has recently been relaxed in several States.

As mentioned earlier, an additional feature of the Indian crop microinsurance programme is that it is mandatory for farmers who avail formal agricultural credit in relation to crops for which insurance is offered in a given district in a particular season from public sector based finance undertakings in the country. These loans taken for cropping purposes are referred to as Seasonal Agricultural Operations (SAO) loans. All farmers who avail such loans are referred to as *loanee* farmers. Crop insurance is bundled with credit on a mandatory basis for such farmers.

Insurance is also offered on a voluntary basis to farmers who have not availed formal public sector loans for insurable crops in a given season. Such farmers are referred to as *non-loanee* farmers.

There are some important caveats that need to be mentioned in relation to *loanee* and *non-loanee* farmers in India.[6] The fact that a farmer is *loanee* or *non-loanee* is season specific. Farmers do not necessarily avail public loans in each season. A farmer who is categorised as *loanee* in one season may become *non-loanee* in the following season.

The distinction between *loanee* and *non-loanee* is purely based on public sector loans taken for cultivation of crops that are insurable during the given season. This means that *non-loanee* farmers may have also purchased loans for cultivation of insurable crops in a given season, but these are not taken from notified public sector undertakings. They could be taken from informal sources or moneylenders. Note that a *loanee* farmer is not necessarily a small or marginal farmer. Even large farmer take formal agricultural loans for several purposes

The distinction between the two is also crop specific. A farmer is *loanee* if s/he has purchase formal credit for a notified crop only in a given season. Notified crops are the crops for which insurance is provided in a cropping season. Say for example, turmeric is insured in district J during Rabi 2010 i.e. winter season. Only a farmer who buys a loan for turmeric cultivation in this district from a formal public sector bank is a *loanee* famer. Insurance is mandatorily bundled with credit for this farmer. Now, famer K in the same district may cultivate turmeric as well as sugarcane. S/he may choose to buy formal public sector credit for sugarcane cultivation in Rabi 2010. Since turmeric is the only crop insured, farmer K is still *non-loanee*, a potential voluntary buyer of turmeric insurance.

[6] Please note that referring to mandatory and voluntary farmers as *loanee* and *non-loanee* respectively is specific to the Indian context. These terms are not used globally.

Recent statistics on the number of *loanee* and *non-loanee* farmers are not available in public domain. The average *loanee* farmers covered during the five-year period 2000-2004 was 79.5 percent for Rabi and 89.8 percent for Kharif crops (Vyas and Singh, 2006). Clearly, voluntary demand for crop insurance products is low in the country.

2.2 Crop microinsurance products

This sub-section elaborates on the crop microinsurance schemes currently offered in India - the National Agricultural Insurance Scheme (NAIS), the Weather Based Crop Insurance Scheme (WBCIS) and the Modified National Agricultural Insurance Scheme (MNAIS).

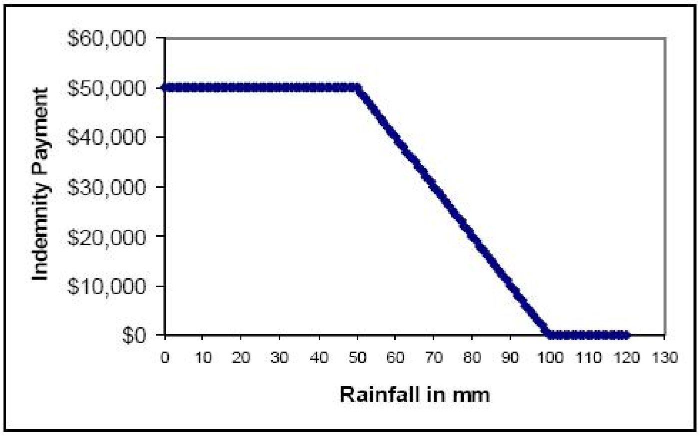
The National Agricultural Insurance Scheme or NAIS is the oldest among the currently operational schemes in India. Launched in 1999, the product address two risk components –downside yield risk and localised individual risk. The yield risk is hedged using area-yield indices. Under the assumption of homogeneity, area-yield index schemes use the aggregated volumes of produce in a given unit of land to determine insurance payouts. The NAIS also covers individual losses resulting from pest attacks and weather calamities.

The causality demonstrated between revenue losses in agriculture and weather in India simulated interest in developing weather index based insurance products. In India, over 80 percent of agricultural land is rainfall dependent and less than 40 percent of this area receives irrigation facilities. The Weather Based Crop Insurance Scheme or WBCIS was formally launched in 2007. Weather index contracts make payments if there are deviations in the chosen weather parameter from the historical average during a given season. Box 1.1 provides an example of a typical weather insurance contract.

Box 1.1: An illustration of a typical weather insurance contract

An example a function of how much liability is purchased. There are 50 ticks between the 100 mm strike and 50 mm limit. Thus, if $50,000 of liability were purchased, the payment for each 1 mm below 100 mm would be equal to $50,000/ (100-50), or $1,000. Once the tick and the payment for each tick are known, the indemnity payments are easy to calculate. An example of a typical deficit rainfall insurance scheme is provided here (Skees, 2003). Consider a contract that is being written to protect against deficient cumulative rainfall during a cropping season. The writer of the contract may choose to make a fixed payment for every 1 mm of rainfall below the strike. If an individual purchases a contract where the strike is 100 mm of rain and the limit is 50 mm, the amount of payment for each tick would be

For example, if the realized rainfall is 90 mm, there are 10 ticks of payment at $1,000 each; the indemnity payment will equal $10,000. The figure below maps the payout structure for a hypothetical $50,000 rainfall contract with a strike of 100 mm and a limit of 50 mm.



Source: Skees (2003)

The Modified National Agricultural Insurance Scheme or MNAIS was introduced as a revision to the NAIS scheme in 2010. Thus scheme is still in its nascent stages and is currently being evaluated by several national and international organisations.

The specific Government guidelines relating to nature of risks covered, premiums, sum insured and claim assessments for each scheme are detailed in Annexure A1.1. However, the main features of each scheme are highlighted in Table 1.3.

The crop microinsurance schemes mainly differ in terms of the risks covered. While NAIS and MNAIS focus on downside yield risk, WBCIS provides a cover against weather risks. All three schemes are mandatorily bundled with credit for *loanee* farmers and offered on a voluntary basis for *non-loanee* farmers. NAIS is only offered by the public-owned Agriculture Insurance Company of India (AIC). Both AIC and select private insurance companies offer WBCIS and MNAIS products to farmers in the country.

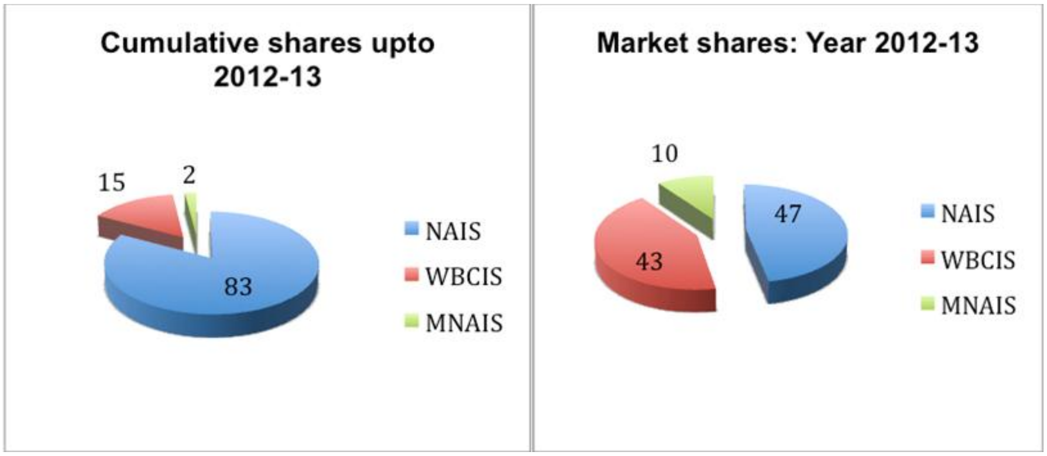
Table 1.3: Salient features of crop microinsurance schemes in India			
Particulars	**NAIS**	**WBCIS**	**MNAIS**
Type of scheme	Area yield index and individual losses	Weather index insurance	Modified version of the NAIS scheme
Risks insured	Yield losses based on area yield index and individual losses	Adverse weather incidences relating to rainfall and temperature variability	Yield losses based on area yield index and individual losses
Launch season	Rabi 1999-2000	Kharif 2007	Rabi 2010-11
Insurance provider	AIC only	AIC and five private insurance companies	AIC and four private insurance companies
Offered to	*Loanee* and *non-loanee* farmers	*Loanee* and *non-loanee* farmers	*Loanee* and *non-loanee* farmers
Sum insured	Loan amount/Average yield	Cost of cultivation	Loan amount/Average yield
Premium rates	Food crops: 1.5-3.5% Commercial crops: Actuarial basis	Actuarial basis	Actuarial basis
Premium Subsidies	10% to small and marginal farmers	Subsidies based on premium slabs	Subsidies based on premium slabs
Risk carrier	AIC and Central Government via *ex-post* claim subsidies	Insurance provider only; no *ex-post* Government support	Insurance provider only; no *ex-post* Government support
Claim assessment	Crop cutting experiments and individual plots assessments	Weather stations located at the block or district level	Crop cutting experiments at more localised units

Source: Author

In terms of coverage, NAIS holds the major cumulative market share primarily since it has been in operation since Rabi 1999-2000. Current trends show that NAIS and WBCIS have a formidable share of the crop insurance market at 47 percent and 43 percent respectively. The MNAIS scheme occupies a small yet significant market base at 10 percent (AFC, 2013).

Despite being one of the world's largest crop insurance programme, the currently operational insurance schemes in India have been criticised on several grounds. In case of NAIS, the scheme aims to cover a large range of risks including localised calamities paving way for possible instances of moral hazard. In some cases, *loanee* farmers are not made fully aware of the terms of the insurance policy and demand from *non-loanee* farms has generally remained low . Additionally, premium rates are uniform for food crops and oilseeds for all farmers without due consideration for microclimates and other geographical factors (Manuamorn, 2007). There is also substantial delay in claim settlements due to the time taken in claim assessment procedures.

Figure 1.2: Trends in the growth of current crop insurance policies in India (in percentage)



Source: Agricultural Finance Corporation (2013)

Similarly, WBCIS also has its shortcomings. There are issues of basis risk i.e. differences in the amount of actual losses and claims received, due to micro-climatic variations within districts. Premium rates, though subsidized, could be relative high for certain areas and/or crops. There is also a problem of poor weather infrastructure with limited weather stations in each district.[7]

Following from the above, it seems that the low demand for crop insurance could indicate that the product design or insurance delivery mechanisms of existing crop insurance schemes are not efficient. It may not correspond to the actual challenges faced by farmers in the country. The MNAIS scheme was developed mainly to address the challenges faced by the NAIS scheme. However, since it is a relatively new scheme, it is too early to conclude on its effectiveness in addressing the product design and delivery challenges faced by the India insurance sector.

However, the crop microinsurance industry in India remains a pioneering model in several ways. The existence of stringent regulations on rural sector business, Government's role in setting up insurance schemes, the recently emerging public-

[7] There is an ongoing debate on how some of the subsidies provided for WBCIS can be diverted towards improving weather infrastructure in the country.

private partnerships to enhance product design and outreach are factors that contribute to the continuous growth of microinsurance businesses in the country.

3. Research questions

Crop microinsurance is a vital safety net that enables low-income farm households to potentially escape poverty traps. The development of products as well as outreach models in India has also been duly recognised. The fact that Indian markets are very little studied also offers a huge opportunity for this thesis to contribute to the sector.

It is useful to assess how these policies have contributed to overall growth of the agricultural sector. These contributions could range from immediate effects on input and output patterns to long-term changes in the household structure and improvements in the standard of living.

It will be interesting to study if the presence of an *ex-ante* hedge against crop losses may motivate farmers to re-model their input portfolios. It may either encourage the use of better quality inputs or promote moral hazard behaviour leading to the use of lesser inputs in production. Both these aspects have a direct impact on the output levels. The first research question of this thesis studies the impact of crop microinsurance on productivity. The second research question explores the impact of crop microinsurance on the use of different inputs in agricultural production.

While the Indian crop microinsurance sector has its merits, one factor that stands out as a limitation is the low demand for such products from *non-loanee* farmers. Though the recent coverage numbers are not available, informal sources suggest that there is not much change in the trends exhibited in the earlier section. The percentage of *loanee* farmers covered by mandatory insurance schemes continues to remain significantly higher than the demand generated from *non-loanee*, voluntary buyers of insurance.

It is important to identify precisely why the demand for crop microinsurance policies is low among voluntary buyers. This is not an easy task as demand for a product involves several intricate features that need to be effectively captured. While some households have a clear yes/no reason for investment in such products, there are an equally number of farmers who are unsure of whether such schemes are worth their time and money. Capturing this ‘doubtfulness’ is extremely significant in demystifying crop microinsurance demand. The third research question of the thesis explores the demand for voluntary crop microinsurance among small and marginal farmers in India.

All the research questions examined in this thesis require detailed household level data on agricultural input-output, risk attitudes and insurance experiences. While there is a slow-growing research in this space, access to such existing household level datasets is limited. Also, the data requirements of the dissertation in relation to both the impacts and demand study are quite specific. There is a need for data compiled using purpose-designed surveys in order to be able to effectively capture the demand and impact of crop microinsurance schemes.

Primary data is collected from two field sites in India for effectively examining the demand and impact of crop microinsurance in India. This data has been compiled solely for this thesis through extensive fieldwork. A combination of household survey questionnaires and detailed field interviews via focussed group discussions (FGDs) constitute an important component of this thesis. The process involved fostering several partnerships with international organisations, insurance companies as well as local institutions.

Apart from own primary data, the thesis also uses secondary, district data for analysis. Secondary level data on agricultural input-output and crop insurance is compiled using various sources and databanks in India.

The first research question examines the impact of crop microinsurance on agricultural output expressed in terms of productivity. The initial analysis is based on district level data from three Indian states insured under mandatory NAIS for paddy. Results are not conclusive and demonstrate the need for more specific, household level data across multiple crops for an effective assessment of the relationship between insurance and output.

The next part of the Chapter uses primary household data collected in two consecutive years from Howrah, West Bengal. The insurance product under study is a voluntary

WBCIS based insurance cover provided for two varieties of paddy crops grown in the region. Findings indicate that the insurance impacts productivity based on the nature of the input requirement portfolios of the respective crops. It also highlights the need to study individual inputs separately rather than estimate the net impact of insurance on all inputs via output. A two-step IV regression is used to account for the endogeneity of insurance purchase decisions.

The second empirical study of this thesis analyses the association between insurance and inputs. Impact of crop microinsurance on inputs such as seeds, fertilizers, pesticides, irrigation and hired labour are studied using a two-year primary household level data compiled from Howrah, West Bengal. The sample respondents comprise both insured and uninsured farmers. Rainfall index insurance under WBCIS is provided on a voluntary basis for two varieties of paddy crops cultivated in the district Since both insurance and input purchase decisions are made simultaneously at the beginning of the season, both two-step IV and simultaneous equation models are estimated for two varieties of paddy. Findings indicate that insurance affects crops either positively or negatively based on the flexibility of the crop's input structure and the relative significance of the crop in the income portfolio of the farmer.

The final research question of this thesis examines the gaps between the willingness to join (WTJ) and willingness to pay (WTP) for a hypothetical crop microinsurance scheme. Farmers who are aware of crop insurance benefits do not always purchase such market based formal risk management solutions and this Chapter aims to ascertain the factors driving this. A contingent valuation based experiment is conducted on a sample of small and marginal farmers in Erode, Tamil Nadu for this purpose. A Heckman selection model is used to estimate the results under a parametric approach. Results indicate that WTJ is driven by household wealth, product literacy and risk attitudes. The WTP analysis suggests *crowding-out* of *ex-ante* market based crop microinsurance in favour of alternative informal risk coping mechanisms available to a household.

While crop microinsurance demand and impact are important research questions, there are some factors that affect both these aspects in significant ways. These include microinsurance education, product specific knowledge, risk aversion levels and trust in the insurance provider and local institutions among others. Some of these themes are continually explored either implicitly or explicitly under different Chapters of this thesis. The manner in which information on some of these variables is elicited is described in the next Chapter.

The structure of this thesis is as follows. Chapter II elaborates on the field experiences and datasets used in the analysis. Chapter III presents the first research question on the impact of crop microinsurance on output measured by productivity. Chapter IV examines the second research question on the impact of crop microinsurance on agricultural input use. The final research question on the willingness to pay for crop microinsurance policies is analysed in Chapter V. Chapter VI presents the concluding remarks

Chapter II

Data on crop microinsurance in India

1. Introduction

The microinsurance research space is quite nascent. The sector has attracted academic attention only in the last decade following the exponential growth of this *ex-ante* market based risk management technique especially in Asia.

This dissertation focuses on the impacts and demand of crop insurance purchase decisions. The thesis aims to identify the impacts of crop microinsurance on both input and output. There is merit to estimating impacts at both household and aggregate levels. Measuring the impact of insurance at an aggregate level allows a study of how a potential risk management intervention benefits the overall community. For instance, one may observe that districts that experience historically lower yields are likely to buy more insurance. Alternatively, districts with greater insurance coverage may produce higher yields when compared to relatively less insured districts. A comparison at the aggregate level provides a macroeconomic perspective of how formal risk management interventions assist in district or state welfare.

However, aggregate data can prove limited in some cases. For instance, it fails to account for the individual and behavioural aspects that have a bearing on decision-making. This is more specific to the study of the impact of insurance on inputs, where household specific characteristics play a significant role. For instance, a household's risk preferences hugely impact its input choices. District level data cannot capture this variable at the aggregate level.

The demand analysis aims to examine the low demand for voluntary insurance products. This study is based on a contingent valuation experiment that has to be conducted in a field environment. This research question by itself is household specific and thus, requires individual level data for an effective analysis.

Thus, this thesis requires both aggregate and household specific data for a comprehensive analysis of both the impact and demand of crop microinsurance in India.

Specifically, the impact of crop microinsurance on output can be studied at both aggregate and household level. The impact of insurance on inputs may require a household specific dataset in order to incorporate the behavioural aspects of the analysis. The demand study is based on individual responses to a field experiment.

Secondary aggregate data is easily accessible for state and district level for agriculture input-output and insurance. This data is a useful starting point to assess the aggregate impacts of insurance on output at the district level. It will aid in unravelling the 'real' impacts of crop microinsurance at various levels of administration.

Few household level datasets are available in the public domain. Also, the data requirement for the impacts and demand studies are quite specific. Thus, this thesis undertakes extensive fieldwork to collect primary data using purpose-designed surveys and personal interviews with farmers. The eight months of fieldwork conducted provides not just robust household specific information but also general insights on farming practises in India, household's financial investment decisions and perspectives on local and Government support.

The fieldwork is focussed on two locations – Howrah in West Bengal and Erode in Tamil Nadu. The Howrah survey is conducted over two consecutive years in order to gather multi-season data on agricultural input-output and insurance. The Erode survey hosts the contingent valuation experiment under the demand study.

In line with some the additional themes identified by this thesis, the primary data solicits specific information on household perceptions of its poverty status, risk attitudes and trust in institutions. The definition and construction of some of these variables are also detailed in this Chapter.

This Chapter describes both the secondary and primary level data used in the thesis. The rest of this Chapter is organised as follows. Section 2 describes the secondary, district level data and Section 3 and 4 describe the primary data collection processes at Howrah and Erode respectively. Section 5 describes the construction of some important variables used in the analysis and Section 6 summarises the thesis's datasets.

2. District level data for three India states

The district level data is mainly useful in assessing the impact of crop microinsurance on output levels. This section describes the district level dataset used in this thesis. A brief description of the data heads and sources of data is provided here. The section also discusses the limitations of aggregate data and the need for primary data collection.

2.1 Description of the district level data

District level data is compiled using multiple secondary sources for three states in India - Andhra Pradesh (AP), Gujarat (GUJ) and Tamil Nadu (TN). Since the aim is to explore the relationship between output and insurance, the data includes detailed information on agricultural outputs, insurance coverage and performance as well as rainfall and soil measures. The data covers the period 2007-08 to 2009-10 i.e. three years. Seasonal data is available for each period.

All data relating to output and insurance is collected for paddy (rice). Paddy insurance coverage is provided under the National Agricultural Insurance Scheme or NAIS for all districts under analysis. The reasons driving the choice of crop, states and insurance schemes are elaborated in Chapter III. This Chapter only briefly highlights the available dataset, data sources and summarises the averages of key variables.

Before the description of the data heads, it is important to highlight the paddy producing seasons in the selected states. There are three possible cropping seasons for paddy production in India- autumn or Kharif, winter or Rabi and summer seasons.

Rice is cultivated for two seasons, autumn/Kharif and winter/Rabi, in Andhra Pradesh and three seasons, Kharif, Rabi and summer, in Tamil Nadu. In Gujarat, rice is primarily cultivated in only one season i.e. Kharif. Summer paddy is cultivated in less than ten districts mainly for subsistence reason in Gujarat. The months covering each season is defined in Table 2.1. Note that the cropping months differ across states.

Table 2.1: Paddy cropping seasons in selected states			
State	**Kharif or Autumn**	**Rabi or Winter**	**Summer**
Andhra Pradesh (AP)	July-November	December- April	No crop
Gujarat (GUJ)	July-December	No crop	No crop
Tamil Nadu (TN)	April-August	September-February	December-March

Source: Rice Knowledge Management Portal (http://www.rkmp.co.in/)

Data is available at the seasonal level for all districts under analysis. Also note that, there were two-three district bifurcations during the study period in the selected states. The data of these districts are merged and analysis is based on the political administrative units prevailing in 2007-08.

2.2 Secondary data on output, insurance and other variables

A description of the important data heads is now provided. Agricultural output data i.e. information of paddy production, area under cultivation and productivity at the district level was provided by the Ministry of Agriculture, Government of India[8]. The averages of these variables at the state-level are provided in Table 2.2. More information on the season-wise averages can be found in Sections 3 and 4 of Chapter III.

Table 2.2: State-wise annual averages for paddy output during the period 2007-08 to 2009-10					
Variable	**Unit**	**State-wise averages**			**Annual average**
		AP	**Gujarat**	**TN**	
Area under paddy	in Hectare	89485	43888	23195	46505
Production of paddy	in Tonnes	290935	79796	66229	138747
Yield of paddy	in Tonne/Hectare	3.05	1.71	3.56	3.19

Source: Ministry of Agriculture, Government of India

Agricultural insurance data is provided by the Agricultural Insurance Company of India (AIC), which is the largest and only public crop insurance company in the country. The insurance scheme is the NAIS, which is an area yield index based insurance policy. This data contains detailed information on insurance coverage, subsidies, sum insured and beneficiaries per season for paddy farmers in AP, GUJ and TN. Table 2.3 summarises these variables at the state level.

[8] Information on area, production and yield is readily available in the website of the Ministry of Agriculture, Government of India for all states and districts in the country. For more information, see http://eands.dacnet.nic.in/

Table 2.3: State-wise annual averages for insurance specific variables during the period 2007-08 to 2009-10					
Variable	**Unit**	**State-wise averages**			**Annual average**
		AP	**GUJ**	**TN**	
Number of farmers insured	Total number in '000	28377	4669	4066	14092
Area under paddy insurance	in Hectare	40596	7449	5929	20291
Sum insured for paddy	Rs. in '000	604622	104834	98735	306723
Premium collected for paddy	Rs. in '000	14515	2621	2040	7212
Subsidies received for paddy	Rs. in '000	1059	51	359	535
Claims made for paddy	Rs. in '000	16109	6873	14843	14570
Number of beneficiaries	Total number in '000	3497	1389	1479	2297
Proportional area covered	Area under insurance/ Area under paddy	0.44	0.09	0.16	0.24

Source: Agriculture Insurance Company of India

The secondary district level dataset covers *loanee* farmers only, i.e. mandatory buyers of paddy crop insurance only. Recall that there are two types of insured farmers in India - *loanee* or mandatory farmers and *non-loanee* or voluntary farmers. Mandatory insurance is bundled with the purchase of formal credit from public sector banks and other notified lending agencies. Not all *loanee* farmers are happy with the mandatory aspect of the scheme (Singh, 2010). In most cases, loanee farmers are not even aware that they are insured. There is also lack of clarity on claims processing. Similarly *non-loanee* farmers purchase insurance for selected crops only. It will be interesting to study how crop microinsurance influences output for mandatory buyers in this framework.

Other information collected includes monthly rainfall and soil fertility measures. Sources of these data sets are the Indian Meteorological Department (IMD) and the Indian Institute of Soil Sciences (IISS) respectively. Soil fertility data is provided via fertility maps indicating the nitrogen (N), phosphorous (P) and potassium (K) levels of the soil at district level through chloropeth maps. Information is also collected on significant national and state level schemes relating to paddy cultivation prevalent during the study period. Table 2.4 presents the sources of all variables available for the district level analysis.

Table 2.4: Sources of the district level data	
Area, production and yield of paddy	Ministry of Agriculture, India
NAIS Crop insurance data	Agriculture Insurance Company of India (AIC)
Paddy irrigation data	Ministry of Agriculture, India
Monthly rainfall	Indian Meteorological Department (IMD)
Soil fertility maps	Indian Institute of Soil Sciences (IISS)

Source: Compiled by Author

Other data heads that could be useful in the district level analysis include agricultural input variables such as fertilizer usage, pesticide usage, proportion of farmers using commercial seeds etc. Information on input usage is only available at the state level in the public domain. This data is not crop specific and only provides the total amount of inputs i.e. fertilizers, pesticides and commercial seeds consumed annually in Indian states. District, crop-specific data is only available for irrigation. More information on this is provided in Section 3 and 4 of Chapter III.

Also, addition of other states in the district level analysis was not possible due to the restricted availability of insurance data. The specific issues are highlighted in Section 3 of Chapter III.

2.3 Moving beyond district level data

The district level data is quite informative in terms of both insurance and yield. It provides an aggregated perspective of insurance and agricultural dynamics. It helps understand how insurance collectively affects all households in different districts of the country.

However, as discussed earlier, it does not account for individual socio-economic environments, attitudes and preferences that are important factors that affect both *ex-ante* insurance demand and *ex-post* behaviour.

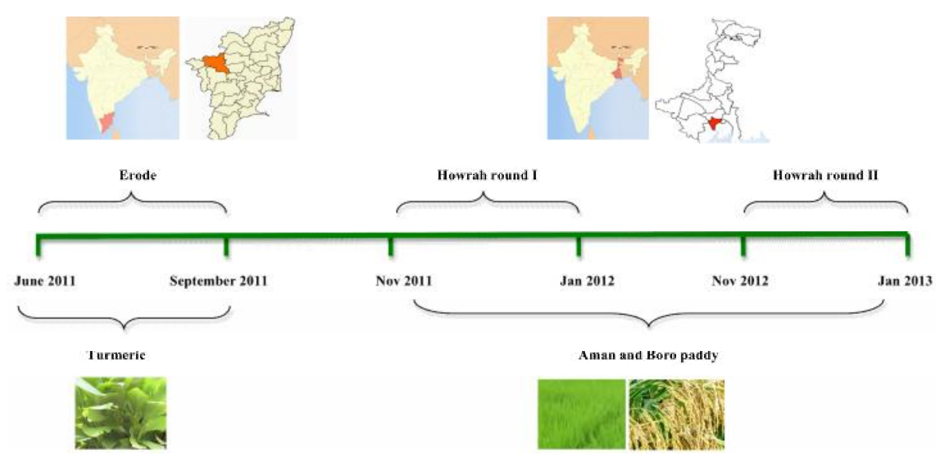
Failure to account for individual household and behavioural dynamics creates a huge bias in the analysis for several reasons. An insurance purchase decision is essentially a risk management 'choice'. These choices depend on individual behavioural traits as well as circumstances including past experiences. Similarly, the impact of insurance on agricultural input-output depends on the cultivation histories of the individual households and their risk aversion levels among others.

There is a need for robust household level data to effectively assess both the demand and impact of insurance. However, household level datasets relating to crop insurance in India are quite scarce. Individuals and institutions that research in this space are not very forthcoming when it comes to data sharing. Since the field is still in its initial growth phases, most of the research is on-going and/or researchers aim to return to their project sites to update data for future research.

Primary data is compiled solely for the purpose of this thesis. The fieldwork and primary data collection constitute an important part of this thesis. Apart from formal data collection through survey questionnaires, fieldwork also enables personal interactions with local individuals and institutions. These focussed group discussions (FGDs) and personal interviews with select farmers can provide valuable insights on the living conditions and agricultural challenges in the area. These factors play an important role in interpreting and/or supplementing the findings of econometric primary data analysis.

Fieldwork is undertaken in two locations over a two-year period. The locations are Howrah, West Bengal and Erode, Tamil Nadu. The Howrah survey is implemented over two consecutive years for examining the impacts of insurance on input and output. The Erode survey collects information on the demand for crop microinsurance policies. The timeline of the fieldwork undertaken for this thesis is provided in Figure 2.1.[9]

Figure 2.1: Timeline of the fieldwork undertaken during this thesis



Source: Author

The next sections describe the institutional framework and a description of the data collected from Howrah and Erode respectively.

[9] The questionnaires of both surveys can be provided on request

3. Primary data collection in Howrah

The questions relating to impact assessments can ideally be answered using at least two seasons or years of data. A preferred sample would comprise both insured and uninsured farmers with a basic knowledge of insurance mechanisms. The insurance product under study needs to be a legal, Government recognised scheme offered in India by either AIC or a private insurance provider.

The next sub-sections describe the institutional set up of the two-year survey and present a description of the dataset.

3.1 Institutional framework at Howrah

As an individual researcher, it was difficult to secure the partnership of an insurance company for a multi-period study. An alternative was to find an on-going research group, where one could contribute to the overall research as well as secure data for this thesis. Such a set-up was identified in a field site based in Howrah, West Bengal. This field site became the source for household level data for the impact assessment of insurance on input and output.

The institutional composition of the Howrah survey is as follows. The data collected in 2011 was a part of larger ILO-funded[10] project on crop insurance in India undertaken by three institutions, namely the Centre for Insurance and Risk Management (CIRM), ICICI Lombard and Weather Risk Management Services (WRMS). CIRM[11] is an independent microinsurance research organisation, ICICI Lombard is a private insurance provider and WRMS[12] is an intermediary insurance product design and agro-services agency, all based in India. As a Consultant to CIRM on the survey design and execution, the author was able to easily access the 2011 dataset. This project culminated in early 2012, though ICICI Lombard continued to provide insurance in these areas. WRMS is also active in the district and provides vital product design and administrative support to insurers.

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[10] The International Labour Organisation's specialised unit called the 'Microinsurance Innovation Facility' provided funding for the 2011 study. For more information, see http://www.microinsurancefacility.org/

[11] For more information, see http://www.cirm.in/

[12] For more information, see http://www.weather-risk.com/provider.aspx.

In mid-2012, formal permission was received from the ILO to return to the project sites for a follow-up interview. All organisations involved in the former project extended full support during the follow-up survey.

Clearly, the choice of field site in this case was purely based on the availability of suitable partners who could accommodate the research questions identified by this thesis. However, the selected field area proved to be an ideal location. The locals in the region had sufficient insurance experiences and the product provided by ICICI Lombard provided a comprehensive coverage against rainfall risks in the district. In impact studies, the insurance product offered plays an important role. Incompatible, complex products that do not cater to the actual risks faced by farmers in the area are not likely to encourage farmers to improve cropping practices or secure higher yields.

In the first round, the questionnaire was developed in association with CIRM and WRMS. The second round's questionnaire contained inputs from ILO. The survey questionnaire solicits information on socio-economic features of the household, crop-wise agriculture input-output data, risk preferences, attitudes and experiences with crop insurance.

WRMS played a significant role in identifying insured and uninsured households for the data collection process. The organization has extensive fieldwork experience in Howrah region and comprehensive management information system (MIS) databases on insured and uninsured (potential clients) farmers with detailed address and contact information. Using the MIS database, all villages in Howrah containing at least one insured household were selected. From the identified 11-12 villages, a random sample of insured households and a matched sample of uninsured was drawn. The matching was based on household income, main occupation, land under cultivation and age of household head. The sampling design was jointly developed by CIRM and WRMS for the first round and the same households were interviewed in the second round.

During both rounds, Sigma,[13] a local institution, offered intensive field support for the study. As part of their role, Sigma translated the questionnaires into the local language (Bengali), identified enumerators and executed the survey and data entry. Sigma provided five enumerators and one supervisor who were fluent in both English and Bengali. The enumerators executed the survey questionnaire, while the supervisor accompanied one enumerator each day to oversee the data collection process. Sigma oversaw the workings of both the enumerator and supervisor and provided daily progress reports on the data collection.

A three-day induction programme was organised for the enumerators and supervisor at Sigma's premises in Howrah to train them on the questionnaire and data entry processes. This also helped enumerators clarify any doubts regarding specific questions in the survey instrument and on the data collection process in general. The enumerators were also introduced to the WRMS staff to facilitate respondent identification. These activities were carried out during both rounds and the same enumerators were recruited in 2011 and 2012. This was a huge advantage as household identification, which was quite crucial in the second round, was easier.

A pilot survey was conducted prior to the actual data collection process during both rounds. This provided enumerators with a practical experience of interacting with farmers. It also helped in the identification of problematic/unclear questions in the survey instrument. Some of these questions were re-framed before the actual data collection began.

Since this study was supported by multiple organisations with specific roles, a diagrammatic representation of the institutional structure of the primary data collection at Howrah is provided in Figure 2.2

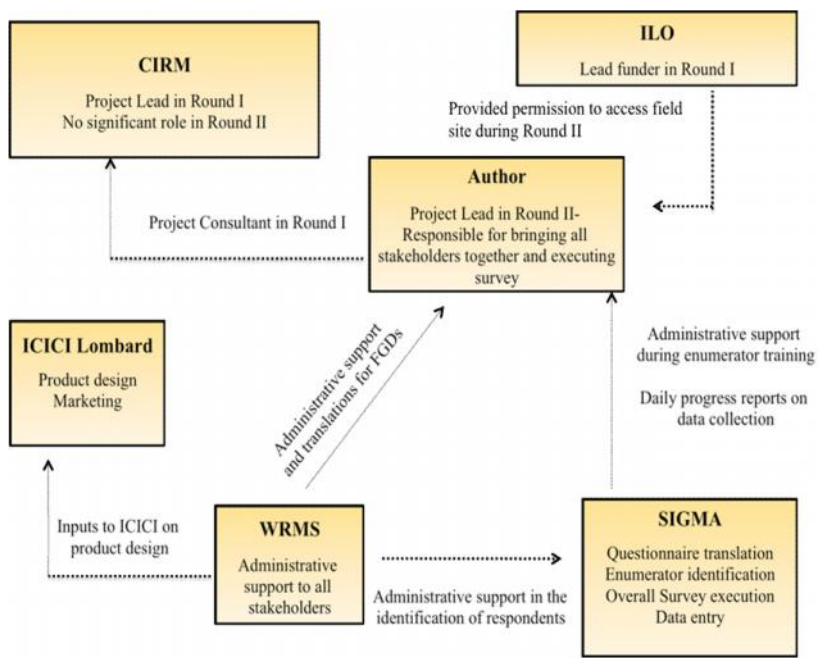
The entire fieldwork process was organised during Nov-Jan 2011 and Nov-Jan 2012. The dates mentioned are inclusive of enumerator training, pilot survey, data collection and data entry. The questionnaires were developed prior to this period in each case. Each questionnaire interview lasted 30-45 minutes. The respondent of the survey is the

[13] For more information, see http://www.sigma-india.in/

household head and s/he provided information on the income, agricultural land and cultivation patterns of the household. More information on the data collected is provided in the next sub-section.[14]

Parallel to the data collection process, focused group discussions were also organised in four villages. Each discussion typically comprised 8-10 local insured and uninsured farmers who shared their ideas during a 45-60 minute meeting. Around four discussions were organised during each round of data collection. WRMS provided ample support with both farmer identification and selection of the locations where the discussions were conducted. A WRMS staff was present during the discussions to help with translations. These meetings played a significant role in the interpreting the findings of the regression analysis.

Figure 2.2: Institutional set up and role definition for the Howrah survey



Source: Author

[14] ILO funded the first round of data collection in 2011. The follow-up study in 2012 was funded by several sources within the University of Sussex.

3.2 Description of the Howrah dataset

The main purpose of this dataset is to understand the association between insurance and agricultural input-output at the household level i.e. for Chapter III and Chapter IV.

Howrah is situated in the south of West Bengal and receives an annual rainfall of 1100-1500 mm. Paddy, potato and other vegetables are the major crops grown in the district. Two main varieties of paddy are produced -Aman and Boro. The former is harvested in the winter and the latter is harvested in early summer. Insurance is provided for both crops on a voluntary basis under the Weather Based Crop Insurance Scheme or WBCIS Primary data is collected from small and marginal paddy farmers using a purpose-designed survey during two consecutive years. This unbalanced panel data follows 422 households in 2011 and 402 households in 2012. Due to budgetary constraints, follow-up interviews were not conducted for 20 households in 2012. The survey follows both insured and uninsured farmers of both Aman and Boro paddy during 2011 and 2012.

Table 2.5 provides a brief description of the households under study. Agriculture is the main occupation, though 90% of households earn more than one source in 2012. The respondents were mostly male, around 45 years of age on average.

Table 2.5: Sample averages of relevant socio-economic variables collected in the Howrah survey

Variable	Description	Sample means	
		2011	2012
Sample size	Number of households surveyed	422	402
Insured for Aman	in percentage	43	34
Insured for Boro	in percentage	21	19
Age	in years	46	45
Household size	Number of members in the household	5	5
Gender	Male=1, female=0	0.77	0.77
Primary occupation	Agriculture=1, others=0	0.80	0.62
Secondary occupation	Have a secondary occupation=1, otherwise=0	0.64	0.91
Annual income	in INR	37745	57545

Note: Sample size for 2011 is 422 and for 2012 is 402. Baring a few households, the enumerators managed to interview the same respondent during both rounds. The individual characteristics such as age, gender and education pertain to the survey respondent, i.e. the household head. Information relating to income, agricultural land and cultivation patterns is provided for the total household. Annual income includes farm and non-farm sources.

Though Aman and Boro are paddy (rice) crops, there are very different from each other in many ways. Aman, grown in the autumn, is used for both subsistence and commercial reasons and has a lower cost of cultivation. Boro, grown in the winter, is a commercial crop that provides very high yields. It is an intensive crop with specific input requirements and thus incurs a higher cost of cultivation. The other differences between the two crops are highlighted in both Chapter III and Chapter IV.

The insurance product provided to the farmers under study is a voluntary weather index based product (WBCIS). Since the insurance is purchased by choice, it is likely to impact the farmer's production choices i.e. both input and output. Also, the data covers both insured and uninsured farmers, which makes the impact assessment more reliable.
Apart from the questionnaire, personal interviews were also conducted during field visits in both 2011 and 2012. The farmers in Howrah were quite open to speaking about their issues and challenges. More information is provided in Chapter IV.

It would have been useful if household data could also be collected from *loanee* farmers to evaluate their awareness and risk aversion levels. However, household level information on mandatory buyers of insurance requires MIS data from insurance companies. Detailed information on names and contacts of mandatory farmers and the specific banks from which they acquired crop loans is essential for the identification of sample households for survey. Such information is not available for public access. Despite several efforts and negotiations with insurance companies, databases on individual mandatory farmers could not be retrieved.[15]

4. Primary data collection in Erode

The final research question of this thesis identifies the factors contribution to the demand for insurance policies. The analysis here involves a contingent valuation experiment on individuals with limited insurance experience.

The institutional set-up and data collection process at Erode is described in the following sub-sections.

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[15]Only district level aggregate information on mandatory buyers was provided by AIC, a description of which is presented in the above sections of this Chapter. Detailed MIS data on voluntary buyers is also not available in the public domain. The Howrah study is a part of a much larger effort funded by the ILO involving multiple stakeholders. The fact that the author was a Consultant to the project was the only reason why this thesis has access to the MIS information for both rounds of the survey.

4.1 Institutional framework at Erode

The support of a local field institution was necessary to identify samples, conduct the experiment and execute the questionnaire. Some useful contacts at the Tamil Nadu Agricultural University (TNAU)[16], a government aided agricultural academic and research institution, helped establish a strong field network for this study.

The guidance of TNAU aided in negotiating with local institutions across the country that could collaborate for this study. Following several discussions, a suitable partner was identified in Myrada, an NGO in Erode, Tamil Nadu.[17] The organisation serves as a Krishi Vigyan Kendra (KVK)[18] for the Government and is thus, in regular contact with farmers in the district. The organisation provided immense support in the identification of sample households and enumerators along with questionnaire translation.

Before the survey execution, it was important to ensure that the field area was a good fit for the contingent valuation experiment. Groups of local farmers were interviewed to assess their agricultural challenges, insurance experiences and openness to participate in the survey. These weeklong discussions, with small and marginal farmers in this district, revealed that farmers in these areas face a variety of risks and limited risk coping mechanisms. They also displayed sufficient cognitive ability to effectively contribute to the bidding game.

The interactions with locals played a significant role in the development of the survey questionnaire, specifically in the construction of the contingent valuation game and post elicitation questions. The final questionnaire was translated into the local language (Tamil) by senior staff at Myrada.

Based on the initial interactions, villages in which farmers had had little or no exposure to weather index-based insurance products were purposefully selected. In each village, all available (on the day the field researcher visited) turmeric farmers were interviewed.

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[16] For more information, see http://www.tnau.ac.in/

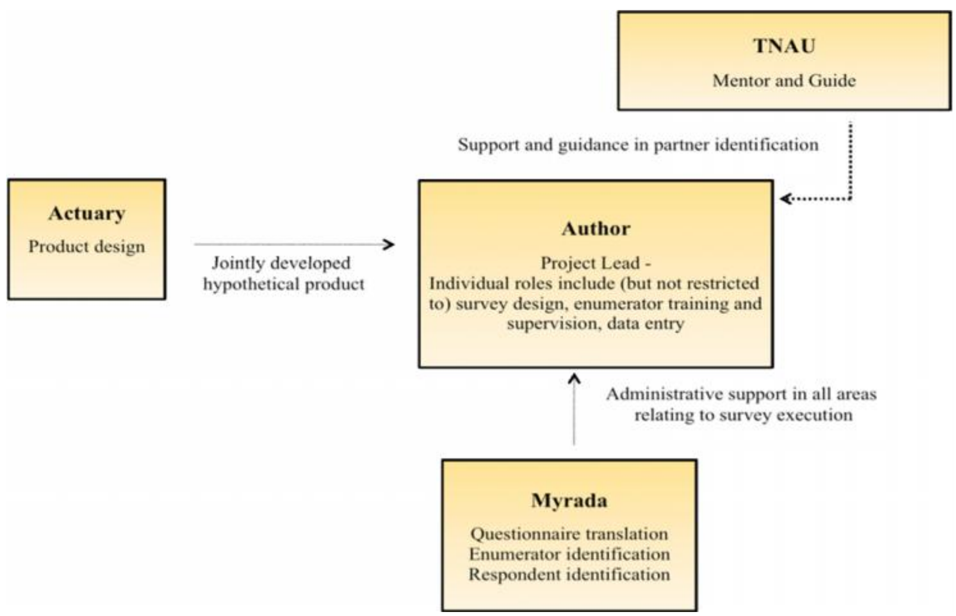
[17] For further details, see http://myrada.org/myrada/

[18] KVKs are front line agriculture extension centres funded by the Indian Council of Agriculture Research (ICAR). They partner with local institutions such as NGOs to provide agriculture extension and cater to the training needs of local farmers.

Five employees of Myrada, who were proficient in both English and Tamil, played the role of enumerators for the survey. They comprised senior members of the self-help groups monitored by Myrada, which ensured that samples were easily identified and that they reported accurate information.[19] The enumerators were supervised on a daily basis by the author. Akin to the Howrah survey, the respondent of the survey is the household head and s/he provided information on the income, agricultural land and cultivation patterns of the household.

The enumerators underwent two-day training at the Myrada head office premises in Erode. A pilot survey was also conducted prior to the actual data collection process to ensure that the contingent valuation bidding game was smoothly executed.

Figure 2.3: Institutional set up and role definition for the Erode survey



Source: Author

An important component is the underlying product for which demand is elicited. Several insurance companies in India were contacted to secure partnership and product design support for the field survey. Most of these talks failed as insurers were not keen

[19] Each enumerator was given a target of 80 interviews. They were assigned different locations within each block to ensure there was no duplication.

to associate with a small-scale data collection process. Alternatively, they were also not willing to contribute to the funding to increase the number of observations under study.

Thus, a formal insurance product is replaced by a *hypothetical* scheme to evaluate a household's response and willingness to pay for *ex-ante* risk management techniques. This hypothetical product is based on the excess rainfall WBCIS scheme and was developed using the assistance of an insurance actuary. The insurance product was developed along the lines of formal schemes. Further information is provided in Section 3 of Chapter V. The institutional set up of the Erode survey is provided in Figure 2.3.

The survey was executed in the summer of 2011 over a four-month period, which included partner identification, questionnaire design, survey execution and data entry. Each questionnaire was filled in 15-25 minutes. The author executed data entry. Section 4.2 below elaborates further on the data collected.[20]

Focused group discussions were also organised in three locations. Each discussion consisted of 10-15 farmers who interacted over a 30-45 minute period in each case. A local staff of Myrada provided administrative and translation support. The findings from these discussions played a huge role in understanding the factors that impede crop microinsurance participation. Chapter V provides the details.

4.2 Description of the Erode dataset

This sub-section elaborates on the data collected in Erode, Tamil Nadu during 2011. The dataset is mainly used to assess the factors impeding the demand for crop insurance policies in the Indian context. Chapter V of this thesis presents the findings.

Erode is a district located in the northern part of Tamil Nadu. It is particularly famous for its turmeric production, with an average annual cultivated area of around 6000 hectares. Agriculture is the major occupation in these areas and major crops grown include turmeric, sugarcane, banana and cotton.

[20] The entire field work was self-funded in this case

Primary data is collected using a purpose-designed survey from 400 small and marginal farmers in Erode district. The survey is concentrated in two blocks within the district, namely Andhiyur and TN Palayam. Around 200 households are interviewed in each block by the enumerators.

The survey questionnaire collects information on socio-economic features of the household, crop-wise agriculture input-output data, risk preferences, attitudes and experiences with crop insurance. The survey then presents a contingent valuation scenario and elicits a household's willingness to participate in and pay for insurance programmes. As part of the fieldwork, focused group discussions (FGDs) were also organised to understand the locals better.

The basic socio-economic variables are described in Table 2.6. Most of the respondents are male with an average age of around 44 years. Agriculture is the main source of income in both blocks, though annual incomes are higher in TN Palayam.

Table 2.6: Sample averages of relevant socio-economic variables collected in the Erode survey

Variable	Description	Sample means		
		Total sample	Andhiyur	TN Palayam
Sample size	Number of households surveyed	400	200	200
Age	in years	44	42	46
Household size	Number of members in the household	4	5	4
Gender	Male=1, female=0	0.88	0.90	0.85
Primary occupation	Agriculture=1, others=0	0.99	1.00	0.98
Education	High school or higher=1; otherwise=0	0.63	0.59	0.68
Annual income	in INR	179197	103162	254849

Note: The individual characteristics such as age, gender and education pertain to the survey respondent, i.e. the household head. Information relating to income, agricultural land and cultivation patterns is provided for the total household. Annual income includes farm and non-farm sources.

While the secondary data and Howrah study focus on paddy, this study conducts an experiment on turmeric, a cash crop. It is one of the major crops produced and an important component in an Erode farmer's income portfolio. Turmeric is subject to several cropping risks, including high rainfall. While the overall requirement of turmeric is high at an annual average requirement of 1500 mm, consecutive daily heavy rainfall and subsequent water stagnation completely corrode the root crop. Accordingly an excess rainfall indexed, hypothetical weather contract is provided to farmers to assess their willingness to pay for insurance.

The respondents under this survey had limited insurance knowledge, having been exposed to mandatory NAIS experiences only. There is also poor institutional support in these areas with very few NGO and MFI operations in place. Some of the respondents used the FGDs as a training ground to understand insurance dynamics and product types. Thus, conducting a contingent valuation study using a hypothetical product was an interesting experience.

The next section provides a description of some common variables collected under both surveys. These variables capture perceptions and risk attributes of households that are likely to affect both demand and impacts.

5. Individual risk attitudes and preferences

The primary data collection in both Howrah and Erode is based on a purpose-defined survey instrument. While the overall construction of both questionnaires is different to incorporate the impact and demand aspects, the surveys solicit similar information on the household risk attitudes and preferences.

The inclusion of variables that capture risk aversion, insurance trust and household's perceptions is important for both the demand and impact studies. These variables capture individual specific attributes that affect purchase and behavioural decisions of the household. The variables are also in line with some additional themes identified by this thesis as explained in Chapter I.

This section elaborates on some of the data collected in this context and their relevance in the analysis. Note that all the variables highlighted below are not necessarily used in the regressions. However, they all lend reliability to the analysis and findings in specific ways.

5.1 Mathematical literacy

Both the surveys elicit the mathematical literacy levels of the respondents through some basic arithmetic exercises. The main aim of these exercises is to check the education levels and understanding abilities of the respondent. The relevant questions are presented in Box 2.1.

Box 2.1: Testing the mathematical literacy of the respondent
1. If a coin is flipped, what is the chance of getting heads or tails? (1= equal chance; 2= any other answer) 2. Say True or False (Code responses as follows: 1= True; 2= False) • 4+3 =7 • 3 X 6 = 18 • 1/10 of 400 is 40 • 15% of 200 is 30

The surveys contain detailed sections on insurance awareness and experiences levels. It is important to ensure that the respondent displays a basic logical skill set so that his/her answers to the survey can be considered credible for the analysis.

Testing mathematical literacy levels of respondents is more crucial for Chapter V, which deals with a hypothetical insurance product and a contingent valuation experiment. In both surveys, respondents exhibited high arithmetic skills. This lends credibility and validity to survey responses and the analysis.

5.2 Household's perception of poverty status

The demand for and/or impact of insurance schemes also depend on a household's own perception of its standing among the other households in the village. For instance, Morduch (1995) finds that households whose consumption levels are close to subsistence devote a larger share of land to safer, traditional varieties rather than to riskier, high-yielding varieties. Similarly, Dercon (1996) observes that households with limited liquid assets such as livestock grow proportionately more sweet potatoes, a low-return, low risk crop in an area in Tanzania. Also, Bendig et al. (2009) find that households that believe they are more vulnerable to risk prefer not to use any financial services.

This means that a household's assumption of its economic conditions influences not just cultivation patterns but also demand for financial services. To some extent, these perceptions also represent peer-effects and responses of the household to the behaviour of other individuals in the community. For instance, a household that considers itself poorer than its neighbours/friends may not necessarily be motivated to purchase a certain product that the latter has invested in. Similarly, a household that considers itself richer than other inmates in the village may be more willing to use insurance as a means to engage in better input investments.

The question asked is presented in Box 2.2. Based on the responses, a variable called 'think poor' is created that takes a value one if the household considers itself poorer than other households in the village and zero otherwise. The responses are presented in Chapter IV and V.

Box 2.2: Testing household's self-perception of poverty status
1. How well off do you consider your household in comparison to other households in your village? Codes for documenting the responses: Much richer =1; Richer=2; The same=3; Poorer =4; Much poorer =5 Resultant variable termed 'think-poor' is coded as: 1= if responses are 4 or 5 and 0= if responses are 1, 2 or 3

5.3 Risk attitudes

Measuring risk attitudes is an important component in assessing both demand and impact of insurance products. Though there are several ways of measuring this variable, this thesis uses the approach followed by Cole et al. (2008) in their estimation of insurance demand.

A Binswanger (1980) game was used to capture the risk aversion levels.[21] The respondent was provided with the following scenario. A coin is tossed and there are three types of pay-offs associated with it: (a) INR 50 for heads and INR 50 for tails (b) INR 40 for heads and INR 120 for tails and (c) INR 0 for heads and INR 200 for tails. The respondent is asked to choose the bid s/he is likely to play for. Choice (a) indicates

[21] The first Binswanger experiment was conducted in India in 1980. The same pay-offs have been use for this thesis. Note that at the time of the survey £1 =INR 78.

extreme risk aversion, (b) is associated with intermediate risk preference and (c) shows risk preference.

Table 2.7: Calculation of the Risk aversion index			
Lottery	**Expected Value (E)**	**Standard deviation (SD)**	**Risk aversion measure (aE/aSD)**
(50, 50)	50	50	1
(40, 120)	80	40	30/40 = 0.75
(0, 200)	100	100	20/60 = 0.33

Source: Author's calculations based on Cole et al. (2009)

The expectation and standard deviation of each bet is calculated and the risk aversion index is defined the change in the expected value divided by the change in the deviation i.e. $\Delta E/\Delta SD$. In other words, it is the rate at which the household is ready to take up additional risk. Note that higher the index, higher the risk aversion. This measure has been used in the econometric analysis of the impact as well as demand studies.

5.4 Trust in the insurance provider

Trust in the insurance provider is an important variable that may affect insurance markets. A household's faith in the insurance provider could stem from different sources. For instance, positive past claim experiences of either the household or peers increases trust in the provider. Similarly, immediate and constructive responses from the insurance company in case of grievances encourage renewals. If the agent that sells the product is known in the community, more households are likely to invest in the insurance product. On the other hand, poor claim experiences or negative feedback from peers or neighbours is a deterrent.

A household's reliance on the provider is elicited by directly questioning the household if it trusts the insurer or not. The variables take the value one if the household trusts the insurance provider and zero otherwise. This variable has been used as a covariate in Chapters III, IV and V to determine insurance purchase decisions.

6. Summary

This Chapter presented the details of the datasets available to this thesis. Apart from secondary district level data, primary data is also collected from two field sites in India. A summary of the datasets and their use in this thesis is provided in Table 2.8

Table 2.8: Summary of the thesis's datasets

S.No	Dataset	Source of data	Crop(s)	Insurance scheme	Data usage
1	District level data	Secondary data collected from several sources	Paddy	NAIS	Chapter III
2	Howrah	Primary data collected through field work	Aman and Boro rice	WBCIS	Chapter III and IV
3	Erode		Turmeric	WBCIS (hypothetical)	Chapter V

Source: Author

Primary data collection involved extensive fieldwork of over eight months in different parts of India. The fieldwork offered rich experiences in project management and enhanced local knowledge. The liaisons with multiple local, national and international agencies presented a solid grounding for compiling a robust primary dataset. The negotiations with these agencies provided useful lessons in project initiation, contractual regulations, relationship management and reporting.

The fieldwork experiences and interactions with local farmers in two different parts of the country provided perspective on the challenges faced by low-income households in the country. Farmers face substantial problems in agriculture with hurdles at every step of the production process. The field discussions were essentially a forum for these households to share their thoughts on pursuing agricultural occupations and the support they require from individual and institutional sources to secure better income levels.

The datasets compiled by this thesis are unique in several ways. Some of these features include:

- Use of both primary and secondary datasets
- Use of both district level and household specific information
- Coverage of both mandatory or *loanee* and voluntary or *non-loanee* insurance buyers

- Coverage of both National Agricultural Insurance Scheme (NAIS) and Weather Based Crop Insurance Scheme (WBCIS)
- Usage of both real-time and hypothetical insurance products

This is a distinctive framework that incorporates most of the singular features of the Indian crop microinsurance sector in the analysis. The use of both district and household data will help evaluate how individual specific effects average out at an aggregate level. The inherent differences in how insurance is perceived among mandatory and voluntary buyers of insurance will unravel in the study of both *loanee* and *non-loanee* farmers. Coverage of NAIS and WBCIS schemes will be useful in identifying if and how usage of area yield indexed and weather indexed products vary across states. While the impact analyses are based on real-time products offered in the market, the demand study relies on a hypothetical product. The use of a hypothetical insurance for the demand study allows developing an efficient, simple product that responds to the risk needs of the community. This also ensures that the sample households and enumerators understand the product features easily and the contingent valuation bidding game is implemented effectively.

The next three Chapters of this thesis use the data presented here to provide an empirical analysis of the research questions put forth in the Chapter I.

Chapter III

Impact of crop microinsurance on the agricultural productivity

1. Introduction

Crop cultivation is subject to a variety of risks and uncertainty resulting in substantial losses. While some losses are easier to manage, some others may cause structural transformations in the occupation and lifestyle patterns of the household. In order to minimise losses, subsistence farmers prefer to cultivate using traditional methods to ensure an average level of productivity. There is an inherent unwillingness in adopting new techniques that comes from greater reliance on conventional methods. There is also an apprehension of incurring higher losses by investing in better quality inputs that are considered as 'higher risk, higher returns' investments.

Crop microinsurance could play a catalytic role in this scenario. Microinsurance is a formal, market based risk coping strategy that is primarily aimed at enabling farmers to deal with weather vagaries and other downside production risks. Formal insurance is an *ex-ante* risk management technique, i.e. investment is made in advance of the season in the anticipation of possible shocks. It is generally purchased at the beginning of the cropping season when input investments are also made.

Though crop insurance claims come to play at the end of the season only, the guarantee of having secured a hedge against possible risks may motivate a farmer to alter his/her crop cultivation practises. It could provide a necessary cushion against the 'higher risk' factor and enable farmers to experiment with newer technology in agriculture, leading to purchase of higher quality inputs or use of *riskier* techniques in cultivation. This is referred to as a risk reduction effect.

Alternatively, the presence of crop insurance may foster a moral hazard impact. An assurance of compensation against low yield may influence farmers to reduce the amount of investments made in inputs. For example, a farmer may choose to reduce the number of fertilizer applications. Or s/he may choose to apply manure (which is cheaper and easily available) instead of chemical fertilizers (which is costlier). Any potential production losses that occur could be covered using crop insurance claims. The extent of moral hazard also depends on the nature of the insurance product and the coverage offered.

Both these potential choices could have a bearing on output measures such as production, productivity or acreage. Investing in better inputs could increase production levels or more significantly, the production per unit area under cultivation termed as yield. Moral hazard may result in lower output. Apart from this, crop insurance could also affect acreage levels. It could lead to greater cultivation of the insured crop.

There is a considerable interest in exploring if and how insurance could impact output levels. There is a significant pool of literature on the associations between crop insurance and agricultural output. Most of the literature in this area has focussed on the US federal insurance schemes. The unit of study is either county level or farm level.

The Indian insurance sector presents a unique scenario. Crop insurance is offered by both public and private insurance companies on a mandatory as well as voluntary basis. Mandatory insurance, offered to *loanee* farmers, is bundled with agricultural credit availed from public sector banks in rural areas. Voluntary insurance is offered to all other farmers i.e. *non-loanee* farmers. Clearly, the effects on output could vary based on the nature of insurance. Mandatory insurance represents a demand for credit rather than formal risk coping mechanisms. Voluntary insurance, on the other hand, is a tangible demand for *ex-ante* market based risk management strategies.

It is imperative to study the effect of both mandatory and voluntary insurance on output. It is also useful to consider the currently operational schemes in the country such as the National Agriculture Insurance Scheme (NAIS) and the Weather Based Crop Insurance Scheme (WBCIS). In order to effectively incorporate all the above components, this Chapter proposes to study mandatory buyers of NAIS and voluntary purchasers of WBCIS. Please note that both policies are offered to *loanee* and *non-loanee* farmers i.e. NAIS is also offered on a voluntary basis and WBCIS could be bundled with formal credit on mandatory basis. However, the choice of only studying mandatory NAIS and voluntary WBCIS relates to data availability, which is elaborated on in the later sections of this Chapter.

This study is one of the first attempts to study the relationship between crop insurance and output for both mandatory and voluntary buyers of such schemes. Apart from examining how insurance impacts output, the study of *loanee* and *non-loanee* farmers will also help address some additional themes mentioned in Chapter I. For instance, it will promote an understanding how microinsurance awareness and product specific knowledge varies among mandatory and voluntary buyers. The differences in risk aversion, insurance and institutional level trust could also be captured.

Similarly, the use of both aggregate level and household specific data has some benefits. The dynamics that is present at the most localised unit, i.e. household level, may average out at an aggregate level. Alternatively, the emerging findings from household surveys could be biased due to the choice of sampling and an analysis of the entire geography may indicate a different effect. Thus, it is important to evaluate impacts at both the individual and aggregate level to help underpin how the impacts of crop microinsurance vary across different levels of administration.

The analysis is organised in two phases. The first phase examines the effect of insurance interventions on output using district level NAIS data for mandatory buyers in a single crop insurance framework. The fact that crop insurance is a purchase decision that precedes output is accounted for using a two-step instrumental variables (IV) approach. However, findings are not conclusive here due to several factors that are discussed in detail in the later sections of this Chapter.

In the light of the limitations of aggregated datasets, the second phase uses primary data collected using fieldwork to analyse the impacts of insurance on output. This household level dataset focuses on WBCIS schemes provided to *non-loanee* farmers on a voluntary basis. The household survey sets the analysis in a multi-crop framework, where insurance is provided for more than one crop. It allows an analysis of how different individual specific characteristics such as trust in local institutions, risk aversion etc. impacts insurance and output levels.

Findings from a two-step IV analysis indicate that the impact of insurance on output is not homogeneous across crops. Insurance interventions affect crop outputs either positively or negatively based on the flexibility of the crop’s input requirement structure. There is a need to study how insurance impacts specific input variables rather than measure the net impact of all inputs via output levels. The study also highlights the advantages of using a household level data over aggregated district measures to analyse insurance impacts.

The rest of this Chapter is organised as follows. Section 2 presents a review of the existing literature. Section 3 and 4 describe the district level data. The econometric methodology and results for the district level analysis are provided in Sections 5 and 6. The household level analysis is introduced in Section 7. Also presented in this section are the descriptive statistics relating to the household data. Section 8 details the results from the household level study and Section 9 presents the conclusion.

2. Literature review

There are a sizeable number of studies that have looked at the impact of crop insurance on output. Using output as a measure to study the impact of insurance on agriculture is preferred due to various reasons. Quiggin et al. (1993) suggest that data on output is more reliable than the data on inputs. If insurance alters the allocation and usage of inputs, this is likely to reflect in the final output as lesser inputs will reduce the probability of high acreage and vice versa. Also, input requirements vary across crops and geographies. Thus, output is a standard measure against which the effectiveness of insurance schemes can be measured across crops.

It is important to define the output measure. Agricultural outputs could relate to acreage, production level or productivity. Other variables assessed include different measures of diversification and loan disbursements. The choice of output depends on the specific research questions of the study and data availability. The use of productivity, defined as production per unit area under cultivation, is more common as it normalises production per unit area and provides a homogeneous base for comparison across crops.

Literature that measures output in terms of either production or productivity include Quiggin et al. (1993), OECD (2006), Larson and Plessmann (2009), Woodard et al. (2009), Miao et al. (2011) and Spörri et al. (2012). Studies that examine output effects using acreage include Young et al. (2001), Rejesus and Lovell (2003), Goodwin et al

(2004), Chen (2005) and Walters et al. (2012). Literature on diversification includes Goodwin et al. (2004), O'Donoghue et al. (2009), Chang and Mishra (2012) and Varadhan and Kumar (2012).

In terms of datasets, the initial literature in this space uses county or district level data for analysis. Though these studies form some of the important references for work in this area, they have been critiqued on the use of aggregated data as it fails to capture individual behavioural attributes such as risk aversion, insurance awareness, product understanding etc.

This literature review is divided into three parts. The first part presents work on the impact of insurance on output measures at the district level and the second part focuses on the farm/household level data. The final section discusses some of the literature in the light of the data available for this Chapter and the dynamics of the Indian insurance system.

2.1 Literature based on district level analysis

The literature using county level data to explore the impact of insurance on output mostly focus on the US federal crop insurance policies. The analysis is based on econometric modeling, simulations or mathematical optimisation techniques. The findings of the literature are mixed, with some showing a positive, risk reduction effect and other showing a moral hazard impact.

For instance, Goodwin et al. (2004) identify that increased participation in crop insurance programs is correlated with additional acreage for corn/soybean and wheat/barley farmers using a nine year county level panel data for the US federal insurance. A two-stage IV (GMM) fixed effects approach is used to account for the endogeneity of insurance purchase decisions. In this case, insurance participation does not refer to the proportion of producers buying insurance. It is a county-level measure of the proportion of potential liability that is insured.

Other studies that show positive, albeit small impacts include Young et al. (2001) and Miao et al. (2011). Both studies use simulation approaches on the US federal insurance policy. The former finds that subsidised insurance leads to an increase in acreage specifically for wheat and cotton. However, this effect varies across different regions in the USA. The paper is based on county level data for eight crops in the USA. Miao et al. (2011) use both county and farm level data to show that higher subsidies are positively associated with an increase in acreage. The data covers corn and wheat farmers during the period 1960-2009.

On the other hand, Chen (2005) uses a combination of county level and farm level data to show that insurance leads to an increase in acreage abandonment. This is attributed to the poor actuarial performance of the insurance scheme. This study is based on a mathematical optimisation approach for cotton farmers in the USA during 1989-2003.

It is important to note that while all of the above studies are based in the USA, they cover different regions and crop mixes. Also, in most of this literature, output is measured using acreage, which is not necessarily a standard unit. Land under cultivation is bound to be higher in larger districts and vice-versa. Another aspect that emerges is the use of a combination of county level and farm level measures to analyse impacts.

2.2 Literature based on household level data

Assessing the impact of insurance on output essentially refers to understanding an individual farmer's ability to use insurance effectively. In the above section, county level data is used to measure individual farmer's behaviour. This may lead to an underestimation of moral hazard, as aggregate yields are less variable than individual yields (Goodwin et al., 2004). Also, the counties or region chosen in these studies may not exhibit the conditions necessary to induce widespread moral hazard (Chen, 2005). Thus, in order to better understand a farmer's behavioural patterns, it is important to use reliable individual level farm data.

Akin to the district level literature, both econometric modeling and simulation techniques are applied to assess the impact of insurance on output. Most of this literature shows a negative impact of insurance on productivity at the household/farm level.

For instance, Quiggin et al. (1993) determine that insured farmers are likely to produce lower yield more frequently than uninsured farmers with similar observed characteristics using a sample of 355 cotton farmers in the US. They employ a two-stage model to account for the endogeneity of insurance. Similarly, OECD (2006) and Spörri et al. (2012) show a negative impact of insurance on productivity in Spain and Hungary respectively. On the assumption that insurance is endogenous to yield, both studies use a two-stage least squares approach on farm level data.

Roberts et al. (2006) also find moral hazard effects using a large increase in US Federal crop insurance subsidies as a natural experiment to examine how harvest changed in response to the policy-induced change in insurance coverage. The study employs a difference in difference approach on administrative data from 1989 to 2002.

Insurance also impact the land under cultivation. LaFrance et al. (2000) hypothesise that land use is unchanged only when an actuarially fair, perfectly separating insurance contract is offered using a partial equilibrium model of stochastic crop production. Walters et al. (2012) find positive acreage effects of insurance for wheat, corn and soybean farmers in the USA using a fixed effects model on farm level data from 1995-2002. A farmers' acreage is also sensitive to the various levels of revenue insurance (Wu and Adams, 2001 as cited in OECD, 2006).

Among other impacts, insurance subsidies are shown to cause modest increase in enterprise specialisation and production efficiency. Using a two-stage IV approach, O'Donoghue et al. (2009) show that an increase in insurance coverage causes an increase in specialisation using farm level data of eight crops in the USA. They find that producers specialised by cutting back activities with little or no direct connection to their operation's main focus.

Similarly, Vardhan and Kumar (2012) find that uninsured farmers are more likely to diversify when compared to insured farmers in India. They employ a Heckman selection model on rice farmers in India to show that insured farmers earn higher revenues due to specialisation. Chang and Mishra (2012) also show a negative association between the decision to purchase crop insurance and work off-farm (i.e. diversify) using a two-stage quantile model on US farmers.

However, in some cases, diversification effects derived from multiple crop production are found to substantially alter the risk reduction effects of crop insurance (Woodard et al., 2009). In other words, insurance of one crop can lead to underinvestment in inputs for the insured crop and more concentration on the uninsured crops. Failure to account that most farmers produce multiple crops can lead to a misinterpretation of the effects on crop insurance.

2.3 Inferences from literature

Section 2.1 and 2.2 present the existing literature on the impact of insurance on output. Most of this work is based on a study of the US federal insurance due to two main reasons. One, it is one of the largest insurance schemes in the world (other than India) with varying subsidy levels across counties. Also, detailed records on the insurance are maintained both at the farm and county level. This helps researchers in creating strong long-term panel datasets for effective analysis.

The regression-based literature uses subsidies an exogenous determinant of insurance in their two-stage approach. Studies that employ simulation techniques also vary subsidies across farm or county levels to ascertain impacts. If not subsidies, then specific land reforms or policies are used as a natural experiment to study the impact of insurance. Recurring covariates in the second stage regression on productivity at household and county level include credit access, area of land under cultivation, rainfall, soil quality, land capability, coefficient of variation of yields or prices etc.

In terms of the unit of analysis, there is more merit in using household level data to capture changes in behavioural patterns among insured farmers. Having said that, district or county level data might prove useful as a starting point to understanding how insurance affects output at an aggregate level, i.e. how individual positive and negative insurance effects average out at a collective level.

Also, the above stated effects of higher acreage and better productivity is only possible only is the presence of an efficient insurance product that responds to the actual needs of the community under study (Cai et al., 2010). Partial insurance covers that do not fully compensate for the cost of cultivation or actual losses faced may not influence changes in production techniques.

Though the Indian crop insurance programme is considered as one of the largest in the world, there is only a handful of literature on the impacts of crop insurance on agriculture in the country. India also presents a unique system where insurance is bundled with formal crop loans on a mandatory basis for *loanee* farmers. Mishra (1994) traces the Comprehensive Crop Insurance Scheme (CCIS), which was a mandatory insurance scheme prevalent in the 1980s to find that loan linked insurance leads to an increase in the flow of credit to insured farmers. In other words, insurance encourages credit behaviour. This may not be the case for voluntary insurance policies.

The manner in which payouts are determined under the NAIS and WBCIS schemes also have a bearing on the risk reduction and moral hazard effects of insurance on output. As elaborated in Chapter I, the claim assessment in NAIS involves crop-cutting experiments at the local levels to assess average yield. In case of WBCIS, payouts are determined using weather stations (rain gauges) located at the district or block levels. Clearly, the possibility of moral hazard is greater under NAIS. Farmers in a specific local unit can collude to show lower yields and receive payouts. This is largely contingent on the unit of the claim assessment experiments, which varies across states. The possibility of moral hazard is almost eliminated in WBCIS as there is no individual contribution in claim assessment. Rainfall data from the Indian Meteorological Department (IMD) is collected on an immediate basis to determine claim payouts. Risk reduction is possible in both NAIS and WBCIS policies.

Additionally, though the percentage of subsidies is homogenous all over the country, they are only provided to small and marginal farmers.[22] There are no subsidy variations and hence, a natural experiment cannot be conducted on the lines of the US federal insurance-based literature.

Thus, any impact analysis on output for Indian farmers needs to assess both mandatory and voluntary insurance policies, as the effects could be different. It should also be

[22] The Indian Government defines marginal farmers as those cultivating agricultural land up to 1 hectare (or 2.5 acres). A small farmer is defined as cultivating between 1 hectare and 2 hectares (as defined in the Financial Budget of 2008). In most Indian states, the small and marginal farmers account for between 70 to 94 per cent of total farmers.

borne in mind that the impacts observed in mandatory policies could be attributed to the loan amount itself rather than the insurance component. This is elaborated on further in the later sections of this Chapter. Similarly, one also needs to deliberate on the nature of endogeneity of crop insurance for mandatory insurance policies as a farmer is selecting into buying a loan rather than insurance.

3. Data set used in the analysis

Following from the literature, this Chapter uses both secondary district level and primary household level data from Howrah for the analysis. As mentioned in Chapter II, the district level data provides detailed information on agricultural input-output aspects as well as crop insurance for all mandatory buyers of the National Agriculture Insurance Scheme or NAIS, which is an area yield index-based product. The household dataset from Howrah, West Bengal traces voluntarily insured and uninsured farmers over a two-year period. Insurance is provided under the Weather Based Crop Insurance Scheme or WBCIS in this case.

As a starting point, this Chapter explores the district level data available for three states in India to understand the association between insurance and productivity at an aggregate level. This is followed by an analysis of household specific data on paddy farmers in West Bengal.

District level data is compiled from three states. Ideally, one would want to study all districts in India. However, this was not possible due to some challenges in acquiring the data. These issues are highlighted in the next sub-section.

3.1 Factors driving the choice of the study areas

The district level data is both crop and insurance specific. Insured is provided under the NAIS, the area index based insurance scheme. Another important feature of the data is that it covers only *loanee* farmers across a three-year period.

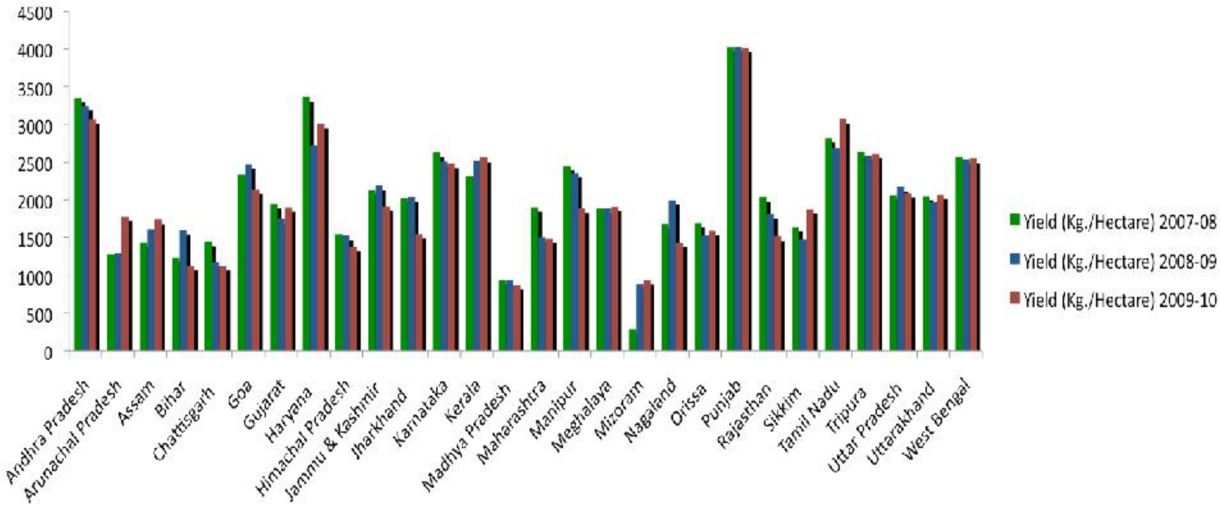
District level information on agricultural production, yield and irrigation is available for all districts in India in multiple data repositories through the Ministry of Agriculture, Government of India. However, there is only once source of data on NAIS crop insurance at the district level. Though this source, the Agricultural Insurance Company of India (AIC), publishes state level insurance coverage, premiums and claims data on their website, district level data is only available on request. Following several negotiations and signing non-disclosure agreements, data was provided for mandatory NAIS insurance coverage in three Indian states. The choice of states and crop was left to the discretion of the researcher.

There are three important choices here- choice of the crop, insurance scheme and the states. These decisions have been discussed below. Please note that agriculture output data was only collected after securing the insurance variables from AIC.

The choice of crop is quite crucial to the analysis. The crop needs to be one that is grown in most parts of the state and represents a significant produce in terms of revenue. Rice is an important crop cultivated all over India. The country is the second largest producer of rice in the world. Annual production of rice in India stood at 104.40 million tonnes in 2012-13, with around 42.41 million hectares of land under paddy cultivation. Rice production in India is extremely vulnerable to rainfall vagaries and insurance for rice has been made available to farmers since the inception of public crop insurance policies in the country.

Figure 3.1 shows the average annual productivity or yield of paddy in all states in India during 2007-08 to 2009-10 (See Annexure A3.1 for more information on annual production and area under cultivation). Note that though West Bengal is the top rice producing state in India, productivity, expressed in kilogram per hectare, is high in states such as Punjab, Haryana, Andhra Pradesh and Tamil Nadu. However, it is also important to consider the state-wise insurance penetration in these states in order to create a comprehensive dataset.

Figure 3.1: Annual productivity of rice in India during 2007-08 to 2009-10



Source: Ministry of Agriculture, Government of India

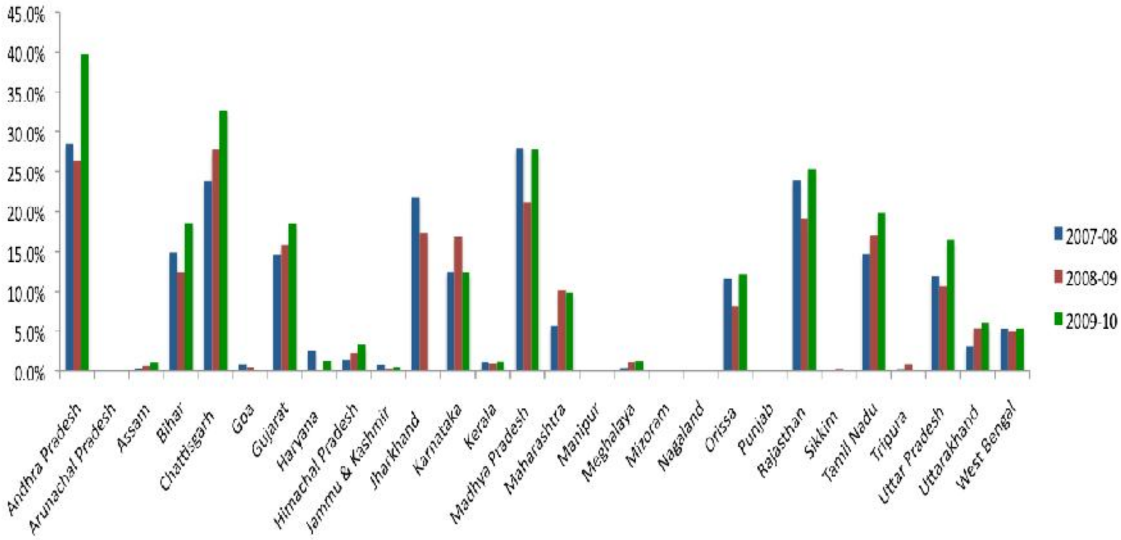
The choice of the insurance scheme is also significant. As mentioned in Chapter I, the National Agriculture Insurance Scheme (NAIS) is the largest public insurance scheme in the country. It has been in operation since Rabi or winter 1999-2000. Almost all states provide NAIS insurance for foodgrains including rice. The fact that NAIS is provided only by AIC also helps as all data can be gathered from a single source. Finally, there is a large base of *loanee* farmers under the NAIS, which will help in the analysis of the impact of insurance on mandatory buyers of the product.

NAIS data at state level is only available as a total of all crops insured[23]; crop wise data is not available through public sources. The area-wise total insurance penetration of all crops in India under NAIS is provided in Figure 3.2. Insurance penetration is calculated as the percentage of the area under insurance of all crops under mandatory or voluntary insurance to the total sown area.

Interestingly, there is very little insurance penetration in both Punjab and Haryana- the states with very high rice productivity. Relative area under insurance is higher in states such as Andhra Pradesh, Chhattisgarh, Madhya Pradesh, Rajasthan, Tamil Nadu and Gujarat.

[23] The state level NAIS data as available on AIC's website provides area covered under both mandatory and voluntary NAIS insurance policy in the respective states during each year.

Figure 3.2: Area-wise insurance penetration for all crops during 2007-08 to 2009-10



Source: Agriculture Insurance Company of India.

Political factors are also an important consideration for the selection of states. Recall that the choice of insurance scheme is left to the discretion of the respective State Governments. Choosing states with the same Party in power may bias results as their preference for a specific scheme could be motivated by political and bureaucratic considerations.

Thus, Andhra Pradesh (AP), Tamil Nadu (TN) and Gujarat were chosen for this study as both rice productivity and total insurance penetration is high in these states. Also, all three states came under the regulation of different political parties during the study period eliminating political biases in the analysis.[24]

[24] Andhra Pradesh came under the jurisdiction of the Telugu Desam Party during 2007-2009 and the Congress from 2009 onwards. Tamil Nadu was ruled by the DMK during 2007-2009 and AIADMK from 2009 onwards. Gujarat has been under BJP's rule during the entire study period.

3.2 Agriculture profiles in the selected states

The next step is to understand the agricultural portfolios of the selected states. Rice is cultivated in almost all districts in Andhra Pradesh and Tamil Nadu. In Gujarat, a little over half of the districts produce rice. Please see Table 3.1 for more information on other crops cultivated in the states.

Table 3.1: Agriculture in the selected states

S.No	Particulars	Andhra Pradesh	Gujarat	Tamil Nadu
1	Total number of districts	23	33	32
2	Major crops produced	Rice, Wheat, Millets, Pulses, Spices, Sugarcane, Vegetables, Fruits, Fibers, Oilseeds, Tobacco, Dyes, Fodder Crops And Green Manure Crops.	Cotton, Groundnut, Sesame, Castor, Rice, Bajra, Maize, Tur, Green Gram, Castor, Vegetables, Fruits, Wheat, Gram, Sugarcane, Spices, Fodder Crops	Paddy, Jowar, Bajra, Ragi, Maize, Small Millets, Pulses, Sugarcane, Spices, Fruits, Vegetables, Fibers, Oilseeds, Drugs, Dyes, Fodder Crops, Green-Manure Crops, Flowers
3	Districts growing paddy	22	17	31
4	Paddy growing seasons	Kharif and Rabi	Kharif and Summer (subsistence only)	Kharif, Rabi and Summer
5	Percentage area under paddy production in 2009-10	34.44%	6.59%	37.74%
6	Insured seasons (NAIS paddy)	Kharif and Rabi	Kharif	Kharif, Rabi and Summer

Source: Author’s research from multiple individual and institutional sources

While rice is the major source of agricultural income for both AP and TN with around 34 percent and 38 percent area under rice cultivation in 2009-10 respectively, Gujarat produces a range of cash crops and spices. Rice is cultivated in seven percent of its net sown area. The seasons covered include Kharif (autumn) and Rabi (winter) for AP, Kharif only for Gujarat and Kharif, Rabi and Summer for TN. Insurance is provided during all these seasons for the selected states. The next section describes the data and variables in greater detail

4. Description of the district level data

This section describes how the output and insurance variables are constructed for the analysis. Information is also provided on the other district level covariates used in the estimations. Note that while most input measures such as chemical and seed usage and credit information are available at the state level, it is difficult to find district level aggregate data on input variables. Initial descriptive statistics and correlations are also provided in this section.

4.1 Variables used in the analysis

The literature reviewed uses three different measures to estimate output – acreage, production and productivity. The acreage and production data depends largely on the size of the district. Larger districts are likely to have higher acres of land under production and produce more output in aggregate terms. A more suitable variable for the analysis is productivity or yield, which is the level of production per unit of land under cultivation. It is expressed in terms of tonnes per hectare. The yield measure normalises production to enable comparison across districts. Table 3.2a provides the season and state specific averages for paddy output measures.

Table 3.2a: State-wise and season-wise averages for paddy output during the period 2007-08 to 2009-10

Variable	Unit	AP		Gujarat	TN		
		Kharif	Rabi	Kharif	Kharif	Rabi	Summer
Area	in Hectare	112787	66182	43888	11983	51442	4803
Production	in Tonnes	341319	240551	79796	45284	133791	16515
Yield	In Tonne/Hectare	2.93	3.16	1.71	3.90	3.30	3.50

Source: Ministry of Agriculture, Government of India

The other important variable required for the study is insurance. Insurance variables, provided by AIC, include the number of farmers covered per district, area under insurance, sum assured, subsidies received, claims made and the number of beneficiaries per state. Table 3.2b summarises these variables specifically for paddy insurance coverage at the seasonal level. The insurance coverage in each district does not change drastically by season across the years under analysis. Chloropeth maps presented in Annexure A3.3 provide further information on this.

Table 3.2b: State-wise and season-wise averages for paddy insurance specific variables during the period 2007-08 to 2009-10							
Variable	**Unit**	**AP**		**Gujarat**	**TN**		
		Kharif	**Rabi**	**Kharif**	**Kharif**	**Rabi**	**Summer**
Number of farmers insured	in '000	46605	10148	3113	673	6060	650
Area under insurance	in Hectare	63902	17290	4966	1083	8836	848
Sum insured	Rs. in '000	961925	247319	104834	34835	172871	38983
Premium collected	Rs. in '000	2408	4946	2621	871	3485	780
Subsidies received	Rs. in '000	1773	344	51	127	851	101
Claims made	Rs. in '000	29134	3085	4582	1191	25389	378
Number of beneficiaries	in '000	5797	1196	927	210	2312	165
Proportional insurance coverage	Insured area/ Total paddy area	0.52	0.36	0.09	0.17	0.14	0.19

Source: Agriculture Insurance Company of India

Several measures were considered to define insurance coverage at the district level. While variables such as farmers and area covered provide absolute numbers, they might not capture the 'actual' insurance coverage at the district level (akin to the discussion on acreage and production above). Since district sizes vary across States, there could be large districts with very small coverage and vice-versa (Please see chloropeth maps provided in Section 4.2 below for details). This Chapter aims to identify if and how productivity varies for a district with a larger proportional area under insurance vis-à-vis a district where the proportional area under insurance is lower. Thus, this study defines a district level insurance participation measure calculated as the area under insurance coverage as a proportion of the total area under paddy production i.e.

$$\text{District insurance participation} = \frac{\text{Area under insurance for rice}}{\text{Total area under rice cultivation}}$$

This average district insurance participation for the entire sample stands at 0.24 with values ranging from zero or no insurance coverage to one or complete insurance coverage. The standard deviation of the measure is 0.32.

However, note that the dependant variable in the regression analysis, i.e. agricultural productivity is also a ratio defined using the total area under rice cultivation. Use of such "ratio variables" in a regression analysis should be dealt with caution as it could lead to issues such as spurious correlation (Kronmal, 1993) and/or hidden identities, especially when the dependant variable is a proportion (Firebaugh and Gibbs, 1985).

Thus, the district insurance participation measure is transformed using three dummy measures, which take the value one if the proportional district insurance participation is greater than or equal to 20 percent, 25 percent and 30 percent respectively and zero otherwise.[25]

Monthly precipitation data from the IMD is used to calculate total seasonal rainfall. Data is also available on season-wise area under irrigation. The issue with this variable is that it provides information on the area that can be irrigated i.e. area for which the Government has provisioned irrigation. However, there is no certainty that the respective area has actually received irrigation during a given season or not. Thus, the use and interpretation of this measure should be dealt with caution.[26]

Chloropeth maps indicating the levels of N, P and K in the soil are converted into dummy variables for the analysis. This variable takes the value zero for low levels and one for medium levels of fertility in the case of N and P. For K, the base category is high fertility and the variable takes the value one for medium fertility. Please see Annexure A3.4 for detailed maps provided by the India Institute of Soil Sciences (IISS).

It is also important to consider other state and national level interventions made during this period that impact rice production. One such scheme in operation is the National Food Security Mission (NFSM). Launched in 2007, NFSM is a centrally sponsored scheme aiming to increase the production of rice by 10 million tons, wheat by 8 million tons and pulses by 2 million tons by the end of the Eleventh Plan (2011-12). Selected districts are provided additional support and advisory for the cultivation of rice, wheat and pulses. More information on NFSM is provided in Annexure A3.5.

Table 3.3 provides the summary statistics. Note that the averages of all variables vary across states. Yield is higher in TN and lower in Gujarat. There is greater insurance coverage in AP, when compared to TN and Gujarat.

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[25] Several levels of insurance coverage were explored for this Chapter including 10%, 15%, 35%, 45% and 50%. The final coverage levels presented in this Chapter are based on the average and standard deviation of the proportional participation measure. The regression results do not vary hugely across the different coverage levels.

[26] For the analysis, proportional irrigation coverage is calculated as the area under irrigation divided by the area under paddy cultivation. A dummy measure is then created that takes the value one if at least 50 percent of the area under paddy is irrigated and zero otherwise. Regression results using this term as an explanatory variable are provided in the Annexure.

Table 3.3: Season-wise averages of the variables used in the analysis for the period 2007-08 to 2009-10							
Variable	**Unit**	**AP**		**GUJ**	**TN**		
		Kharif	**Rabi**	**Kharif**	**Kharif**	**Rabi**	**Summer**
Paddy Productivity (Yield)	in Tonne/Hectare	2.93	3.16	1.71	3.90	3.30	3.50
Insurance dummy (20%)	1= if 20% or more of area under rice is insured; 0= otherwise	0.88	0.55	0.19	0.09	0.20	0.21
Insurance dummy (25%)	1= if 25% or more of area under rice is insured; 0= otherwise	0.76	0.48	0.15	0.16	0.16	0.25
Insurance dummy (30%)	1= if 30% or more of area under rice is insured; 0= otherwise	0.64	0.41	0.15	0.15	0.14	0.20
Total seasonal rainfall	Sum of monthly rainfall per season in mm	683	123	966	342	664	229
Irrigation dummy	1= if at least 50% of the total area is irrigated; 0= otherwise	1.00	1.00	0.54	0.96	0.95	0.96
Soil fertility: Nitrogen content (N)	1= Medium; 0= Low	0.59	0.59	0.50	0.04	0.04	0.04
Soil fertility: Phosphorous content (P)	1= Medium or high; 0=Low	0.50	0.50	0.50	0.86	0.86	0.86
Soil fertility: Potassium content (K)	1= Medium; 0=High	0.64	0.64	0.13	0.31	0.31	0.31
NFSM districts	1=if the district is beneficiary of NFSM; 0= otherwise	0.50	0.50	0.13	0.17	0.17	0.17

Source: Author's calculations

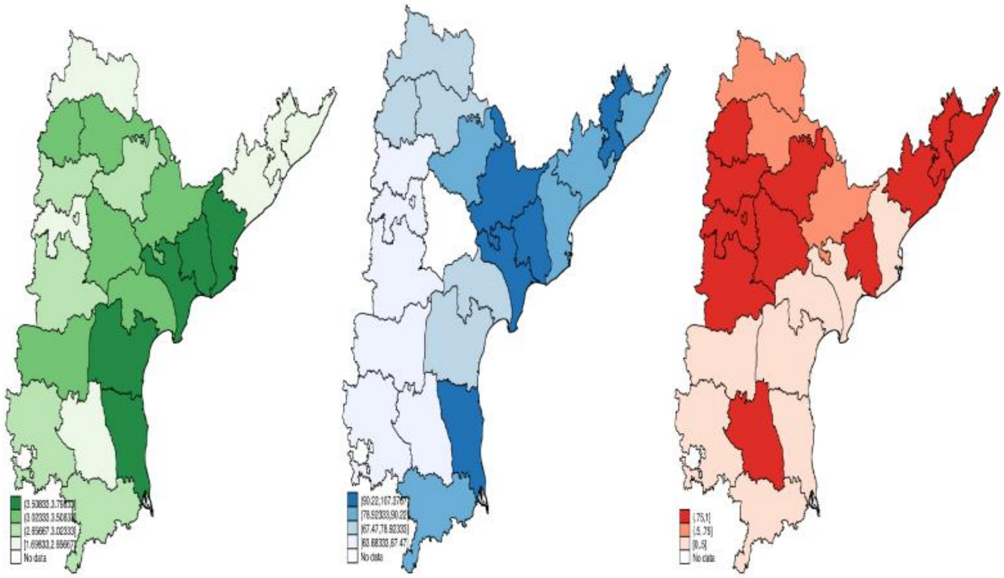
4.2 Associations among yield, insurance and rainfall

It is prudent to initiate the regression analysis by examining the relationship between the different variables in the dataset. This will provide a sense of yield and insurance relate with each other at the state level.

Chloropeth maps are used in order to understand the relationships between different variables across states. These maps compare annual average yield, rainfall and insurance coverage (20% dummy) [27] across selected states. This section compares the average annual data only. Season-wise maps are provided in Annexure A3.6.

[27] Please note that while the insurance coverage maps for AP and TN show the ranges from no coverage (i.e. less than 20% district insurance penetration) to medium and higher levels of coverage, the maps for Gujarat show only two levels of district insurance penetration – less that 20% proportional coverage and higher than 20% proportional insurance coverage. The white spaces relate to districts where no data was available for the variables under consideration.

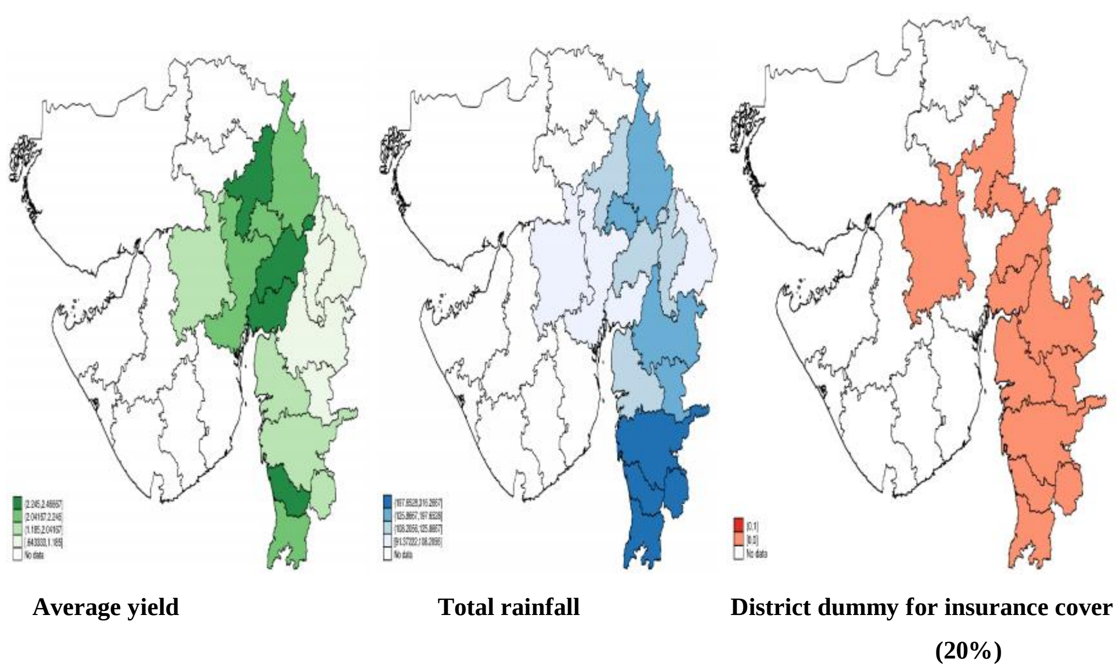
4.2.1 Andhra Pradesh



Average yield **Total rainfall** **District dummy for insurance cover (20%)**

The maps visually suggest that there is a positive association between yield and rainfall and a negative association between yield and insurance. Insurance is concentrated in areas with low productivity. It could be that the areas that experience historically low yields tend to buy more formal credit (and thus mandatory insurance) for cultivation.

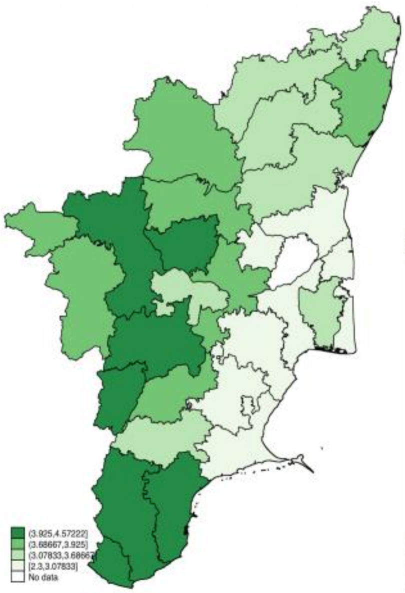
4.2.2 Gujarat



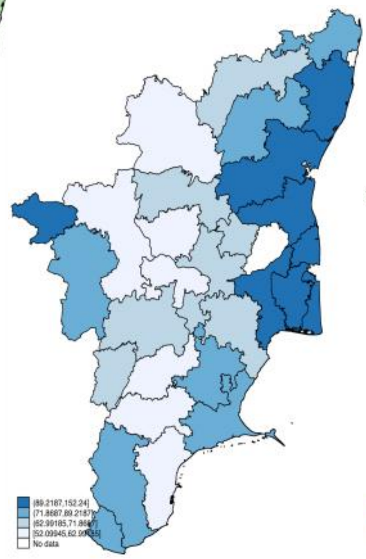
Average yield **Total rainfall** **District dummy for insurance cover (20%)**

In the case of Gujarat, while there is a positive association between yield and rainfall, the relationship between yield and insurance is unclear. This could be attributed to the fact that insurance coverage in Gujarat is quite low for paddy when compared to the other two states.

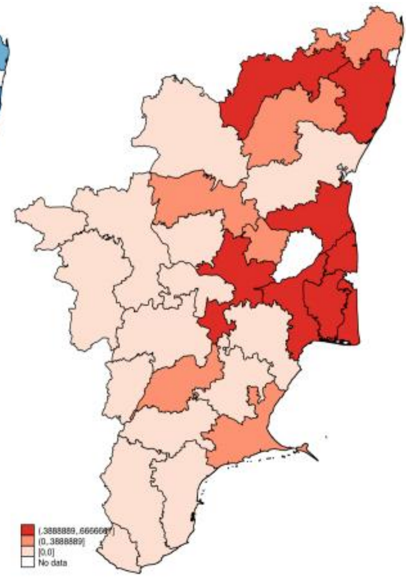
4.3.3 Tamil Nadu



Average yield



Total rainfall



District dummy for insurance cover (20%)

Yield and insurance are negatively associated for Tamil Nadu, with higher insurance coverage in areas of lower productivity. However, the relationship between yield and rainfall also appears to be negative as districts with higher yield receive lower rainfall. Note that the areas that record both higher rainfall and irrigation are on the coastal part of Tamil Nadu. Yield may be lower in these areas due to too much water and lower levels of land.

To sum up, in most cases the chloropeth maps visually show that the relationship between insurance and yield is negative. However, the literature reviewed highlights that the insurance decision is likely to be endogeneous to output. Specifically, with mandatory insurance, it may be the case that districts with lower yields are more likely to buy loans and thus insurance for current production. The next section describes the econometric approach followed by this Chapter.

5. Econometric analysis

Panel data covering most districts in three states is compiled for an analysis of the impact of district level crop insurance coverage on productivity of paddy. This season level data covers a three-year period i.e. 2007-08 to 2009-10.

The literature review and the descriptive analysis indicate that insurance could be endogeneous to productivity. The econometric analysis for the district level data adopts the following approach. To start with, pooled OLS and panel Fixed/Random effects models are estimated to explore the impact of crop insurance. Next, a two-stage least squares approach is employed, where insurance purchase is measured using a set of instruments in the first stage.

5.1 Single stage modeling assuming no endogeneity

The single stage model comprises three approaches - pooled OLS, fixed effects and random effects models

A pooled OLS model assumes that the intercepts and slope coefficients are homogenous across all districts through 2007-08 to 2009-10. This model exploits both the temporal dimension or the 'within' variation and the spatial dimension or the 'between' variation of the data but does not do so effectively. The model can be set up as follows:

$$Yield_{it} = \sim + \quad x_{it}^{'} + \yen Z_i^{'} + \pounds_{it} \text{......................(3.1)}$$

where, i represents the district and t represents the seasons over time, $\sim$ is the constant, x_{it} represents a vector of covariates, Z_i represents the time invariant variables and $\pounds_{it}$ is the error term**.**

The use of panel data models is preferred as they improve the effectiveness of econometric estimations in many ways. The fixed effects model is useful in estimating the effects of variables that vary over time. It explores the relationship between the predictor and outcome variables within an entity, in this case a district. It can be expressed as follows:

$$Yield_{it} = \sim_i + \quad x'_{it} + £_{it} \text{...........................}(3.2)$$

where, i represents the district and t represents the seasons over time, $\sim_i$ represents the individual fixed effects that do not vary over time, x_{it} represents a vector of covariates and $£_{it}$ is the error term**.**

This model assumes that each entity has certain specific characteristics that do not vary over time, which may impact the outcome variable. The model, thus, removes these time invariant individual level effects to identify the net impact on the outcome variable. Another important assumption of this model is that those time-invariant characteristics are unique to the entity and should not be correlated with other entity characteristics. In other words, each district is different therefore the error term and the constant (which captures individual characteristics) should not be correlated with the others.

The random effects model allows the entity specific 'fixed' effects to be treated as random. The model can be specified as follows:

$$Yield_{it} = « + \quad x'_{it} + ¬_{it} \text{...........................}(3.3)$$

$$v_{it} = \sim_i + u_{it} \text{....................................}(3.4)$$

where, i represents the district and t represents the seasons over time, $«$ is the constant term, x_{it} represents a vector of covariates and v_{it} is the error term.

This model is sometimes referred to as the variance components model as the error term is composed of two errors – a cross sectional component representing the individual specific effects treated as random ($\sim_i$) and a combined time series and cross sectional error component (u_{it}) The random effects model thus allows the use of time invariant variables in the analysis.

For all three cases, output is measured in terms of yield expressed as tonnes per hectare. Insurance participation is measured using three district level dummy measures representing 20, 25 and 30 percent aggregate insurance coverage. The measurement of this variable was elaborated in Section 4.1 above.

Precipitation data is calculated as total rainfall per season. The average total seasonal rainfall requirement for paddy cultivation in the selected areas is 1200-1400 mm. The relationship is likely to be non-linear. In other words, very low and very high levels of rainfall leads to lower output and normal rainfall increases productivity. Thus, it is useful to capture the effect of different levels of rainfall on output rather than directly estimate the impact of total/average rainfall in mm on yield.

Linear rainfall splines are used in the analysis to effectively capture this relationship. The splines are as follows:

i. Rainfall between 1200-1400 mm i.e. three linear splines knotted at 1200 and 1400 mm
ii. Rainfall above 1200 mm i.e. two linear splines knotted at 1200 mm

Soil fertility is measured based on the levels of N, P and K relative to a base category. Participation in the NFSM is also used to capture the other schemes that could affect yield variability in selected districts. However, these time invariant variables have not been included in the fixed effects modeling.

The next section describes the two-stage approach to account for the possible endogeneity of insurance purchase decisions

5.2 Two-stage IV approach to account for endogeneity of insurance

The literature shows that insurance could be endogeneous to productivity. The insurance purchase decision could lead to a reallocation of inputs, which in turn affect outputs. These reallocations could be defined as a risk reduction effect or a moral hazard effect. A risk reduction effect refers to the consideration of insurance as a useful hedge instrument, encouraging the use of better quality inputs and superior production techniques in cultivation. On the other hand, moral hazard leads to a reduction in the use of inputs in anticipation of a possible insurance payout. These behavioural aspects are explained in greater detail in Chapter IV, which looks at the immediate effects of insurance on the use of specific inputs.

With respect to this Chapter, it is important to understanding that both risk reduction and moral hazard effects are likely to affect the output or productivity in this case. Thus, a two-stage least squares approach is employed to study the impact of insurance on yield after having accounted for the possible endogeneity of insurance.

In this case, equation (3.6) is considered the structural equation. Insurance is estimated by the reduced form equation (3.5) using a set of instruments (that affect only the insurance purchase decision and not yield) and other explanatory variables. The predicted values from the first stage are then used to determine the impact of insurance on yield in equation (3.6). The model is set up as follows:

$$Insurance_{it} = \sim_0 + \quad _1 z'_{it1} + \quad _2 x'_{it2} + £_{it1} \quad .... \quad (3.5)$$

$$Yield_{it} = \sim_1 + \sim_2 Insurance_{it} + \quad _3 x'_{it2} + £_{it2} \quad .... \quad (3.6)$$

where, i represents the district and t represents the seasons over time. z_{it1} represents a set of instrumental variables, x_{it2} represents a vector of other explanatory variables (including time invariant factors), $£_{it1}$ and $£_{it2}$ are unobserved error terms.

F-tests and Sargan tests are conducted to check for the relevance and orthogonality of the instruments. Durbin-Wu-Hausman tests are conducted to determine the exogeneity of insurance purchase decisions. A rejection of the null indicates the presence of endogeneity in this case.

An additional complication here is that the insurance provided under the district level analysis is mandatory in nature. Specifically, it is linked to the purchase of an agricultural loan for paddy availed at the beginning of the cropping season. The endogeneity here could be related to either the loan itself or the insurance component of the loan. Thus, the choice and interpretation of the instruments used as exogeneous determinants of insurance need to be carefully deliberated on. The other covariates used to explain output in the second stage are similar to the ones used in the pooled OLS and panel models.

The next section provides the results of the district level analysis.

6. Results of the district level analysis

The results obtained from both the single stage pooled OLS/panel models and the two-stage IV models are presented and interpreted in this section. This is followed by a discussion on the validity of the results in the light of the unit of analysis and the use of a mandatory insurance policy.

6.1 Pooled OLS and panel model results for the district level analysis

The single stage pooled OLS and panel model results are presented in this section. As mentioned in the earlier section, rainfall is measured using two different linear spline specifications for three different district level insurance participation measures.

The three different insurance participation measures include a 20 percent, 25 percent and 30 percent district level insurance coverage. Table 3.4a and 3.4b present the results for linear rainfall spline knotted at 1200 and 1400 mm and rainfall spline knotted only at 1200 mm respectively. These results do not include an irrigation measure. See Annexure A3.7 for results including a dummy irrigation measure.

The results are consistent across the pooled OLS, fixed effects and random effects models. They are also similar for both linear rainfall spline measures. Finally, the impact of insurance on yield is also similar across different district level coverage measures.

The outcome variable i.e. yield is expressed as tonne/hectare in this analysis. Results indicate that insurance is negatively associated with productivity. This negative relationship is consistent across all specifications in both Table 3.4a and 3.4b. For instance, a district insured for at least 20 percent of its total area under paddy cultivation is likely to experience a lower yield to the extent of 0.31 tonne/hectare, when compared to districts insured below the threshold coverage *on average and ceteris paribus* as per column (2) of Table 3.4a. For a 30 percent insurance coverage, yield is likely to be lower by 0.23 tonne/hectare for the insured *on average and ceteris paribus* as per column (3) of Table 3.4a. This result is similar to the descriptive analysis presented in Section 4 that illustrates a negative association between insurance coverage and yield.

Several reasons could be attributed to this. It may show an aggregate moral hazard impact where insured household reduce use of important inputs. It could be a case of substitution, where since the loan amount is net of insurance premium, there is lesser money to allocate across all inputs. Or, perhaps the modeling is not appropriate since insurance is likely to be endogenous to output. This is investigated further in the next section.

The impacts of other covariates are described below. Rainfall splines knotted at 1200 and 1400 mm of rainfall i.e. Table 3.4a, indicate that rainfall below 1200 mm has a significant and negative impact on productivity. Rainfall between 1200-1400 mm is also negatively associated with yield, though it is only significant in random effects specifications. Rainfall splines knotted only at 1200 mm of rainfall in Table 3.4b shows that rainfall below 1200 mm has a negative and significant impact on yield. Rainfall above 1200 mm does not significantly affect output.

Participation in the NFSM scheme is negatively (and significantly) associated with yield under all specifications in the pooled OLS case. NFSM participation reduces yield by 0.31 tonnes/hectare *on average and ceteris paribus*, when compared to a non-participating district as per column (2) of Table 3.4a. A closer look at the components under the NFSM scheme (Annexure A3.5) indicates that most of the benefits are in the form of monetary assistance towards specific agricultural activities. It may be the case that farmers use these financial incentives for purposes other than intended for under the scheme.

Among the soil chemical content measures, productivity is significantly higher if the phosphorous (P) content in the soil is medium or higher. However, for both nitrogen (N) and potassium (K), higher soil quality is associated with lower yields. For instance, areas with medium levels of N record lesser yields when compared to the base category i.e. lower levels of N. Similarly, areas with medium levels of K record higher yields when compared to the base category i.e. higher levels of K. This may reflect an over-application of fertilizers. Most farmers are not fully aware of the fertility levels of the soil and tend to over-apply fertilizers rich in NPK components to improve output.

Yield is significantly higher during Kharif or autumn season, which is the major season for paddy cultivation in most states of India. The base category here is Summer season. This variable is particularly significant in the panel models across both rainfall spline measures.

Annexure A3.7 includes an additional irrigation dummy covariate. Results show that a district that receives irrigation is likely to generate higher productivity. Inclusion of the dummy does not affect the other results of the analysis and insurance continues to have a negative and significant impact on yield.

The key result here is that insurance has a negative association with yield at an aggregate level. However, this is based on a one step analysis. The next section explores the likelihood of the endogeneity of insurance decisions and its impact on yield.

Table 3.4a: Pooled OLS, FE and RE results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm and 1400 mm rainfall									
Particulars (1)	**Pooled OLS**			**Fixed effects model**			**Random effects model**		
	20% coverage (2)	**25% coverage (3)**	**30% coverage (4)**	**20% coverage (5)**	**25% coverage (6)**	**30% coverage (7)**	**20% coverage (8)**	**25% coverage (9)**	**30% coverage (10)**
Insurance district dummy	-0.3075***	-0.2344**	-0.3447***	-0.3261***	-0.2672***	-0.3064***	-0.2902***	-0.2344**	-0.3012***
	0.0893	0.0916	0.0963	0.1005	0.0815	0.0894	0.1094	0.1001	0.1012
Rain1 (<1200 mm)	-0.0012***	-0.0012***	-0.0012***	-0.0006***	-0.0007***	-0.0007***	-0.0008***	-0.0008***	-0.0008***
	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Rain2 (1200-1400 mm)	-0.0017	-0.0015	-0.0015	-0.0033	-0.0034	-0.0034	-0.0026**	-0.0025**	-0.0025**
	0.0017	0.0017	0.0017	0.0047	0.0050	0.0062	0.0012	0.0013	0.0013
Rain3 (>1400 mm)	0.0002	0.0003	0.0002	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002
	0.0007	0.0007	0.0007	0.0060	0.0096	0.0048	0.0003	0.0003	0.0003
NFSM district	-0.3106***	-0.3298***	-0.3029***				-0.2257	-0.2497	-0.2339
	0.1041	0.1081	0.1075				0.1768	0.1814	0.1798
Soil N quality_medium	-0.3718***	-0.3930***	-0.3821***				-0.3986**	-0.4094**	-0.4035**
(B: Low)	0.1029	0.1022	0.1013				0.1776	0.1749	0.1712
Soil P quality_medium	0.2873***	0.2974***	0.2890***				0.3866*	0.3927*	0.3893*
(B: Low)	0.0986	0.0985	0.0969				0.2051	0.2040	0.2017
Soil K quality_medium	0.2810***	0.2688***	0.2922***				0.3854**	0.3700*	0.3857**
(B: High)	0.0809	0.0806	0.0807				0.1904	0.1895	0.1878
Kharif season dummy	0.1564	0.1570	0.1716	0.3100***	0.3153***	0.3320***	0.2764**	0.2822**	0.2948***
	0.1125	0.1132	0.1143	0.1013	0.1015	0.1075	0.1127	0.1128	0.1114
Rabi season dummy	0.1399	0.1435	0.1563	0.0529	0.0659	0.0865	0.0853	0.0942	0.1086
	0.1070	0.1079	0.1078	0.1101	0.1068	0.1088	0.1449	0.1456	0.1428
Year 2007-08	0.0915	0.1041	0.0858	0.0190	0.0310	0.0233	0.0435	0.0537	0.0421
	0.0978	0.0967	0.0970	0.0677	0.0667	0.0635	0.0707	0.0694	0.0686
Year 2008-09	0.0154	0.0293	0.0031	-0.0027	0.0107	-0.0053	0.0042	0.0159	-0.0035
	0.1026	0.1026	0.1026	0.0676	0.0656	0.0701	0.0538	0.0526	0.0530
Constant	3.5401***	3.5132***	3.5175***	3.4490***	3.4178***	3.4155***	3.1064***	3.0844***	3.0838***
	0.1507	0.1492	0.1473	0.1109	0.1120	0.1144	0.2598	0.2582	0.2547

Table 3.4a continued: **Pooled OLS, FE and RE results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm and 1400 mm rainfall**									
	Pooled OLS			**Fixed effects model**			**Random effects model**		
Particulars (1)	**20% coverage (2)**	**25% coverage (3)**	**30% coverage (4)**	**20% coverage (5)**	**25% coverage (6)**	**30% coverage (7)**	**20% coverage (8)**	**25% coverage (9)**	**30% coverage (10)**
Number of observations	409	409	409	412	412	412	409	409	409
R-squared	0.34	0.33	0.34	0.20	0.18	0.19			
F value/ Chi2 value	16.65	16.08	16.97	52.70	47.41	47.46	114.83	118.89	127.05

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. 20%, 25% and 30% coverage represent dummy measures for district level insurance penetration. Robust standard errors for pooled OLS and random effects and Bootstrapped standard errors for fixed effects model are provided below the coefficients. Rainfall spline1 represents rainfall below 1200 mm, Rainfall spline2 represents rainfall between 1200-1400 mm and Rainfall spline3 represents rainfall above 1400 mm. For soil quality N and P, the base category is low levels of fertility and base category for K is high fertility. The base category for season is 'Summer' and for year is '2009-10'.

Table 3.4b: Pooled OLS, FE and RE results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm rainfall									
	Pooled OLS			**Fixed effects model**			**Random effects model**		
Particulars (1)	**20% coverage (2)**	**25% coverage (3)**	**30% coverage (4)**	**20% coverage (5)**	**25% coverage (6)**	**30% coverage (7)**	**20% coverage (8)**	**25% coverage (9)**	**30% coverage (10)**
Insurance district dummy	-0.3044***	-0.2330**	-0.3440***	-0.3409***	-0.2850***	-0.3227***	-0.2908**	-0.2381**	-0.3047***
	0.0888	0.0914	0.0962	0.0921	0.0831	0.0867	0.1130	0.1040	0.1056
Rain4 (<1200 mm)	-0.0012***	-0.0012***	-0.0012***	-0.0007***	-0.0007***	-0.0007***	-0.0008***	-0.0009***	-0.0009***
	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Rain5 (>1200 mm)	-0.0003	-0.0002	-0.0002	-0.0001	-0.0002	-0.0001	-0.0003	-0.0003	-0.0002
	0.0004	0.0004	0.0004	0.0015	0.0018	0.0014	0.0003	0.0003	0.0003
NFSM district	-0.3082***	-0.3273***	-0.3004***				-0.1930	-0.2168	-0.2015
	0.1037	0.1077	0.1071				0.1740	0.1789	0.1769
Soil N quality_medium	-0.3763***	-0.3968***	-0.3856***				-0.4337**	-0.4435**	-0.4370**
(B: Low)	0.1022	0.1015	0.1006				0.1799	0.1766	0.1728

Table 3.4b continued: **Pooled OLS, FE and RE results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm rainfall**									
Particulars (1)	**Pooled OLS**			**Fixed effects model**			**Random effects model**		
	20% coverage (2)	**25% coverage (3)**	**30% coverage (4)**	**20% coverage (5)**	**25% coverage (6)**	**30% coverage (7)**	**20% coverage (8)**	**25% coverage (9)**	**30% coverage (10)**
Soil P quality_medium	0.2878***	0.2976***	0.2891***				0.3901*	0.3956*	0.3923**
(B: Low)	0.0980	0.0980	0.0963				0.2032	0.2022	0.1999
Soil K quality_medium	0.2869***	0.2743***	0.2977***				0.4103**	0.3949**	0.4103**
(B: High)	0.0808	0.0804	0.0806				0.1893	0.1883	0.1865
Kharif season dummy	0.1639	0.1638	0.1781	0.3148***	0.3196***	0.3378***	0.2858**	0.2907**	0.3035***
	0.1126	0.1133	0.1144	0.1048	0.1073	0.1084	0.1129	0.1131	0.1116
Rabi season dummy	0.1440	0.1472	0.1598	0.0451	0.0575	0.0797	0.0862	0.0945	0.1092
	0.1069	0.1079	0.1078	0.1097	0.1098	0.1085	0.1464	0.1472	0.1441
Year 2007-08	0.0997	0.1113	0.0929	0.0232	0.0350	0.0274	0.0511	0.0605	0.0489
	0.0971	0.0961	0.0964	0.0692	0.0646	0.0624	0.0695	0.0684	0.0678
Year 2008-09	0.0226	0.0357	0.0093	-0.0024	0.0109	-0.0055	0.0103	0.0214	0.0018
	0.1025	0.1024	0.1024	0.0640	0.0639	0.0624	0.0537	0.0525	0.0531
Constant	3.5419***	3.5153***	3.5199***	3.4468***	3.4160***	3.4123***	3.0908***	3.0701***	3.0694***
	0.1506	0.1491	0.1472	0.1128	0.1001	0.1021	0.2587	0.2573	0.2537
Number of observations	409	409	409	412	412	412	409	409	409
R-squared	0.33	0.33	0.33	0.19	0.18	0.18			
F value/ Chi2 value	18.69	18.01	19.02	61.32	50.64	53.38	93.44	97.36	103.99

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. 20%, 25% and 30% coverage represent dummy measures for district level insurance penetration. Robust standard errors for pooled OLS and random effects and Bootstrapped standard errors for fixed effects model are provided below the coefficients. Rainfall spline4 represents rainfall below 1200 mm and Rainfall spline5 represents rainfall above 1200 mm. For soil quality N and P, the base category is low levels of fertility and base category for K is high fertility. The base category for season is ‘Summer’ and for year is ‘2009-10’.

6.2 Two-stage IV results for the district level analysis

Most of the literature on the effect of insurance on output makes a case for the endogeneity of insurance decisions. Insurance purchased at the beginning of the cropping season could induce change in input allocations in terms of both amount and timing of application leading to a change in the productivity. In other words, insurance could be correlated with the unobservable factors that impact yield. It is important to capture the effect of this potential endogeneity for an effective assessment of the associations between insurance and output.

Hence, two-stage least squares approach is used to model the impacts. The endogeneity in this case needs to be considered with caution. Since the insurance product in contention is bundled with credit, the instruments need to be carefully identified and interpreted.

Ideal instruments that effectively capture purchase of formal credit/mandatory insurance but do not affect output at district level could include rate of interest on loans, distance to the nearest public sector bank, number of public lending institutions in the district etc. However, the availability of such data is limited at the district level for all states in India, not just the selected states.

Suitable instruments could be identified only using the available dataset. The secondary level data on insurance provided by the AIC has detailed information on not just insurance coverage, but also variables such as subsidies, claims etc. Using this information, two possible instruments are chosen for the study: (i) Previous season's (or lagged) subsidies (in '000 Indian rupees) and (ii) previous season's (lagged) insurance claims (in '000 Indian rupees). These variables are described in the next paragraphs.

A 10% subsidy is provided to only small and marginal farmers under this particular insurance scheme (Chapter I provides detailed information on insurance subsidies for NAIS). Since the loan amount provided is net of premium, farmers who are eligible for subsidies are likely to receive a higher net loan as compared to large farmers. This may encourage farmers to avail loans from the same institutions in the current season as they get a desired net loan amount plus crop insurance bundled with it.

Crop insurance claims in the past season write-off losses and the farmer is less likely to require a loan in the current season. Alternatively, encouraged by the insurance component, the farmer might either buy more loans with insurance or choose to purchase only insurance as a voluntary buyer. Both these variables are likely to affect the insurance component but will not directly impact yield.

However, using these variables affects the size of the data set available for analysis. Both the chosen instruments are lagged measures and data is strictly available only for the years 2007-08 to 2009-10. Using lagged measures means that only the 2008-09 and 2009-10 data set can be used for the two-stage analysis. Though the data set reduces by a year, there are still a sizeable number of observations to enable an effective analysis.

Thus, lagged subsidies and claims are used as exogeneous determinants of aggregate insurance coverage in the first stage regressions and the second stage explores the impact of insurance on yield. Durban-Wu-Hausman endogeneity tests have also been conducted to validate the use of a two-step approach to study the association between yield and insurance. Given that the study is based on two years, only estimates based on the pooled data are provided.

Results are provided in Table 3.5a and 3.5b for linear rainfall spline knotted at 1200/1400 mm and linear spline for 1200 mm only respectively. Annexure A3.8 presents the results with an additional irrigation dummy covariate.

Table 3.5a: Two-stage IV results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm and 1400 mm rainfall

Particulars (1)	20% coverage		25% coverage		30% coverage	
	First stage (2)	Second stage (3)	First stage (4)	Second stage (5)	First stage (6)	Second stage (7)
Lagged insurance subsidies	0.0003***		0.0003***		0.0002***	
	0.0000		0.0000		0.0000	
Lagged insurance claims	-0.0008		-0.0005		0.0003	
	0.0005		0.0005		0.0005	
Insurance district dummy		0.2267		0.2208		0.2378
		0.2402		0.2354		0.2684
Rain1 (<1200 mm)	-0.0002	-0.0012***	-0.0002*	-0.0012***	-0.0002**	-0.0012***
	0.0001	0.0002	0.0001	0.0002	0.0001	0.0002
Rain2 (1200-1400 mm)	-0.0006	-0.0008	-0.0003	-0.0009	-0.0001	-0.0010
	0.0007	0.0023	0.0008	0.0023	0.0008	0.0023
Rain3 (>1400 mm)	-0.0002	0.0003	-0.0002	0.0003	-0.0001	0.0003
	0.0002	0.0008	0.0002	0.0008	0.0002	0.0008
NFSM district	0.0557	-0.4618***	0.0384	-0.4579***	0.0621	-0.4638***
	0.0670	0.1359	0.0632	0.1346	0.0624	0.1388
Soil N quality_medium (B: Low)	0.2332***	-0.5056***	0.2350***	-0.5037***	0.1980***	-0.4970***
	0.0739	0.1450	0.0710	0.1440	0.0707	0.1432
Soil P quality_medium (B: Low)	-0.1456**	0.3849***	-0.1488***	0.3838***	-0.1433***	0.3821***
	0.0569	0.1382	0.0538	0.1370	0.0526	0.1382
Soil K quality_medium (B: High)	0.0744	0.1590	0.0718	0.1613	0.1028**	0.1564
	0.0538	0.1151	0.0517	0.1136	0.0504	0.1173
Kharif season dummy	0.0313	0.1328	0.0075	0.1385	0.0368	0.1316
	0.0788	0.1646	0.0726	0.1634	0.0694	0.1633
Rabi season dummy	0.0196	0.2525*	-0.0033	0.2569*	0.0200	0.2494*
	0.0801	0.1486	0.0775	0.1482	0.0755	0.1477
Year 2009-10	0.1278***	-0.0923	0.1094**	-0.0882	0.1387***	-0.0987
	0.0485	0.1114	0.0457	0.1095	0.0444	0.1161

Table 3.5a continued: **Two-stage IV results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm and 1400 mm rainfall**						
Particulars (1)	**20% coverage**		**25% coverage**		**30% coverage**	
	First stage (2)	**Second stage (3)**	**First stage (4)**	**Second stage (5)**	**First stage (6)**	**Second stage (7)**
Constant	0.2315***	3.4584***	0.2104***	3.4653***	0.1504**	3.4780***
	0.0823	0.1787	0.0769	0.1750	0.0725	0.1714
No. of observations	271	271	271	271	271	271
F value (overall significance of the regression)	17.7884	10.1171	17.9768	10.0758	16.4529	9.8769
Prob >F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Centered R2	0.3662	0.271	0.3788	0.2784	0.349	0.2688
Uncentered R2	0.5907	0.9347	0.5622	0.9354	0.5099	0.9345
Instruments validation						
Cragg-Donald Wald F statistic		34.0210		40.5660		34.5940
Underidentification test						
Anderson canon. corr. LM statistic						
Chi2 value/P-value	36.7520	0.0000	32.3770	0.0000	20.5590	0.0000
Over identification/validity of all instruments						
Hansen's J statistic						
Chi2 value/ P-value	0.1900	0.6628	0.2510	0.6162	0.4020	0.5261
Endogeneity tests						
Durbin-Wu-Hausman						
Chi2 value/P-value	8.5610***	0.0034	7.4440***	0.0064	7.7030***	0.0055

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. 20%, 25% and 30% coverage represent dummy measures for district level insurance penetration. Robust standard errors are provided below the coefficients. Rainfall spline1 represents rainfall below 1200 mm, Rainfall spline2 represents rainfall between 1200-1400 mm and Rainfall spline3 represents rainfall above 1400 mm. For soil quality N and P, the base category is low levels of fertility and base category for K is high fertility. The base category for season is ‘Summer’ and for year is ‘2008-09’. The null hypothesis of exogeneity of insurance purchase is rejected under all three insurance coverage categories.

Table 3.5b: Two-stage IV results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm rainfall

Particulars	20% coverage		25% coverage		30% coverage	
	First stage (2)	Second stage (3)	First stage (4)	Second stage (5)	First stage (6)	Second stage (7)
(1)						
Lagged insurance subsidies	0.0003***		0.0003***		0.0002***	
	0.0000		0.0000		0.0000	
Lagged insurance claims	-0.0008*		-0.0005		0.0003	
	0.0005		0.0005		0.0005	
Insurance district dummy		0.2266		0.2186		0.2295
		0.2405		0.2354		0.2675
Rain4 (<1200 mm)	-0.0002*	-0.0013***	-0.0002*	-0.0013***	-0.0002**	-0.0013***
	0.0001	0.0002	0.0001	0.0002	0.0001	0.0002
Rain5 (>1200 mm)	-0.0003	0.0001	-0.0002	0.0000	-0.0001	0.0000
	0.0002	0.0005	0.0002	0.0005	0.0001	0.0005
NFSM district	0.0565	-0.4614***	0.0387	-0.4572***	0.0623	-0.4619***
	0.0666	0.1359	0.0629	0.1346	0.0620	0.1387
Soil N quality_medium (B: Low)	0.2318***	-0.5076***	0.2346***	-0.5055***	0.1978***	-0.4980***
	0.0735	0.1443	0.0704	0.1432	0.0699	0.1422
Soil P quality_medium (B: Low)	-0.1450**	0.3856***	-0.1486***	0.3842***	-0.1432***	0.3816***
	0.0568	0.1376	0.0537	0.1363	0.0524	0.1374
Soil K quality_medium (B: High)	0.0757	0.1635	0.0722	0.1664	0.1030**	0.1628
	0.0536	0.1152	0.0514	0.1134	0.0503	0.1168
Kharif season dummy	0.0343	0.1417	0.0084	0.1481	0.0373	0.1419
	0.0782	0.1636	0.0721	0.1621	0.0686	0.1618
Rabi season dummy	0.0219	0.2579*	-0.0026	0.2627*	0.0204	0.2557*
	0.0792	0.1479	0.0763	0.1474	0.0742	0.1468
Year 2009-10	0.1269***	-0.0960	0.1092**	-0.0920	0.1385***	-0.1017
	0.0483	0.1106	0.0454	0.1090	0.0441	0.1156

Table 3.5b continued: **Two-stage IV results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm rainfall**

Particulars (1)	**20% coverage**		**25% coverage**		**30% coverage**	
	First stage (2)	**Second stage (3)**	**First stage (4)**	**Second stage (5)**	**First stage (6)**	**Second stage (7)**
Constant	0.2321***	3.4619***	0.2105***	3.4695***	0.1505**	3.4830***
	0.0821	0.1789	0.0768	0.1749	0.0723	0.1710
No. of observations	271	271	271	271	271	271
F value (overall significance of the regression)	19.4611	11.3654	19.4827	11.3471	17.6933	11.1788
Prob >F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Centered R2	0.3659	0.2705	0.3788	0.2783	0.349	0.27
Uncentered R2	0.5905	0.9347	0.5622	0.9354	0.5099	0.9346
Instruments validation						
Cragg-Donald Wald F statistic		34.847		41.121		35.019
Underidentification test						
Anderson canon. corr. LM statistic						
Chi2 value/P-value	36.8390	0.0000	32.2790	0.0000	20.2530	0.0000
Over identification/validity of all instruments						
Hansen's J statistic						
Chi2 value/ P-value	0.3190	0.5722	0.4070	0.5237	0.5770	0.4476
Endogeneity tests						
Durbin-Wu-Hausman						
Chi2 value/P-value	8.4910***	0.0036	7.3820***	0.0066	7.6180***	0.0058

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. 20%, 25% and 30% coverage represent dummy measures for district level insurance penetration. Robust standard errors are provided below the coefficients. Rainfall spline4 represents rainfall below 1200 mm and Rainfall spline5 represents rainfall above 1400 mm. For soil quality N and P, the base category is low levels of fertility and base category for K is high fertility. The base category for season is 'Summer' and for year is '2008-09'. The null hypothesis of exogeneity of insurance purchase is rejected under all three insurance coverage categories.

It is evident from Table 3.5a and 3.5b that the results are consistent across all measures of insurance and rainfall. More interestingly, insurance is now positively associated with yield though it is no longer significant. This indicates the domination of a risk reduction effect, where insurance encourages the use of better quality inputs and cultivation techniques leading to an increase in output in the medium-term. A more elaborate discussion on this is presented in Section 6.3 below.

The impact of other covariates on yield is similar to the single stage models. Rainfall below 1200 mm rainfall has a negative impact on output. Under column (4) of Table 3.5a, rainfall lower than 1200 mm rainfall decreases output by 0.0012 tonne/hectare *on average and ceteris paribus*. Similarly, participation in the NFSM is also negatively associated with output. The yield of a district that participates in the NFSM scheme is likely to be 0.48 tonne/hectare lower than a non-participating district *on average and ceteris paribus* under column (4) of Table 3.5a i.e. under a 25% aggregate insurance coverage. The soil fertility measures also show similar associations, though potassium (K) no longer has a significant impact on yield.

Under all specifications in both Tables 3.5a and 3.5b, lagged subsidies are positively associated with insurance purchase. This is consistent with the assumption that more subsidies encourage farmers to buy loans and thus, insurance. Lagged claims have a negative association with insurance purchase, though this is only significant at 20% insurance coverage in Table 3.5b.

Instrument validation tests are also provided. In both cases, the null hypothesis of instrument validity/over-identification under the Hansen's J statistic cannot be rejected. Durbin-Wu-Hausman tests are also provided to check for the exogeneity of insurance purchase decisions. The null hypothesis here is that the variable is exogeneous. A rejection of the null confirms the presence of endogeneity as evident in Tables 3.5a and 3.5b.

Annexure A3.8 incorporates an irrigation dummy as an additional covariate. Though insurance does not significantly impact yield in this case, the Durbin-Wu-Hausman test cannot be decisively rejected. As mentioned earlier, the irrigation variable has a very high average and is also significantly correlated with rainfall. Thus, it is preferable to consider only the results presented in Tables 3.5a and 3.5b.

The two-stage IV is estimated under other specifications- using different or limited combinations of the available covariates. In all cases, insurance does not have a statistically significant effect on yield. Two-stage IV is also analysed under a panel framework. The findings are similar to the pooled estimations. However, the instrumental variables are not valid in the first stage fixed effects model. This could be due to the lagged nature of the instruments. These results are not presented in this Chapter.

To summarise, results show that insurance is endogeneous to yield. Districts with higher insurance coverage are likely to produce higher yield, though this result is not significant. However, these results have to be considered with caution as the underlying insurance component is bundled with formal credit. The next sub-section presents an elaborate discussion on the significance of the district level results.

6.3 Limitations of the district level analysis

An analysis of the impact of insurance on yield is conducted at the district level using both single stage pooled OLS/panel and two-stage IV regression models. In the single stage models, insurance is found to negatively impact yield. In other words, insurance seems to encourage moral hazard behaviour at the aggregate level. However, chloropeth maps indicated the possibility of insurance being directed to areas where yields are historically lower, which could explain this negative association.

Drawing from literature where insurance is assumed endogeneous to output, two-stage IV estimation is also explored. The results confirm the presence of endogeneity and also show a positive association between insurance and yield, but this is not significant.

Evidently, the IV approach is a more appropriate model in this case. Failure to account for the endogeneity of insurance purchase decisions would have led to an incorrect estimation of the association between insurance and productivity.

However, one cannot generalise that insurance has a positive effect on output based on these results. The reasons include aggregate level analysis, mandatory nature of the insurance product and focus on a single crop framework.

The impact of insurance on output is hypothesised based on individual behaviour with and without the presence of insurance. As indicated earlier, insurance could either motivate an individual farmer to employ better agricultural practices or foster a moral hazard effect leading to lower input investment. Clearly, it is not prudent to aggregate such household level decisions at the district or county level.

This study is also restricted due to the non-availability of crop specific input use data at the district level. Input usage in terms of fertilizers, use of high yielding variety seeds etc. are important covariate measures that impact yield. There are very few reliable sources for crop specific input usage at the district level, so these aspects could not be included in the analysis. There is a need to use household data that provides detailed information on crop specific agricultural input, output and insurance coverage to study how insurance could impact input decisions and thus, output variability.

The insurance product in this case is mandatory for all buyers of credit. In an ideal scenario, the insurance is expected to be an added advantage and thus help the farmer earn higher yields. However, several studies on the NAIS functioning (Singh, 2010; Mahajan and Bobade, 2012; AFC, 2012) mention that in most cases, the *loanee* farmers are not even aware that they are insured. There is poor communication at the lender end and farmers are only aware of insurance if and when they receive a payout. The fieldwork experiences through this thesis also validate this fact. Thus, the insurance component is not likely to impact input/output decisions in this case.

Even if the *loanee* farmer is aware that s/he is insured, it may not necessarily impact her/his agricultural decisions. For a farmer in need of funds (loans) for cultivation, insurance could be just another reason (apart from say, taxes) for banks to reduce the amount of loan provided. However, if insurance is purchased voluntarily, it is likely to have an impact on production decisions. In this case, it is a legitimate investment *choice* made by a farmer to hedge against possible crop losses. There is a need to study voluntary insurance policies that are not bundled with any other benefit to truly assess the impact of insurance on output.

Also, the analysis is based on a single crop only. Most farmers grow multiple crops in each season and this diversification may impact how single-crop insurance is valued as a risk management tool. Insurance for one crop may impact input decisions for other non-insured crops grown by a farmer. In some cases, insurance is not likely to alter production decisions for certain crops that require a more intensive input regime. Thus, it is important to understand the association between insurance and production in a multi-crop framework.

Additionally, using aggregate level data makes it difficult to capture individual specific effects of factors such as risk aversion, microinsurance awareness, product literacy etc. on insurance and crop yields.

While there is some credibility in the finding that aggregate, district level insurance has a positive association with yield, it is important to delve deeper into how these dynamics work using a smaller unit of data for voluntary insurance policies. A household or farm level data with a robust mix of both insured and uninsured farmers engaged in multi-cropping is an ideal starting point. The next section describes a similar data set acquired through primary data collection and explores the relationship between insurance and yield in this context.

7. Household level data analysis

A comprehensive analysis of the impact of insurance on inputs needs to incorporate individual farm level data and voluntary insurance products in a multi-crop framework.

Section 3 of Chapter II described a household level dataset collected for two consecutive years in Howrah, West Bengal. The household survey collected through fieldwork focuses on a combination of insured and uninsured farmers. Crop insurance is provided on a voluntary basis under the Weather Based Crop Insurance Scheme or WBCIS to farmers in the district. Insurance is provided for two different paddy varieties grown in the state.

Ideally, household level data from both mandatory and voluntary buyers of insurance will allow a more comprehensive analysis of the associations between insurance and productivity. It will also allow an exploration of some additional themes identified by the analysis on how microinsurance awareness, risk perceptions and product knowledge vary across these two groups. However, this data could not be collected due to reasons mentioned in Section 3 of Chapter II

Since this data set is used for both Chapter III and Chapter IV, only the insurance-output variables are described here. A more detailed description of the study area and the data including information on risk attitudes and past insurance experiences are provided in Chapter IV.

7.1 Description of the household level data

The analysis focuses on paddy farmers. Land under cultivation is around 2.39-2.78 bighas[28] per household and two crops are produced on average each year. Major crops grown are Aman and Boro paddy. Other crops cultivated include potato, maize, wheat, other vegetables and cash crops (refer Table 3.6).

Table 3.6: Crops grown by the sample population (in percentage)

Particulars	2011	2012
Aman paddy	99.30	83.83
Boro paddy	74.88	69.90
Potato	9.00	9.45
Maize	0.00	0.50
Wheat	0.47	0.25
Vegetables	2.84	0.00
Cash crops	0.47	0.25
Others*	9.95	17.16

Note: The above figures represent percentage of farm households growing each crop in a given year. *Other crops refer to flowers, betel etc.

Aman is harvested during December and Boro is harvested during April-May. Insurance is provided for both these crops. Aman is grown for both subsistence and commercial purposes. While Boro was traditionally grown for subsistence, it has slowly emerged as a commercial crop given its higher productivity levels when compared to Aman. At the

[28] 1 bigha (India) =0.3306 acre

district level, the average yield of Aman is 2259 kg/hectare and Boro is 5405 kg/hectare.

Table 3.7 shows the output and insurance averages for Aman and Boro paddy among the sampled households. Production and yield are lower in 2011 due to the heavy rainfall shocks. Production and productivity are higher for Boro when compared to Aman. Output is generally sold to the agents of rice mills in the district at a price, which is higher than the Minimum Support Price (MSP) but lower than the market rate. Boro fetches a better price when compared to Aman. Insurance coverage is higher for Aman paddy. The fact that these paddy varieties are distinct from each other provides an interesting framework for analysis.

Table 3.7: Output and insurance coverage for Aman and Boro paddy

Particulars	Description	2011	2012
Aman			
Households growing Aman	in percentage	99.30	83.83
Area under crop	in bighas	2.61	2.53
Production	in maund[29]	15.27	20.13
Yield	in maund/bigha	6.71	8.18
Sales	in maund	5.01	5.31
Insured households	in percentage	42.65	33.58
Boro			
Households growing Boro	in percentage	74.88	69.90
Area under crop	in bighas	2.52	2.64
Production	in maund	28.24	39.16
Yield	in maund/bigha	12.30	15.56
Sales	in maund	11.61	14.11
Insured households	in percentage	21.32	18.91

Note: Production, yield and sales data are only provided for households that report production for Aman and Boro in 2011.

The study area faced an excess rainfall shock that adversely affected production in 2011. This shock occurred during Aman cultivation and there are a significant number of households that almost lost all of its harvest due to the rains. While these households have provided detailed input usage information, they did not report any output. These households lost either the entire or nearly entire crop in 2011. There are 132 such households in 2011 for Aman. Similarly, 38 households do not report yield for Boro.

[29] 1 maund (India)=37.3 kilogram

7.2 Associations between output and insurance

This section uses the raw data to explore possible associations between insurance and yield. Table 3.8 provides the summary statistics of output measures based on insurance status. The effect of the 2011 rainfall is evident in the table, where the statistics are higher for 2012. Yield is higher for the uninsured during both years for Boro. Area under cultivation is higher in 2011 for all samples.

Correlations between insurance and yield are presented in Table 3.9. The raw data does not reveal any significant associations between insurance and yield in most cases.

Table 3.8: Summary statistics of outputs by insurance status

Particulars	2011		2012	
	Insured	**Uninsured**	**Insured**	**Uninsured**
Aman				
Area under crop	2.89	2.40	2.62	2.46
Production	17.59	12.90	20.02	20.21
Yield	6.73	6.69	7.88	8.38
Boro				
Area under crop	3.10	2.27	3.90	2.18
Production	33.51	25.99	53.72	33.76
Yield	11.46	12.65	15.12	15.72

Note: Please see Table 3.7 for sample sizes and units of measurement for area, production and yield. Production, yield and sales data are only provided for households that report production for Aman and Boro in 2011. 132 and 38 households do not report production for Aman and Boro respectively in 2011.

Table 3.9: Correlation between insurance and yield

Particulars	Pooled sample		2011		2012	
	Rho	**P-value**	**Rho**	**P-value**	**Rho**	**P-value**
Aman insurance						
Aman yield	-0.0510	0.2034	0.0048	0.9355	-0.0899*	0.0993
Boro insurance						
Boro yield	-0.0762*	0.0718	-0.0752	0.2113	-0.0703	0.2401

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Please see Table 3.7 for sample sizes and units of measurement for area, production and yield. The correlations are based on only households that report yield data in 2011 and 2012.

The descriptive statistics do not indicate any particular trends in the associations between output and insurance. The next step is to estimate the relationship using regression models. The econometric modeling strategy is described in Section 7.3.

7.3 Econometric methodology

The econometric methodology for the household level analysis is similar to that of the district level analysis. Both single stage and two-stage least square models are estimated. The description of both models is provided below.

7.3.1 Single stage models

To start with, a single stage pooled OLS model is estimated using a set of covariates. For the household case, the model is set up as follows:

$$Yield_{it}^{k} = \sim + \quad x_{it}^{'} + £_{it}^{k} ....(3.7)$$

where, i represents the household, k represents the crop and t represents the year, $\sim$ is the constant, x_{it} represents a vector of covariates and $£_{it}$ is the error term**.**

Since it is a two-year data panel, the main emphasis is on the pooled OLS model. However, the single stage model is also estimated using panel data models. The fixed effects case is described as follows:

$$Yield_{it}^{k} = \sim_{i}^{k} + \quad x_{it}^{'} + £_{it}^{k} ....(3.8)$$

where, i represents the household, k represents the crop and t represents the year, $\sim_{i}$ represents the individual fixed effects that do not vary over time, x_{it} represents a vector of covariates and $£_{it}$ is the error term**.**

The random effects model, which allows the individual specific ‘fixed’ effects to be treated as random is specified as follows:

$$Yield_{it}^{k} = « + \quad x_{it}^{'} + ¬_{it}^{k} ....(3.9)$$

$$v_{it}^{k} = \sim_{i}^{k} + u_{it}^{k} ....(3.10)$$

where, i represents the household, k represents the crop and t represents the year, « is the constant term, x_{it} represents a vector of covariates and v_{it} is the error term. The error term comprises the individual specific 'random' effects ($\sim_i$) and a combined time series and cross sectional error component (u_{it}). However, since it is a two-year panel, only fixed effects model is estimated for the panel case.[30]

7.3.2 Two-stage IV model

Akin to the district level analysis, a two-stage IV model is estimated assuming the endogeneity of insurance purchase decisions. Equation (3.12) is the structural equation and insurance is estimated using equation (3.11) using a set of instruments and other covariate measures. The predicted values from the first stage are then used to determine the impact of insurance on yield in equation (3.12):

$$Insurance_{it}^{k} = \sim_0 + \ _1 z_{it1}^{'} + \ _2 x_{it2}^{'} + \pounds_{it1}^{k} \quad .... \quad (3.11)$$

$$Yield_{it}^{k} = \sim_1 + \sim_2 Insurance_{it}^{k} + \ _3 x_{it2}^{'} + \pounds_{it2}^{k} \quad .... \quad (3.12)$$

where, i represents the household, k represents the crop and t represents the year. z_{it1} represents a set of instrumental variables, x_{it2} represents a vector of other explanatory variables (including time invariant factors), $\pounds_{it1}$ and $\pounds_{it2}$ are unobserved disturbances that are assumed to be normally distributed with constant variances.

As noted in the district level analysis, F-tests and Sargan tests are conducted to confirm for the relevance and orthogonality of the instruments. Durbin-Wu-Hausman tests are also performed to determine the exogeneity of insurance purchase decisions. A rejection of the null indicates the presence of endogeneity in this case.

Since the insurance product under study in this case is voluntary, the choice of instruments is straightforward when compared to mandatory insurance policies. The instruments are required to impact the insurance purchase decision but not productivity.

[30] The estimates obtained from the random effects model can be provided on request

7.3.3 Validation checks

An important consideration in the household level analysis is that the dependant variable under study, i.e. yield is not reported by all households under study. As mentioned in Section 7.1, 132 households cultivating Aman paddy did not provide production or yield information in 2011. Similarly, 38 households do not provide yield data for Boro in 2011. Due to a severe rainfall shock in 2011, some households lost most of their crop. They incurred either no output or very low output that would not fetch them any income for the season. The details of the rainfall shock and subsequent losses are discussed in Chapter IV.

For this Chapter, it is important to consider this missing data from an econometric standpoint in the analysis of the associations between yield and insurance for Aman and Boro paddy. While the pooled OLS, Fixed Effects and two-stage IV modeling is based on households that report yield only, a hurdle model is also employed to assess if the missing yield data leads to a bias in the estimates.

The basic framework for hurdle model is as follows. There is an event, which at each observation may or may not occur. If it does occur, associated with it will be a continuous, positive random variable. If it does not occur, this variable has a zero value (Cragg, 1971, pp. 829). In this case, the event is 'if the households has reported yield or not'. Accordingly, a two-stage model is estimated taking 'yield reported' (0, 1) as the first stage dependent variable and yield (conditional on reporting) as the second stage dependent variable for Aman and Boro paddy.[31]

The second stage of the hurdle model is compared to the pooled OLS estimates derived from the model that only accounts for reported yields. If the estimates are similar, one can conclude that the missing yields do not create any bias the analysis.

The next section provides the results of the household level analysis for Aman and Boro paddy.

[31] Please refer to Cragg (1971) for a detailed description on the theoretical framework and likelihood function of hurdle models. On Stata, these models can be analysed using the user-written command called 'craggit' developed by Burke (2009)

8. Household analysis results and discussion

This section describes the results obtained from the single and two-stage econometric analysis. Following this, a discussion on the relevance of the results and the use of household level data is also presented.

A description of the variables used in the regression analysis is provided in Table 3.10. This table is divided into two parts. Table 3.10a presents the summary statistics of the yield data for two sub-samples – (i) all households that cultivate Aman/Boro paddy (ii) Only households that report Aman/Boro yields. The pooled OLS, Fixed Effects and two stage IV models are based on only households that report yield i.e. category (ii). Table 3.10b provides a description of the explanatory variables used in the analysis.

Three different specifications are used in both the single stage and two-stage analysis to confirm the robustness of the results. These specifications are described below:

i. Specification 1 does not include risk aversion or household demographic variables in the model
ii. Specification 2 includes a risk aversion term calculated using the Binswanger game described in Chapter II
iii. Specification 3 includes both a risk aversion term and household demographic factors such as respondent age and household size.

The single stage analysis also includes a hurdle model to account for the missing data on yield. The hurdle model incorporates the zero yields and is based on the sub-sample (i) of Table 3.10a.

Table 3.10a: Aman and Boro yield data						
	2011			2012		
Variable name	**Obs.**	**Mean**	**Std. deviation**	**Obs.**	**Mean**	**Std. deviation**
(i) All households that cultivate Aman/Boro paddy						
Aman yield	419	4.60	5.02	337	8.18	2.74
Boro yield	316	10.82	7.90	281	15.56	3.77
(ii) Only households that report Aman/Boro yield						
Aman yield	287	6.71	4.75	337	8.18	2.74
Boro yield	278	12.30	7.26	281	15.56	3.77

Note: The total Aman producers are 756 (419+337) and total Boro producers are 597 (316+281). Out of this 597, only 588 (316+272) grow both Aman and Boro. Only 287 and 278 households report Aman and Boro yields respectively in 2011. This is due to a heavy rainfall shock in 2011, details of which are provided in Section 7 above. Also refer to Chapter IV for more information relating to the rainfall shock.

Table 3.10b: Description and summary statistics of explanatory variables used in the regression analysis					
Variable name	**Description**	**2011**		**2012**	
		Obs.	**Mean**	**Obs.**	**Mean**
Aman insurance	1=insured; 0= otherwise	422	0.43	402	0.34
Boro insurance	1=insured; 0= otherwise	422	0.21	402	0.19
No of crops grown	Number of crops produced in a year	422	1.90	402	1.84
Diversification	1= if the household has multiple sources of income; 0= otherwise	422	0.64	402	0.64
Use machinery	1= if the household uses tractor/tiller; 0= otherwise	422	0.15	402	0.20
Land under crops	Bighas of land under all crops	422	2.78	402	2.39
Cooperative affiliation	1= if the household is affiliated to a cooperative; 0= otherwise	422	0.05	402	0.06
SHG membership	1= if the household is an SHG member; 0= otherwise	422	0.25	402	0.35
Risk aversion	Calculation detailed in Chapter II	422	0.82	402	0.49
Age	in years	422	45.59	402	45.38
Household size	No. of members in the household	422	4.81	402	4.54
Trust insurer	1= if the household trusts insurer; 0= otherwise	422	0.48	402	0.21

Note: Sample size for 2011 is 422 and for 2012 is 402. Barring a few households, the enumerators managed to interview the same respondent during both rounds.

8.1 Pooled OLS results for the household level analysis

The pooled OLS, fixed effects (FE) and hurdle model results for Aman and Boro productivity are presented in Table 3.11a and Table 3.11b respectively.

As mentioned in the earlier section, the first stage analysis mainly focuses on the pooled OLS case. These results are presented in Columns (2), (3) and (4) in Tables 3.11a and 3.11b.

For Aman paddy, the regressions show that insurance has a positive impact on yield, though it is not significant in this case. This could be attributed to several reasons, including the possible endogeneity of insurance. Section 8.2 and 8.3 of this Chapter present a more elaborate discussion.

Among other covariates for Aman paddy, the number of crops cultivated is negatively associated with yield. An extra crop cultivated reduces the yield of Aman paddy by 0.74 maund per bigha *on average and ceteris paribus* as per column (2) of Table 3.11a. This is often the case when there is crop diversification.

Specification (1) of Table 3.11a shows that deriving income from multiple sources increases yield by 0.94 maund per bigha *on average and ceteris paribus* when compared to households that derive income from a single source. Holding multiple occupations increases the annual income of the household, which allows the use of superior technology and inputs in production. It is worth noting that while crop diversification tends to reduce yield per crop, occupation diversification has a positive impact on productivity.

Using machinery such as tractors and tillers increases Aman yield by 1.00 maund per bigha *on average and ceteris paribus* when compared to households that do not invest in machinery. Land under crops is negatively associated with Aman productivity. Yield is significantly higher in 2012.

The second stage results of the hurdle model are provide in columns (8), (9) and (10) of Table 3.11a for Aman paddy. Results are similar to those obtained from the pooled OLS case for each specification, indicating that the missing yields do not bias the econometric estimations for Aman paddy. The first stage hurdle model results are provided in Annexure A3.9.

Table 3.11a: Pooled OLS, Fixed effects and Hurdle model results on the impact of household level crop insurance coverage on Aman paddy productivity									
Particulars	**Pooled OLS**			**Fixed effects model**			**Hurdle model (second stage only)**		
(1)	**Specification 1 (2)**	**Specification 2 (3)**	**Specification 3 (4)**	**Specification 1 (5)**	**Specification 2 (6)**	**Specification 3 (7)**	**Specification 1 (8)**	**Specification 2 (9)**	**Specification 3 (10)**
Aman insurance	0.1147	0.1068	0.0890	-0.3742	-0.4971	-0.4719	0.1321	0.1244	0.1066
	0.2893	0.2930	0.2940	0.9703	0.9759	0.9926	0.3484	0.3520	0.3521
Risk aversion		0.2214	0.2847		0.9291	1.3621		0.2219	0.3013
		0.6771	0.6880		1.2123	1.2256		0.7856	0.8005
Age			-0.0093			-0.1171			-0.0113
			0.0116			0.0973			0.0140
Household size			0.0018			0.3493			0.0096
			0.0719			0.2298			0.0881
No. of crops produced	-0.7404*	-0.7345*	-0.7287*	-1.0117*	-0.9324*	-0.862*	-0.9334*	-0.9271*	-0.9197*
	0.3904	0.3922	0.3931	0.5160	0.5174	0.5130	0.5023	0.5036	0.5039
Diversification	0.9342***	0.9237***	0.9226***	0.3717	0.3238	0.1924	1.1225***	1.1120***	1.1102***
	0.3266	0.3242	0.3254	0.4682	0.4807	0.4988	0.4097	0.4047	0.4055
Use machinery	1.0046**	1.0049**	1.0103**	1.0511	1.0518	1.0442	1.2451**	1.2443**	1.2470**
	0.4405	0.4405	0.4424	0.7394	0.7303	0.7269	0.5388	0.5364	0.5367
Land under crops	-0.2989***	-0.2961***	-0.3008***	-0.4013***	-0.3769***	-0.4041***	-0.3978***	-0.3946***	-0.4015***
	0.0665	0.0660	0.0687	0.1216	0.1266	0.1286	0.1028	0.1016	0.1053
Cooperative member	0.7063	0.7038	0.7356	0.8205	0.7846	0.5427	0.8512092	0.8482	0.8804
	0.7133	0.7157	0.7237	1.1522	1.1417	1.2002	0.8123	0.8145	0.8233
SHG member	-0.1476	-0.1421	-0.1805	-0.7464	-0.7246	-0.7801	-0.1633373	-0.1585	-0.2055
	0.3327	0.3356	0.3408	0.5807	0.5671	0.5671	0.4011	0.4035	0.4084
Year 2012 dummy	1.4816***	1.5504***	1.5673***	1.9051***	2.1857***	2.4501***	1.8104***	1.8785***	1.9010***
	0.3161	0.3879	0.3947	0.3488	0.5568	0.5781	0.3882	0.4771	0.4841
Constant	8.1234***	7.9335***	8.3166***	9.4951***	8.6043***	11.8795***	7.9880***	7.7982***	8.2282***
	0.8763	1.0970	1.1402	1.1800	1.6453	4.5432	1.0832	1.3569	1.4077
No. observations	624	624	624	624	624	624	756	756	756
R-squared	0.0995	0.0996	0.1006	0.1809	0.1838	0.2009			
F value	8.2682	7.4023	6.0523	9.3485	8.4912	7.3145			
Chi2 value							5031.64	5073.88	5114.53

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust standard errors are provided below the coefficients. Specification 1 does not include risk aversion or household demographic variables. Specification 2 includes risk aversion, Specification 3 accounts for age, household size and risk aversion. First stage results from the Hurdle model are presented in Annexure A3.9

Table 3.11b: Pooled OLS, Fixed effects and Hurdle model results on the impact of household level crop insurance coverage on Boro paddy productivity									
Particulars (1)	**Pooled OLS**			**Fixed effects model**			**Hurdle model (second stage only)**		
	Specification 1 (2)	**Specification 2 (3)**	**Specification 3 (4)**	**Specification 1 (5)**	**Specification 2 (6)**	**Specification 3 (7)**	**Specification 1 (8)**	**Specification 2 (9)**	**Specification 3 (10)**
Boro insurance	-0.7020	-0.7309*	-0.7694*	0.4909	0.4841	0.5330	-0.7481	-0.7836	-0.8217
	0.4362	0.4371	0.4480	0.8973	0.9007	0.8828	0.5009	0.5041	0.5149
Risk aversion		-1.7599*	-1.8623*		-0.4554	-0.4439		-1.8957**	-2.0071*
		0.9233	1.0266		1.1372	1.1380		0.9612	1.0723
Age			0.0153			-0.0299			0.0167
			0.0204			0.0511			0.0220
Household size			0.1007			-0.6159*			0.1091
			0.0923			0.3503			0.1001
No. of crops produced	1.0436	0.9840	0.9581	-0.1220	-0.1155	-0.3087	1.1246	1.0613	1.0359
	0.8807	0.8983	0.9033	0.8557	0.8551	0.9029	0.9621	0.9767	0.9787
Diversification	1.2802***	1.3954***	1.3717***	0.7756*	0.8220*	0.8353*	1.3791**	1.5031**	1.4763**
	0.4729	0.4740	0.4655	0.4638	0.4717	0.4858	0.5785	0.5846	0.5705
Use machinery	2.1578**	2.1337**	2.1005**	0.6455	0.6447	0.3855	2.3174**	2.2946**	2.2625**
	0.9561	0.9637	0.9621	0.7839	0.7871	0.6889	1.1006	1.1076	1.1023
Land under crops	-0.2795***	-0.2971***	-0.3078***	-0.2166	-0.2259	-0.1572	-0.3136**	-0.3339**	-0.3479**
	0.1024	0.0996	0.1070	0.1737	0.1765	0.1778	0.1342	0.1327	0.1436
Cooperative member	-0.0189	0.0282	-0.0505	-1.3962	-1.3629	-1.0078	-0.01545	0.0378	-0.0472
	0.8770	0.8949	0.9086	1.1590	1.1631	1.1525	0.9267	0.9440	0.9572
SHG member	-0.4110	-0.4726	-0.4162	0.1506	0.1106	0.2056	-0.4277	-0.4895	-0.4269
	0.3755	0.3757	0.3647	0.5948	0.6073	0.6448	0.4111	0.4113	0.3958
Year 2012 dummy	2.9280***	2.3228***	2.3066***	3.1995***	3.0417***	2.8570***	3.1358***	2.4817***	2.4637***
	0.5326	0.5725	0.5874	0.3578	0.5187	0.5465	0.4289	0.5202	0.5392
Constant	10.2234***	11.7892***	10.8099***	12.4877***	12.8566***	17.3348***	9.7745***	11.4643***	10.3968***
	1.7396	2.2945	2.0711	1.9718	2.2542	3.6795	2.0357	2.5365	2.4123
No. observations	559	559	559	559	559	559	597	597	597
R-squared	0.1161	0.1202	0.1231	0.3051	0.3055	0.3322			
F value	16.8290	16.3772	14.2428	13.0717	11.6230	10.7361			
Chi2 value							825.02	875.61	

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust standard errors are provided below the coefficients. Specification 1 does not include risk aversion or household demographic variables. Specification 2 includes risk aversion, Specification 3 accounts for age, household size and risk aversion. First stage results from the Hurdle model are presented in Annexure A3.9

Table 3.11b present the results for Boro paddy. Under certain specifications, Boro insurance has a negative effect on Boro productivity. Since Boro paddy is an intensive crop with a high cost of cultivation, buying insurance may lower the total investment available for inputs leading to a fall in productivity. However, the results of the two-stage model also need to be considered before drawing a conclusion on this association.

The impacts of other covariates are consistent with normal convention. For instance, income diversification increases Boro yield by 1.28 maund per bigha *on average and ceteris paribus* compared to a single-income farm as per specification (1) of the pooled OLS model.

A one-bigha increase in the land under cultivation reduces Boro yield by 0.28 maund per bigha *on average and ceteris paribus*. Under specification (2) and (3) of Table 3.11b, risk aversion is negatively associated with yield.

A farmer who does not take positive risks in production is likely to experience a lower yield. However, this is significant only at 10%. The year dummy indicates that production was lower in 2011, which is clearly due to the weather shocks experienced.

Akin to the Aman regressions, estimations from the Hurdle model indicate that the analysis is not affected by the missing yield data. However, note that in the hurdle model, the coefficient of the insurance variable is no longer significant for all specifications.

The major findings here is that Aman insurance is positively (but not significantly) associated with yield whereas Boro insurance has a negative and significant (at 10%) impact on Boro output. These results are investigated further in the next section.

8.2 Two-stage IV results for the household level analysis

The two-stage IV results are presented in Table 3.12a and Table 3.12b. Since the data covers only two years, the analysis focuses on pooled data for only households that report yield information.

The instruments used to determine exogeneous insurance purchase decisions are an important consideration. The choice of instruments is straightforward in this case as the underlying insurance product is voluntary. The exogeneous instruments need to capture the choice of insurance purchase and not credit as in the mandatory insurance case.

Drawing from the literature and an understanding of crop microinsurance demand decisions, two suitable instruments are identified for the analysis. The exogeneous determinants of insurance include (i) Trust in the insurance provider and (ii) Insurance purchased for other crops. A description of these variables is provided in the following paragraphs.

Trust in the insurance company is likely to affect the purchase of insurance. A farmer who trusts the insurance company is more likely to purchase insurance on a regular basis. Several factors contribute to trust including receipt of claims, positive past experiences of colleagues/friends/neighbours, known agent etc. All these factors affect insurance choices but not yield. In this study, the respondent is directly asked if s/he trusts the insurance company or not. The resultant dummy measure is used in the regression. Section 5 of Chapter II provides more information of the measurement of this variable.

The second instrument accounts for insurance of the other crop(s). The data as well as field experiences indicate that a farmer is likely to buy insurance only for one crop in a particular year i.e. there could be a negative association between insurance purchases across crops. Alternatively, the experience of purchasing insurance for one crop is likely to affect purchase of the other crop. In this case, the relationship could be positive or negative depending upon the experiences of purchasing the first insurance. This will affect only insurance purchase and not yield.

The regressions for Aman paddy are presented in Table 3.12a. Findings indicate that insurance has a positive and significant impact on yield. Note that this variable was not significant in the pooled OLS single stage model.

The impacts of other covariates are similar to the pooled OLS case. An extra crop cultivated reduces the yield of Aman by 0.91 maund per bigha *on average and ceteris paribus*. Income diversification increases yield by 0.93 maund per bigha *on average and ceteris paribus*.

Land under crops has a negative association and use of machinery is positively associated with higher output. Yield is significantly higher in 2012. These results are based on specification (1) of Table 3.12a

Among the exogeneous determinants of Aman insurance, trust in the insurer is positively correlated with insurance purchase. A farmer who trusts the provider is 67.8 percentage points more likely to purchase Aman insurance *on average and ceteris paribus*.

On the other hand, a farmer who has already purchased insurance for Boro is 13 percentage points less likely to buy Aman insurance *on average and ceteris paribus* as per column (2) of Table 3.12a.

The Hansen's J statistic presented in Table 3.12a indicates that the null hypothesis of instrument validity cannot be rejected. Exogeneity tests using the Durbin-Wu-Hausman statistic confirm the endogeneity of Aman insurance to productivity at the household level.

The results for Boro paddy are presented in Table 3.12b. Boro insurance is negatively associated with output. However, this association is not statistically significant. The effects of other covariates are similar to the pooled OLS case.

A household with multiple sources of income is likely to harvest a 1.28 maund per bigha higher Boro yield when compared to a single income household *on average and* *ceteris paribus* as per column (2) of Table 3.12b. Use of machinery increases output by 2.18 maund per bigha *on average and ceteris paribus.*

A unit increase in the bighas of land under cultivation reduces Boro yield by 0.27 maund per bigha *on average and ceteris paribus.* Productivity is significantly higher in 2012. All these results are based on Specification (1) of Table 3.12b.

The impacts of the exogeneous determinants of Boro insurance also confirm to convention. Trust in the insurance company increases Boro insurance purchase by 46 percentage points *on average and ceteris paribus.* Investment in Aman insurance is likely to negatively impact Boro insurance purchase to the extent of 8.4 percentage points *on average and ceteris paribus* as per column (2) of Table 3.12b.

Instruments are valid under the Hansen's J statistic presented in Table 3.12b. In this case, the null hypothesis of insurance exogeneity cannot be rejected under the Durbin-Wu-Hausman test indicating that Boro insurance is not endogeneous to output. This is plausible as Boro is an intensive crop with fixed input requirements. The presence of insurance is not likely to alter the use of the overall input investment, which in turn, will not affect output.

To understand this further, it is important to carefully analyse the inputs used in Boro production and how each input responds to an insurance component.

Table 3.12a: Two-stage IV results on the impact of household level crop insurance coverage on Aman paddy productivity

Particulars (1)	Specification 1		Specification 2		Specification 3	
	First stage (2)	Second stage (3)	First stage (4)	Second stage (5)	First stage (6)	Second stage (7)
Trust in the insurance company	0.6679***		0.6648***		0.6590***	
	0.0319		0.0322		0.0331	
Insurance for the other crop (Boro)	-0.1281**		-0.1229**		-0.1215**	
	0.0547		0.0545		0.0548	
Aman insurance		0.9114*		0.9052*		0.8913*
		0.4717		0.4764		0.4804
Risk aversion			0.0900	0.1022	0.0886	0.1585
			0.0691	0.6812	0.0693	0.6926
Age					0.0002	-0.0080
					0.0011	0.0116
Household size					-0.0076	0.0225
					0.0060	0.0721
No. of crops produced	0.1376***	-0.9109**	0.1398***	-0.9075**	0.1384***	-0.8973**
	0.0247	0.3854	0.0249	0.3872	0.0248	0.3879
Diversification	0.0055	0.9318***	0.0016	0.9270***	0.0045	0.9179***
	0.0326	0.3256	0.0327	0.3228	0.0331	0.3231
Use machinery	-0.1406***	1.1217**	-0.1400***	1.1215**	-0.1381***	1.1204**
	0.0437	0.4412	0.0437	0.4410	0.0436	0.4414
Land under crops	0.0014	-0.3055***	0.0023	-0.3042***	0.0041	-0.3127***
	0.0091	0.0658	0.0092	0.0654	0.0094	0.0682
Cooperative member	-0.0322	0.6785	-0.0341	0.6774	-0.0301	0.6934
	0.0690	0.7105	0.0690	0.7115	0.0695	0.7199
SHG member	0.1137***	-0.2717	0.1154***	-0.2688	0.1164***	-0.3014
	0.0349	0.3317	0.0349	0.3349	0.0352	0.3392
Year 2012 dummy	0.0683**	1.5966***	0.0954***	1.6280***	0.0917**	1.6471***
	0.0304	0.3195	0.0355	0.3873	0.0358	0.3925
Constant	-0.0958**	8.0830***	-0.1730**	7.9955***	-0.1452*	8.2289***
	0.0440	0.8844	0.0718	1.0967	0.0876	1.1480

Table 3.12a continued: **Two-stage IV results on the impact of household level crop insurance coverage on Aman paddy productivity**						
	Specification 1		**Specification 2**		**Specification 3**	
Particulars (1)	**First stage (2)**	**Second stage (3)**	**First stage (4)**	**Second stage (5)**	**First stage (6)**	**Second stage (7)**
Number of observations	624	624	624	624	624	624
F value (overall significance of the regression)	106.5339	8.8057	99.6133	7.8671	84.3367	6.4021
Prob >F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Centered R2	0.4375	0.0900	0.4392	0.0902	0.4403	0.0913
Uncentered R2	0.6899	0.8096	0.6909	0.8096	0.6915	0.8099
Instruments validation						
Cragg-Donald Wald F statistic		182.1950		180.7810		171.4600
Under identification test						
Anderson canon. corr. LM statistic	185.5210	0.0000	184.0980	0.0000	176.2940	0.0000
Chi2 value/P-value						
Over identification/validity of all instruments						
Hansen's J statistic						
Chi2 value/ P-value	0.6190	0.4315	0.6140	0.4331	0.5540	0.4566
Endogeneity tests						
Durbin-Wu-Hausman						
Chi2 value/P-value	6.1380**	0.0132	6.0850**	0.0136	5.9080**	0.0151

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust standard errors are provided below the coefficients. Specification 1 does not include risk aversion or household demographic variables. Specification 2 includes risk aversion, Specification 3 accounts for age, household size and risk aversion. The null hypothesis of exogeneity of insurance purchase is rejected under all specifications.

Table 3.12b: Two-stage IV results on the impact of household level crop insurance coverage on Boro paddy productivity

Particulars	Specification 1		Specification 2		Specification 3	
	First stage (2)	Second stage (3)	First stage (4)	Second stage (5)	First stage (6)	Second stage (7)
(1)						
Trust in the insurance company	0.4642***		0.4657***		0.4791***	
	0.0492		0.0491		0.0483	
Insurance for the other crop (Aman)	-0.0844*		-0.0825*		-0.0798*	
	0.0480		0.0480		0.0477	
Boro insurance		-1.0558		-0.9576		-0.7230
		1.2545		1.2324		1.1362
Risk aversion			-0.1078	-1.7749*	-0.1328*	-1.8586*
			0.0710	0.9504	0.0700	1.0544
Age					0.0030**	0.0152
					0.0012	0.0211
Household size					0.0108	0.1006
					0.0085	0.0908
No. of crops produced	-0.1127***	0.9977	-0.1166***	0.9541	-0.1208***	0.9643
	0.0431	0.9747	0.0426	0.9894	0.0426	0.9848
Diversification	0.0032	1.2746***	0.0106	1.3928***	0.0106	1.3723***
	0.0353	0.4713	0.0363	0.4705	0.0363	0.4617
Use machinery	0.0369	2.1788**	0.0354	2.1470**	0.0301	2.0979**
	0.0472	0.9122	0.0469	0.9208	0.0467	0.9191
Land under crops	0.0269***	-0.2656**	0.0257***	-0.2883**	0.0245***	-0.3096**
	0.0086	0.1321	0.0086	0.1265	0.0085	0.1312
Cooperative member	0.1753**	0.0738	0.1772**	0.0880	0.1608**	-0.0624
	0.0759	0.9442	0.0764	0.9581	0.0768	0.9596
SHG member	-0.0064	-0.4173	-0.0103	-0.4772	0.0009	-0.4156
	0.0378	0.3741	0.0378	0.3745	0.0377	0.3593
Year 2012 dummy	0.0926***	2.9203***	0.0561	2.3127***	0.0538	2.3088***
	0.0323	0.5249	0.0389	0.5749	0.0383	0.5859
Constant	0.2362***	10.3807***	0.3307***	11.9032***	0.1655	10.7902***
	0.0913	2.0775	0.1083	2.6554	0.1239	2.2955

Table 3.12b continued: **Two-stage IV results on the impact of household level crop insurance coverage on Boro paddy productivity**

Particulars (1)	**First stage (2)**	**Second stage (3)**	**First stage (4)**	**Second stage (5)**	**First stage (6)**	**Second stage (7)**
Number of observations	559	559	559	559	559	559
F value (overall significance of the regression)	26.1518	17.5513	23.9099	16.8095	22.5559	14.2550
Prob >F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Centered R2	0.2601	0.1155	0.2627	0.1199	0.2751	0.1231
Uncentered R2	0.4705	0.8620	0.4724	0.8627	0.4813	0.8632
Instruments validation						
Cragg-Donald Wald F statistic		67.7260		68.4660		72.8820
Under identification test						
Anderson canon. corr. LM statistic						
Chi2 value/P-value	89.2200	0.0000	90.0910	0.0000	93.7930	0.0000
Over identification/validity of all instruments						
Hansen's J statistic						
Chi2 value/ P-value	1.1080	0.2926	1.3500	0.2452	1.5990	0.2061
Endogeneity tests						
Durbin-Wu-Hausman						
Chi2 value/P-value	0.5760	0.4477	0.4430	0.5054	0.1620	0.6874

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust standard errors are provided below the coefficients. Specification 1 does not include risk aversion or household demographic variables. Specification 2 includes risk aversion, Specification 3 accounts for age, household size and risk aversion. The null hypothesis of exogeneity of insurance purchase cannot be rejected under all specifications

8.3 Discussion

The household level analysis focuses on voluntary insurance products provided for two crops in Howrah, West Bengal. The two crops under consideration i.e. Aman and Boro paddy are distinct from each other in their input structure, cost of cultivation and average yield rates. Aman has a more flexible input requirement structure while Boro incurs a higher cost of cultivation due to its intensive cropping nature. This allows a more detailed analysis on if and how insurance affects output in the short run for each crop.

The results indicate that the impact of insurance on yield is not homogeneous across crops. Aman paddy insurance decisions are endogenous to output justifying the use of two-stage IV estimation. The second stage structural model confirms that Aman insurance has a positive impact on Aman productivity. On the other hand, Boro insurance decisions are exogeneous to productivity. Under the single stage pooled OLS approach, Boro paddy is negatively associated with insurance. There are several implications of these results.

The first implication relates to the endogeneity of insurance purchase decisions to output. Most of the literature focuses on crops such as corn, soybean, cotton etc. in the USA. Nearly all of these studies indicate that insurance is endogeneous to output and use a two-stage modeling framework. This Chapter, however, substantiates that insurance is not necessarily endogeneous to output for all crops. There are certain crops for which an insurance intervention is not likely to significantly alter output.

Secondly, the results seem to imply that Aman insurance fosters a risk reduction effect on input leading to an increase in output whereas Boro insurance leads to a either moral hazard or substitution across inputs reducing productivity. However, this may not hold true with respect to each specific input. For instance, insurance may encourage farmers to use higher quality seeds in production, which may reduce the amount of money available for other inputs such as fertilizers. Using higher quality seeds is a risk reduction measure whereas lesser fertilizers represent a moral hazard effect. Though the net impact of this may be lower productivity, it cannot be assumed that the farmer wholly indulged in moral hazard, particularly because the underlying product is based on a rainfall-index. The fact that payouts are not assessed by individuals, but through rainfall gauges located at the block level reduces the possibility of moral hazard to a great extent. It is important to study the impact of insurance on each individual input rather than consider the net effect of all inputs by evaluating output to effectively capture the possible effects of insurance on output levels.

Finally, it is also important to note that the results for both Aman and Boro are only significant under certain specifications. It may be the case that insurance decisions can alter input investments in the short run but significantly impact output only in the medium or long term. This means that while the results presented in this Chapter have their own standing, it is important to take this investigation one step further to trace how insurance impact output through a study of individual inputs.

Based on all above implications, there is a need to explore if and how input decisions are altered by an insurance intervention. Chapter IV of this thesis estimates the impact of insurance on input usage using the same dataset.

The next section presents a summary of the findings from both the district and household level analysis and concludes the Chapter.

9. Conclusion

This Chapter evaluates the impact of *ex-ante* crop insurance on output. The initial premise of this study was that insurance affects input decisions that could in turn impact acreage, production and/or productivity. Based on an analysis of literature, output is measured using productivity or production per unit area for this study.

The study is a significant addition to the existing literature due to both the structure and the findings of the analysis. In terms of structure, the study incorporates different types of insurance buyers and examines impacts at both individual and aggregate levels.

The fact that Indian crop microinsurance provides both mandatory and voluntary insurance provided a broad framework for the analysis. To recall, mandatory insurance is bundled with formal credit purchased for agricultural purposes in a given season.

Mandatory and voluntary buyers are bound to react differently to insurance interventions. The fact that most mandatory farmers are not even aware that they are insured presents an interesting case for analysis.

Another structural contribution is the use both district level as well as household level data for paddy crops to estimate the impact of crop microinsurance on productivity in different parts of India. Existing literature focuses on either district/county level or household level data only, though the latter is preferred as it captures individual farm behaviour more effectively. The studies that use both aggregate and individual level data use the aggregate information only to construct historical indices that are used in the household regression analysis.

In terms of findings, the district level analysis is inconclusive on the impact of crop microinsurance on yield. The coefficient of insurance in the two-stage IV analysis is not significant. However, the findings from the district level analysis cannot be fully considered as they are based on a mandatory product, i.e. bundled with formal credit. It is difficult to fully delineate the effect of the insurance component from the formal loan. This means that the study is more likely to have estimated the impact of formal credit on output, rather than crop insurance on productivity.

The district level analysis also fails to account for the individual behavioural responses to an insurance component as it is based on an aggregate level that averages out household specific effects.

The household analysis is preferable given its focus on smaller unit, voluntary insurance for two varieties of paddy crops- Aman and Boro. The primary level data collection using a purpose-designed questionnaire also allows the use of variables such as risk attitudes, diversification measures and insurance experiences that account for individual behavioural dynamics that affect both insurance and output.

The findings indicate that the impact of insurance differs across crops. Voluntary crop microinsurance could either positively or negatively impact output based on crop cultivation techniques and input-requirement structures. Aman paddy, which is more flexible to input variations, responds positively to an insurance intervention.

The household analysis also indicates that trust in the insurance provider is crucial determinant of voluntary insurance purchase. Similarly, risk aversion is negatively associated with both insurance and productivity for Boro paddy. Households that are risk averse prefer to not purchase crop insurance on a voluntary basis. This could mean that insurance is viewed as a 'risky' production investment and households prefer to invest in the traditional, informal techniques of risk coping. The negative association between productivity and risk aversion also demonstrates the preference of traditional agricultural inputs and techniques as highlighted in Section 1 of this Chapter.

As an empirical contribution, the household level analysis shows that insurance is not necessarily endogeneous to output for all crop types. The extent to which insurance purchase decisions are correlated with the unobservable factors that determine output depends on the nature of the underlying crop in consideration. Crops such as Boro paddy that have a fixed input requirement structure are less likely to be affected by insurance interventions.

As a final note, the usage of both NAIS and WBCIS schemes in the study help evaluate how output responds to an insurance intervention for both area yield index and weather index based products. While it is clear that, both schemes could result in a risk reduction effect based on the underlying crop, the case of moral hazard is low in WBCIS.

In this context, there is a need to understand how insurance could impact output through the use of inputs under weather index based insurance schemes. The next Chapter uses the same household level dataset to examine how rainfall index insurance impacts the usage of each individual input for both Aman and Boro paddy. It also explores the possibility of *substitution effect*, apart from the risk reduction and moral hazard effects of weather index based crop microinsurance on production.

Chapter IV

Impact of crop microinsurance on the use of agricultural inputs

1. Introduction

Farm households across developing countries deal with risk and uncertainty on a regular basis. The possibility of incurring losses due to unanticipated shocks tends to have a substantial effect on a farmer's production decisions.

Households whose consumption levels are close to subsistence and highly vulnerable to income shocks are likely to cultivate safer, traditional crops rather than riskier, high-yielding variety crops. Such households also tend to make low investments in chemical inputs and prefer to use traditional inputs and production techniques. While these measures ensure an average level of output, the production possibilities of the household is restricted due to lower investments in newer technology, better inputs and advanced methods of production.

There is a need for some kind of an external stimulus that can play a catalyst in allowing farmers to embrace new technology. The presence of *ex-ante* risk management mechanisms such as crop microinsurance may play a critical role in enabling farmers to accept and invest in riskier, better quality inputs in production leading to an increase in overall output. This is referred to as the risk reduction effect of crop microinsurance investments. A moral hazard effect could also emerge leading to lower investments across all inputs in anticipation of insurance claims.

Chapter III focused on the impacts of crop microinsurance on output. The measurement of output is fairly straightforward. However, several inputs are used in production. Each input has its own unique contribution not just towards output levels, but also the downside production risks. Though all input applications are aimed at increasing output, some inputs may be 'riskier' than others. For instance, high yielding variety (HYV) seeds help in producing higher yields, which can fetch a higher output price. However, using HYV seeds is also a risk as poor rainfall and inadequate fertilizer usage could result in much lower output when compared to the output produced using traditional seeds under similar circumstances. It is important to individually evaluate each input, rather than study the collective impact of all inputs via output.

This Chapter is one of the first attempts to study the impact of crop microinsurance on a range of inputs such as seed variety, fertilizers, pesticides, irrigation and hired labour in a non-randomised framework. The study focuses on two types of paddy - Aman and Boro - with distinct input requirements.

Primary data is collected using a purpose-designed survey from insured and uninsured farmers in Howrah, West Bengal. A private insurance company provides crop insurance on a voluntary basis under the Weather Based Crop Insurance Scheme (WBCIS) to *non-loanee* farmers in the district. Ideally, primary data from both mandatory and voluntary buyers of insurance will help evaluate how each group changes input allocations due to the insurance intervention. However, it is difficult to incorporate household level information on mandatory buyers of insurance for several reasons outlined in Chapters II and III.

Crop microinsurance is expected to foster risk reduction or moral hazard effect on output. The underlying insurance scheme in this case, WBCIS, determines claims using weather stations and not through actual field investigation. Thus, insurance is not likely to influence moral hazard behaviour for an informed farmer. A risk reduction effect is however plausible.

This Chapter proposes that insurance interventions could also lead to a *substitution effect*. A farmer has a basic amount of money for input financing in a given season. Since both insurance and input purchases have to be funded from this amount of money, the farmer who chooses to buy insurance is required to immediately reallocate the finances across all inputs to include the insurance component. In this case, it is interesting to study which inputs are discarded or purchased in lower amounts in favour of crop microinsurance.

In line with the themes of the thesis, this Chapter also explores the roles of risk aversion, product knowledge and trust in the insurance provider and local institutions either implicitly or explicitly under various sections of the analysis.

The econometric framework in this case also requires some deliberation. Insurance and input decisions are made *ex-ante*, i.e. at the beginning of the cropping season. This means that both insurance and inputs decisions could be endogeneous to each other. In other words, these decisions could be simultaneous to each other. It will be interesting to study the dynamics that emerge when both input and insurance investments have to be made within the same time frame.

Results indicate that the impact of crop microinsurance varies based on the type of crop and its significance in the income portfolio of a farmer. While crop microinsurance encourages the use of HYV seeds for commercial crops, it reduces chemical usage for crops that have a more flexible input mix.

As an additional contribution, the study demonstrates how the nature of the endogeneity or simultaneity of insurance and input purchase decisions is different for each input based on its availability, and nature of usage in the cultivation process.

The rest of this paper is organised as follows: Section 2 details the existing literature on insurance and inputs, Section 3 provides a description of the primary data and Section 4 underlines the econometric methodology. Section 5 presents the analysis, Section 6 discusses the findings and Section 7 concludes the Chapter.

2. Literature review

The previous Chapter compiled evidences on the impact of insurance on output. This Chapter takes a more intricate perspective on the immediate effects of crop microinsurance on the usage of inputs. While the definition and role of output in production is quite clear, it is not the same for inputs. A variety of inputs are used in production and each has their own specific relevance in the crop cultivation process. The roles played by inputs also vary across crops, seasons and geography.

The common inputs used in production are seeds, pesticides, fertilizers, irrigation, labour (human and animal). All these inputs may be applied either manually or through machinery. While all inputs are essentially used to increase yield, certain inputs may also increase the variability of yield (Just and Pope, 1978). The example relating to

HYV seeds mentioned in the earlier section is relevant here. Thus, it is important to critically evaluate the role played by different inputs in production for a comprehensive analysis on the role of insurance in input allocation behaviour.

An additional consideration is the timing of purchase decisions for inputs and insurance. Since both these decisions are typically made at the beginning of the season, the econometric methodology and the underlying assumptions governing the modeling need to be reviewed.

The literature review section incorporates a brief overview on input usage in agriculture as well as a detailed review on the impact of crop microinsurance on input provisioning. This section is organised in three parts. The first part examines the nature of agricultural inputs in production and the second part focusses on the impact of insurance on input allocation patterns. The final sub-section presents the gaps in literature and the contributions of the Chapter in this context.

2.1 Agricultural inputs

The notion that inputs could impact the variability of output was first put forth by Just and Pope (1978). Pope and Kramer developed a formal definition in 1979. An input is defined as marginally risk increasing (decreasing) if the marginal risk premium is positive (negative) at the optimum for the risk-averse firm. In other words, risk increasing (decreasing) inputs refer to inputs which may reduce the occurrence of low yields but increase (decrease) yield variability overall (Chatterjee, 2010). From a farmer’s perspective, if the marginal risk of an input is positive (negative), then the risk averse producer will use less (more) of that input (Roll et al., 2006).

Under this convention, several studies have explored the risk natures of different inputs. For instance, irrigation is risk decreasing as it reduces the effect of uncertain rainfall (Chavas, 2004). Similarly, Roll et al. (2006) show that labour has a risk decreasing effect, while land and pesticides have a risk-increasing effect based on a cross-section of subsistence farmers in Tanzania. Contrarily, Pope and Kramer (1979) show that pesticides have a risk decreasing effect on output.

With respect to fertilizers, Yusef et al. (2009) use a moments approach to show that fertilizers increase downside risk in production based on two-year cross-section of farmers in the Ethiopian highlands. They argue that any policy design that propagates an increased use of fertilizer should be complemented by a strategy to ensure that farm households are hedged against this downside risk. Roll et al. (2006) also find a similar effect of fertilizers on yield.

However, one must also bear in mind that the extent to which an input is risk increasing or decreasing also depends on the nature of the crop and the mineral content of the soil on which the crop is cultivated. For instance, Paulson and Babcock (2010) show that an input can be simultaneously defined as risk increasing and over-applied by both risk-neutral and risk-averse producers. They find that though the risk averse farmers choose fertilizers application rates below those of the risk neutral producers, both tend to apply more fertilizer when nitrogen availability is uncertain based on a sample in Iowa, USA.

To summarise, inputs may be either risk increasing or risk decreasing to output. The nature and extent to which these associations pan out depends on the crops and locations under study. The next section presents a review of literature on the impact of insurance on different inputs.

2.2 Inputs and insurance

The relationship between inputs and insurance has been studied from both a theoretical and empirical standpoint. Ahsan, Ali and Kurian (1982) made one of the first attempts to provide a theory on the direct provision of crop insurance by the public sector. They develop a model of crop insurance as a decentralised plan where farmers determine factor utilization taking the insurance contract as given. In turn, the agency chooses optimal contract so as to maximise output.

The theoretical framework to ascertain the impact of insurance on input use was set by Ramaswami (1993). He proposes that since insurance reduces risk, risk averse decisions could move towards risk neutral decisions encouraging farmers to use better quality and risk increasing inputs in production (risk reduction effect).

Alternatively, insurance could also lead to a moral hazard effect,[32] which reduces the use of inputs and decreases mean output. Liu and Black (2004) extend the above model for a two-shock case and propose that, risk reduction effect tends to increase risk-increasing input use, but has an indeterminate influence on risk-decreasing input use for all constant and decreasing risk averse utility functions.

Though the theoretical work in this space is limited to the above, there is extensive empirical literature on the impacts of insurance on output especially for the US markets. A range of approaches have been employed to explore this relationship, including: (i) econometric modeling via regressions or randomised control trials (ii) simulations and (iii) mathematical optimisation.

One common theme that cuts across most of the literature, irrespective of the modeling approach, is the importance of considering the *timing* of input investment and insurance purchase decisions. There could be three possible scenarios (Smith and Goodwin, 1996):

i. Crop insurance is offered prior to input allocation: In this case, the amount of crop insurance purchased could determine the quantity of inputs used.
ii. Crop insurance is offered after input allocation: In this case, the amount of insurance purchased may depend on the amount already invested in inputs.
iii. Crop insurance and input use decisions are made simultaneously: This is closest to the real world scenario where both insurance purchase and input allocation decisions are made at the start of the cropping season.

The initial empirical research in this space, conduct by Horowitz and Lichtenberg (1993), examines a cross section of 376 corn farmers in the US to find that insured farmers use more nitrogen, pesticides and insecticides indicating a risk reduction effect. They use a two-step regression framework under the assumption that crop insurance is

[32] Quiggin et al. (1993) highlight that it is important to distinguish between moral hazard and adverse selection to understand the impacts effectively. *Moral hazard* means that the insured person's optimal decision may change as a result of taking out insurance. Because the insurance contract reduces the loss associated with the insured event, such changes in behavior will normally increase the probability of the insured event occurring or the severity of the loss. *Adverse selection* means that people who are more likely to suffer the insured event will be more willing to insure at a given rate. In our framework, we are only interested in moral hazard and not adverse selection.

endogenous to input purchase decision making. In response to this, Smith and Goodwin (1996) suggest that both insurance and input use decisions are simultaneous to each other. They use a simultaneous equations model on data from wheat farmers in Kansas, USA to report that insurance reduces the use of chemical inputs in production.

Following the Smith and Goodwin article, most of the regression based studies in this space have used simultaneous equations approach to study impacts. The findings of these studies have been quite mixed – showing risk reduction effects in some cases and moral hazard in others.

Studies that find risk reduction effects of insurance on inputs include Karlan et al. (2012) and Cole et al. (2012). The former uses a randomized field experiment on maize producers in north Ghana to show that insurance leads to larger agriculture investment and riskier production choices in the medium term. The two stage instrumental variable approach observes 512 maize farmers during the period 2008-2011.

Cole et al. (2012) also find that insurance induces farmers to switch to higher risk (and higher return) crops using 1063 farm households in Andhra Pradesh, India. Both these papers study the impact of insurance on a range of inputs such as fertilizers, pesticides, seeds, labour and land preparation costs among others. Funing et al. (2006) also find that a cotton farmer who applies more fertilizer is more likely to purchase crop insurance in China using a simultaneous equations approach indicating a risk reduction effect.

Some other articles conclude that insurance leads to a moral hazard effect on inputs. Quiggin et al. (1993) use a two-step Cobb-Douglas framework controlling for endogeneity of both insurance and input use to show that insured wheat farmers in the US have lower observed levels of variable inputs and lower total factor productivity when compared to uninsured farmers. However, these results are not statistically significant.

Goodwin et al. (2004) find that insurance participation is lower for farms that use greater chemicals and fertilizers using an instrumental variable approach in the context of GMM on US federal insurance data. The crops covered here are corn, soybean, wheat and barley. Similarly, Nimon and Mishra (2001) uses a simultaneous equations approach to conclude that that moral hazard effect of federally subsidized revenue insurance products induces U.S wheat farmers to increase expenditures on pesticides and reduce expenditures on fertilizers, though, the overall effect is ambiguous.

There is also a pool of literature that uses simulations and mathematical optimization to study insurance and input use. Some relevant articles showing a risk reduction effect include increase in nitrogen consumption in tomato and wheat cultivation due to insurance in Italy (Capitanio, 2008) and increase in fertilizer consumption by 1-3% in Texas, USA for insured cotton farmers (Seo et al., 2004).

On the same lines, Hazell et al. report that an actuarially fair and complete insurance programme leads to higher expected production levels and a shift towards riskier crops based on a survey in Mexico (as cited in Ramaswami, 1993). Studies by Miller and Walter, King and Oamek, and Gardner and Kramer identify that disaster assistance (in the form of insurance or otherwise) encourages the production of riskier crops on marginal lands (as cited in Glauber, 2004).

On the other hand, Babcock and Hennessy (1994) simulate that insurance increases input application for corn farmers in USA if more inputs increase the probability of low yields indicating a moral hazard effect.

Among other findings, Turvey et al. suggest that partial insurance may help in correcting an insured's incentive to indulge in moral hazard using a simulations framework. They add that policy makers and/or crop insurers should consider introducing *ex-ante* regulations on minimum input use combined with closer monitoring in order to deliver more efficient agricultural insurance to farmers.

The literature is not conclusive on the effects of insurance on inputs. Studies show a positive or negative effect relative to crops and location of the study. The next section presents some important inferences from the literature and the contributions of this Chapter.

2.3 Inferences from the literature

The above sections compile both literature on the impacts of insurance as well as nature of different inputs used in production. Akin to Chapter III, most of the literature on insurance and inputs is focussed on the US federal insurance programme. Another aspect that emerges is that most of the analysis is restricted to chemical inputs such as fertilizers and pesticides only. Very few studies focus on multiple crops.

Since inputs by themselves contribute to production risk in different ways, it is useful to study the impacts of insurance on a range of inputs. This will help evaluate how each specific input responds to insurance and how these individual impacts collectively affect output. The findings from Chapter III also endorse assessments of these associations in a multi-crop insurance framework.

Drawing from the above, this Chapter uses the household survey data collected from Howrah to estimate the relationship between inputs and insurance. The inputs under study include seeds, fertilizers, pesticides, irrigation and human labour for two varieties of paddy, namely, Aman and Boro. The insurance product under study is a weather index based insurance cover provided on a voluntary basis to households in this district.

With respect to methodology, the major empirical work is based on regression analysis on household or farm level data. The empirical modeling of insurance and output is more straightforward as insurance is an *ex-ante* investment and output is generated at the end of the season. This is not the case for inputs. Both insurance and input investment decisions are *ex-ante* to production. Most of the literature thus employs simultaneous equation models to study the impacts of insurance on inputs.

In order to effectively incorporate the timing of purchase decisions, this study starts with a basic single stage pooled OLS approach and then goes on to explore both the endogeneity and simultaneity of insurance purchase and input investment decisions.

Finally, as mentioned in Section 1, this Chapter makes a case for a *substitution effect*. The product under study is a voluntary Weather Based Crop Insurance Scheme (WBCIS). The payouts are determined by an independent third party, i.e. a local weather station. Thus, there is no scope for moral hazard. This is applicable at least for the informed farmer who has proper product and claim processing knowledge.

Rather, insurance could lead to a simple *substitution effect*. In this case, insurance purchase reduces the total funds available *ex-ante* for all agricultural investments. The farmer is then forced to ration the available resources among insurance and inputs required for production. This aspect is explored in greater detail in the later sections.

The next section describes the dataset used in the analysis. This is followed an explanation of the econometric modeling framework.

3. Survey design and data

As mentioned in the earlier section, this Chapter's estimations are based on the Howrah household survey data. To reiterate, primary data is collected over two consecutive years i.e. 2011 and 2012 from Aman and Boro paddy cultivators in Howrah, West Bengal. A brief description of this data has been provided in both Chapter II and Chapter III.

This section outlines the differences between Aman and Boro paddy with respect to input usage and presents the findings of the variables that capture risk aversion and insurance experiences of the sample. Recall that Chapter III also tracked certain rainfall issues experiences by sampled households during 2011. The first sub-section describes these rainfall vagaries in greater detail. It also highlights some of the other significant events that may impact the input analysis.

3.1 Significant events in Howrah during 2011 and 2012

There are certain significant events that took place in Howrah during the study period that impacts both the data collection and the analysis.

Average annual rainfall in Howrah is around 1100 mm. The monsoon season is around July-October and there is very little rain in the other months of the year. However, rainfall has been consistently high in past years and was particularly heavy during 2008-

09 and 2011-12 (see Table 4.1a and 4.1b). Significant losses were incurred in 2008-09 following the cyclone *Aila* that caused damages to life and property in Bangladesh and some parts of West Bengal. The ICICI Lombard insurance was launched on a voluntary basis during 2009-10 immediately following this disaster and thus saw an impressive uptake across the district.

Table 4.1a: Season-wise and Annual rainfall distribution in Howrah during 2008-09 to 2012-13			
Year	**Annual rainfall (June-May)**	**June-Nov**	**Dec-May**
	in mm	**Aman**	**Boro**
2008-09	1897.3	1565.3	332.0
2009-10	1095.3	975.3	120.0
2010-11	1329.6	1106.1	223.5
2011-12	1406.0	1257.8	148.2
2012-13	1057.7	1017.4	DNA

Source: Indian Meteorological Department (IMD). DNA denotes that data is not available.

Table 4.1b: Monthly rainfall distribution in Howrah during 2008-09 to 2012-13

Year	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**
2008-09	562.5	312.6	258.1	362.1	70.0	0.0	0.0	0.0	0.0	4.0	0.0	328.0
2009-10	43.9	371.3	195.7	298.6	65.8	0.0	0.0	0.0	11.0	0.0	2.2	106.8
2010-11	175.3	212.8	350.6	204.3	160.1	3.0	18.8	4.9	5.3	29.2	38.0	127.3
2011-12	292.8	255.9	433.7	251.5	23.9	0.0	0.0	81.0	14.5	0.0	34.4	18.3
2012-13	226.5	240.8	155.2	256.7	111.9	26.3	40.3	DNA	DNA	DNA	DNA	DNA
1996-2005 Average	219.2	DNA	301.9	231.5	170.5	24.9	4	16	12	44.3	58.6	105.5

Source: West Bengal State Marketing Board website[33]. DNA denotes that data is not available.

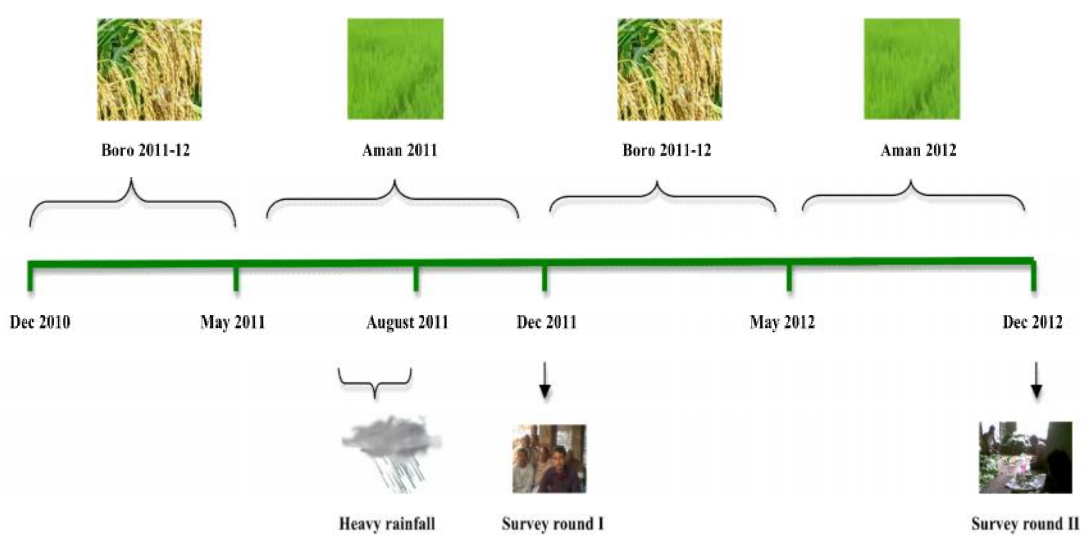
Most farmers incurred heavy losses, which was further exacerbated by the non-realisation of insurance claims, especially for the Aman 2011 losses. This led to unrest and violence in certain villages in mid-2012. The WRMS local staff at block *Bagnan-I* were particularly harassed and threatened by the local villagers so much that the former had to pay up to INR 35000 from their own sources to help the villagers meet losses. Some of the staff members working at a village called *Gauripur* in the same block were also subject to threat and violence. The research team was asked to stay away from this village for the 2012 interviews. However, since 19% of the samples came from *Gauripur*, repeat surveys could not be avoided. The villagers in these areas were quite supportive of the study and provided detailed response and feedback on both agricultural issues and insurance deficiencies faced by the district. Most of the farmers in this village did not renew insurance during 2012.

[33] Data found on: http://www.wbagrimarketingboard.gov.in/Area/Rain.html

As far as the choice of the insurer is concerned, most State governments in India allocate insurance companies to different districts. The insurance companies offer coverage for different crops within the allocated district. This was the general norm in West Bengal as well. However, the West Bengal State government underwent some changes in 2012 and opened their districts to competition. Apart from ICICI Lombard, HDFC-ERGO General insurance provider was also allowed to offer crop insurance in Howrah. Thus, farmers could choose not just the crop they would like to insure but also the provider they would like to buy crop insurance from. However, in the study sample, most households are either uninsured or insured under ICICI Lombard in 2012. There are no shifts to HDFC-ERGO.

It is worth mentioning here that HDFC-ERGO provided claims in some parts of Howrah for Aman 2012, which has hopefully restored some faith in crop insurance policies in the state. Please note that the manner in which weather index based crop insurance is administered is slightly different when compared to other types of insurance policies. In the case of index insurance, the insurance provider receives weather information and ascertains areas where a claim is due. The claim is then declared in the respective unit and cheques are distributed to farmers. A timeline on data collection in Howrah is presented in Figure 4.1.

Figure 4.1: Timeline of data collection in Howrah



Source: Author

The rainfall shocks faced by farmers in Howrah present an interesting framework to examine the precise impact of insurance on input use. Drawing from the literature review, if insurance does lead to a risk reduction effect, it would encourage farmers to invest in inputs despite the weather vagaries. However, since the sample has not received insurance payouts in the last two years, insurance may not be an incentive to experiment with either inputs or crop mix.

3.2 Socio-economic characteristics

The key socio economic features of the household are described in Section 3 of Chapter II. To reiterate, the average age of the respondents is around 45 years and majority of the respondents are male. There is a fall in the household size in 2012, which can be attributed to the migration of the some members of the households on account of education, employment or marriage.

There is also a significant change in the occupation type in 2012. Most households are now diversifying their income portfolios and manage consumption through multiple sources such as agricultural or construction labourers and private sector employments. Annual incomes are also higher in 2012. Less than half of the sample participate in the MNREGA[34] scheme and/or are members of self-help groups (SHG) during both years, though there is an increase in SHG affiliation in 2012. Interestingly, there is a 48 percent increase in the use of mobile phones in 2012. Most households live in their owned dwellings.

3.3 Aman and Boro paddy

This analysis focuses mainly on Aman and Boro farmers. As mentioned in Chapter III, Aman is cultivated in autumn and Boro is cultivated during winter. Insurance is provided for both these crops. The 2011 survey provides details of Boro 2010-11 and Aman 2011. Both these periods experienced excess rainfall as seen in the Table 4.1a and 4.1b. The 2012 survey covers Boro 2011-12 and Aman 2012. These periods experienced normal rainfall.

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[34] MNREGA is a job guarantee scheme provided for by the Government of India in rural areas, where an individual is guaranteed upon 100 days of paid employment during a given year. For more information, see http://nrega.nic.in

Aman is entirely rain-fed and is generally more resistant to pests and diseases. The cost of cultivation is higher for Boro as it requires more chemicals and incurs high irrigation costs. Labour charges are also higher as Boro is prone to more weeds. For both crops, HYV seeds provide higher yields though they require more water, fertilizers and pesticides. Traditional varieties are generally less susceptible to diseases and moisture stress. In the last several years, farmers have preferred to use HYV seeds for Boro. This is true for most of West Bengal and Bangladesh where Boro is an important crop. Table 4.2 provides more information

Table 4.2: Differences between Aman and Boro paddy with respect to input use

Particulars	Aman	Boro
Cultivation period	Jul- Dec	Dec-May
Crop type	Subsistence/Commercial	Commercial
Average yield in Howrah	2259 kg/hectare	5405 kg/hectare
Seeds	Traditional/HYV	HYV
Fertilizers and pesticides	Moderate requirement	High requirement
Irrigation	Entirely rain fed	High irrigation costs incurred
Weeding	Less susceptible to weed attacks	Recurrent weed attacks
Labour	Lower	High
Cost of cultivation	Lower	Higher

Source: Field notes and discussions with WRMS

Table 4.3: Averages of the input data on Aman and Boro paddy

Aman			
Particulars	**Description**	**2011**	**2012**
Households growing Aman	in percentage	99	84
Seed type	HYV=1; Traditional=0	0.13	0.56
Pesticides	Pesticides used=1; Not used=0	0.53	0.07
Fertilizers	Fertilizers used=1; Not used=0	0.92	0.26
Hired labour units	in man days	30	16
Boro			
Particulars	**Description**	**2010-11**	**2011-12**
Households growing Boro	in percentage	75	70
Seed type	HYV=1; Traditional=0	0.24	0.73
Pesticides	Pesticides used=1; Not used=0	0.97	1.00
Fertilizers	Chemical fertilizer=1; Traditional=0[35]	0.96	1.00
Irrigated area	in bighas	2.47	2.53
Hired labour units	in man days	43	18

Source: Author's calculations

Inputs are generally purchased from agricultural cooperative societies on credit basis or financed using own savings or mutual exchange agreements. Table 4.3 provides the

[35] Aman farmers may or may not use fertilizers. Hence, the variable is coded as 1 for usage and 0 for non-usage. However, all Boro farmers are mandated to use fertilizers given the nature of the crop. Hence, the variable is coded as 1 for the use of chemical fertilizers and 0 for the use of traditional fertilizers.

input usage data for Aman and Boro paddy. Note that there is a significant drop in the use of pesticides and fertilizers for Aman in 2012. Almost all Boro cultivators use pesticides and chemical fertilizers in production. There is an increase in the use of HYV seeds in 2012 for both crops. Also, lesser units of labour are hired in 2012. This is attributable to the unavailability of labour due to migration and competition from MNREGA and the private sector.

The next sub-sections present an analysis of the risk attitudes and insurance experiences of the sample population. This is followed by a descriptive analysis of the correlations between insurance and inputs.

3.4 Risk attitudes

This sub-section elaborates on the recent shocks faced in agriculture, common coping mechanisms and risk aversion levels of sampled households. As mentioned earlier, excess rainfall in 2011 had an adverse effect on cropping in Howrah. Other minor shocks reported include livestock diseases and storage pests. There are very few sources of weather information available in villages. Most farmers rely on the services of the radio or television for rainfall and temperature information.

Household reveal that pursuing agriculture in Howrah has become increasingly difficult in the last few years given the rising input costs, low quality of available inputs, weather vagaries, irrigation deficiencies in the region, recurrent pest attacks and lack of agricultural labour.

Common coping mechanisms include savings, borrowings (formal and informal) and *ex-ante* diversifications through multiple cropping or occupation streams. There is a high reliance on informal borrowings as formal bank lending requires land ownership titles and other documents that farmers are unable to provide. Formal lending charges interest at 5-7 percent and no rebate is provided in case of bad weather. In most cases, there are no surpluses in agriculture given the rising input costs. Any surplus is either transferred to their savings or used to pay-off debt.

The results of the Binswanger game used to elicit risk preferences are provided in Table 4.4. Section 5 of Chapter II provides more information on how this game is constructed in the household survey. The table shows that there is a shift in risk preferences in 2012. Majority of the households prefer riskier gambles in 2012.

Table 4.4: Summary statistics of risk and risk aversion index

Year	No. of observations		
	Risk averse	Intermediate risk	Risk preferring
2011	152	245	25
2012	73	34	295

Source: Author's calculations

While risk attitudes are not likely to change in the short term, there is some evidence to suggest otherwise. For instance, Cameron and Shah (2012) show that individuals who recently suffered a flood or earthquake exhibit more risk aversion than individuals living in other villages based on a sample in Indonesia. Voors et al. (2012) report that individuals exposed to conflicts are more risk preferring and have higher discount rates based on a study in Burundi.

The fact that the first survey was conducted following a particularly bad harvest may explain low risk preference in 2011. Additionally, the rainfall shocks of 2011 also led to diversification and shift to other occupations. This shift, along with better weather conditions, fostered an increase in annual incomes in 2012. It may be the case that households experienced instances of higher risk (pursuing alternative employments) leading to higher return. These factors may explain the shift in risk preferences in the sample population.

3.5 Insurance experiences

Aman insurance provides a cover against both excess and deficit rainfall. Boro insurance covers excess rainfall and high temperature. Detailed product notes with information on insurance triggers, sum insured and premium are provided in Annexure A4.1. In the total sample, 50 percent of the households are insured for either Aman or Boro in 2011. However, the number drops to 47 percent in 2012. Table 4.5 provides the details.

Table 4.5: Aman and Boro insurance in 2011 and 2012				
Particulars	**2011**		**2012**	
Insured for Aman (in %)	422	43	402	34
Insured for Boro (in %)	422	21	402	19

Source: Author's calculations

Among insured households, 70 and 90 percent suggest that they purchased insurance mainly to secure themselves against risks in 2011 and 2012. Other reasons for buying insurance include fear of huge losses and assurance to make changes in agricultural practices (cited by 27 percent of households in 2012). The uninsured households suggest that insurance is not necessary. Their main issues against purchase of insurance are the basis risk and lack of trust in both the insurer and the agent. The awareness and understanding of basis risk is higher in 2012. Basis risk is the difference between the rainfall on a farmer's field and rainfall recorded in a weather station situated *x* kilometres away from the field. It represents the potential mismatch between insurance payout and actual losses.

Trust in the insurance provider fell from 95 percent in 2011 to 42.5 percent in 2012. Only 19 percent of the insured households received a claim in 2011 though all insured households surveyed faced a rainfall shock.

Most farmers do not have bank accounts and are not able to easily en-cash the claim cheques provided by the insurance provider. Often, the net claims after payment of bank charges are very low. Several inconsistencies in the MIS systems have also contributed to delays and errors in claim settlement.

Farmers opine that the trigger levels set for both rainfall and temperature are not in tandem with the actual geographical conditions of the area. They also suggest that installing more weather stations will reduce basis risk.[36]

The primary reasons for non-renewal include low claims, bad experiences with the insurance provider and basis risk. Among those who renew, the primary reason for renewal is peer-pressure.

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[36] These are purely the views of the farmers interviewed in the FGDs and do not represent the authors' opinion or feedback in any manner.

In the 2012 questionnaire, farmers are also asked if the 2011 insurance altered their input choices in any manner. Around 19 percent farmers suggested that they shifted towards HYV seeds, 22.8 percent cited a change in the use of chemical fertilizers and pesticides and 21 percent hired higher units of labour.

3.6 Relationship between insurance and inputs

As a precursor to the analysis, this sub-section measures the correlation between each input and insurance for Aman and Boro paddy. Table 4.6 presents the summary statistics of the inputs based on insurance status.

Table 4.6: Summary statistics of inputs by insurance status

Particulars	2011		2012	
	Insured	Uninsured	Insured	Uninsured
Aman				
Seed type	0.09	0.15	0.61	0.53
Pesticides	0.63	0.46	0.05	0.08
Fertilizers	0.97	0.88	0.17	0.31
Hired labour units	37.78	23.59	15.76	15.74
No. of observations	180	239	135	202
Boro				
Seed type	0.26	0.23	0.76	0.72
Pesticides	0.98	0.96	0.99	1.00
Fertilizers	0.94	0.96	1.00	1.00
Irrigation	3.01	2.26	3.50	2.17
Hired labour units	65.70	33.38	20.43	16.72
No. of observations	90	226	76	205

Note: Aman fertilizer usage is coded as 1 for usage and 0 for non-usage. Boro fertilizer usage is coded as 1 for the use of chemical fertilizers and 0 for the use of traditional fertilizers. The manner in which other variables are defined is similar for both crops. Table 4.3 provides the details.

There are two key inferences that can be drawn from Table 4.6. There is a fall in the use of certain inputs such as fertilizers, pesticides and hired labour for all Aman paddy producers in 2012. Also, almost all households use fertilizers and pesticides for Boro paddy irrespective of insurance status. Thus, insurance is not likely to impact use of these inputs for Boro paddy.

Table 4.7 shows the correlations between inputs and insurance. In the pooled sample, insurance is significantly correlated with the use of inputs such as pesticides and hired labour for Aman paddy and irrigation and hired labour for Boro paddy. Most inputs are correlated with insurance for Aman 2011.

Table 4.7: Correlation between insurance and input use						
Particulars	**Pooled sample**		**2011**		**2012**	
	Rho	**P-value**	**Rho**	**P-value**	**Rho**	**P-value**
Aman						
Seed type	-0.01	0.84	-0.08*	0.09	0.08	0.12
Pesticides	0.10**	0.01	0.17**	0.00	-0.06	0.26
Fertilizers	0.01	0.79	0.17**	0.00	-0.16**	0.00
Hired labour units	0.12**	0.00	0.17**	0.00	0.00	0.99
No. of observations	756	767	419	419	337	337
Boro						
Seed type	0.02	0.60	0.02	0.69	0.05	0.44
Pesticides	0.01	0.83	0.04	0.44	-0.10	0.10
Fertilizers	-0.03	0.50	-0.05	0.42	0.04	0.54
Irrigation	0.24**	0.00	0.17**	0.00	0.31**	0.00
Hired labour units	0.19**	0.00	0.25**	0.00	0.09	0.11
No. of observations	597	597	316	316	281	281

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Note: Aman fertilizer usage is coded as 1 for usage and 0 for non-usage. Boro fertilizer usage is coded as 1 for the use of chemical fertilizers and 0 for the use of traditional fertilizers. The manner in which other variables are defined is similar for both crops. Table 4.3 provides the details.

Though Aman and Boro are paddy crops, their input requirement structures are quite different. Aman is a crop with a more flexible input mix, while Boro is an intensive crop with specific pesticide, fertilizer and irrigation requirements. From the descriptive statistics, it seems that almost all households in the study sample use pesticides and fertilizers for Boro, irrespective of insurance status. Capturing the differences in the input usage of these components under Boro paddy insurance may not be feasible. Additionally, the overall insurance figures are also lower for Boro paddy.

Given these factors, this Chapter mainly focuses on Aman paddy only. The inputs studied for Aman paddy are seeds, fertilizers, pesticides and human labour. The Boro paddy analysis is restricted to inputs such as seeds, irrigation and labour only. In both cases, the analysis begins with a description of the risk natures of each input and the relevance of the findings in this context.

The next sections of this paper analyse the relationship between inputs and insurance in a regression framework.

4. Econometric modeling

The primary aim of this Chapter is to provide an intricate analysis of how each input used in production responds to an insurance intervention. As mentioned in the earlier sections, a regression based approach is used to estimate the interactions between insurance and input. The literature reviewed also advised that the *timing* of insurance and input investment decisions may significantly affect the impacts under assessment. These endogeneity issues may be of the following nature:

i. Insurance is endogenous to input allocation decisions: In this case, insurance is offered first and input decisions are taken after insurance is purchased
ii. Input use is endogenous to insurance purchase: Here, affordability of insurance may depend on the amount already invested in inputs
iii. Insurance and input use are endogenous to each other: Both insurance and input decisions are made simultaneously at the start of the each cropping season. Thus, purchase decisions could be endogenous to each other

Case (i): If insurance is endogeneous to input use, a two-step IV or alternatively, a Heckman selection model could be used to analyse the effect of insurance and input use. In case of the latter model, the coefficient of the inverse mills ratio would capture the selection effects and the coefficient of insurance (predicted values from the first stage regression) will help assess the direction and magnitude of the impact of insurance on an individual input. This was the approach followed by Horowitz and Lichtenberg (1993).

Case (ii): In this case, one can only study the profile of input users who invest in insurance and not the impact of insurance on the usage of inputs.

Case (iii): If both insurance and input decisions are jointly determined, then simultaneous equations framework will help assess the impact of insurance on input use and vice-versa. The coefficient of insurance in the input equations will show the impact of insurance on input use and the coefficient of the inputs in the insurance equation will help characterise the profile of farmers who tend to invest in insurance.

This was the approach followed by Smith and Goodwin (1996) where, Wu-Hausman tests are conducted to check if (i) insurance is exogenous in the input use and (ii) input use is exogenous in the insurance purchase. In their analysis, Wu-Hausman tests reject the null hypothesis of exogeneity for both (i) and (ii). Thus, insurance and inputs are considered to be endogenous to each other and are jointly determined using a simultaneous equations framework.[37]

It is important to understand why considering these endogeneity issues are crucial to the analysis. In the Horowitz and Lichtenberg (1993) paper, where only insurance is considered endogenous, results indicated that insurance increase use of fertilizers. However, Smith and Goodwin (1996) show that insurance reduces use of chemicals under the simultaneous equations framework. Thus, there is a possibility that the coefficients may be erroneously determined if the endogeneity issues are not appropriately identified and factored into the analysis.

The inputs included in the analysis are seeds, fertilizers, pesticides, irrigation and hired labour. It is important to establish here that the manner in which each input relates to insurance may be different. The endogeneity or simultaneity observed in input and insurance decisions may not hold true for all inputs. For instance, fertilizer and pesticide purchases are made at the beginning of the cropping season. Seeds may either be purchased or produced. Labour hiring takes place throughout the season, though more significantly during transplanting, weeding and harvesting. Irrigation is also required throughout the season.

In addition, the endogeneity or simultaneity may also vary by crop. For example, almost all Boro farmers use pesticides and fertilizers. This is a decision that is taken irrespective of insurance. Thus, though these decisions may be taken at the beginning of the season, they are likely to be exogenous to each other.

The analysis framework is organised as follows. A pooled OLS model is used to estimate the impact of insurance on each input use. Then, insurance is considered endogenous to the input allocation decision and a two-stage instrumental variables (IV)

[37] However, in this case the only input tested for is 'chemical use', so they use a system of two equations only.

approach is used to assess impacts. Following this, Durbin-Wu-Hausman test is conducted to check for the exogeneity of insurance purchase and input allocation decisions. Final modeling is based on these results.

4.1 Pooled OLS estimation

In this case, a basic regression equation of the following kind is estimated using a pooled OLS framework:

$$Input_{it}^{jk} = \sim_0 + \sim_1 Insurance_{it}^{k} + \quad {}_1 x_{it1}^{'} + \pounds_{it1}^{jk} \quad \ldots\ldots\ldots\ldots\ldots \quad (4.1)$$

where, i denotes cross section, t denotes time period, j refers to the j^{th} input (j= seeds, pesticides, fertilizers, labour) and k refers to the k^{th} crop (k= aman, boro), $x_{it1}^{'}$ represents a vector of other explanatory variables and $\pounds_{it1}^{jk}$ represents the errors, which are assumed to be i.i.d.

The dependant variable is defined as per Table 4.8 provide in Section 5 below. The coefficient of insurance, i.e. $\sim_1$, estimates the impact of insurance on input use for each input case.

4.2 Two-step IV estimation

In case of the IV estimation, where insurance is considered endogenous to input use, equation (4.3) is considered the structural equation. Insurance is estimated by the reduced form equation (4.2) using a set of instruments (that affect only the insurance purchase decision and not the input allocation patterns) and other explanatory variables. The predicted values from the first stage and then used to determine the impact of insurance on inputs in equation (4.3). The basic econometric set up is as follows:

$$Insurance_{it}^{k} = \sim_0 + \quad {}_1 z_{it1}^{'} + \quad {}_2 x_{it2}^{'} + \pounds_{it1}^{k} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4.2)$$

$$Input_{it}^{jk} = \sim_1 + \sim_2 Insurance_{it}^{k} + \quad {}_3 x_{it2}^{'} + \pounds_{it2}^{jk} \quad \ldots\ldots\ldots\ldots\ldots \quad (4.3)$$

where i denotes cross section, t denotes time period, j refers to the j^{th} input (j= seeds, pesticides, fertilizers, labour) and k refers to the k^{th} crop (k= aman, boro). $z_{it1}^{'}$ represents a set of instrumental variables, $x_{it2}^{'}$ represents a vector of other explanatory variables, $£_{it1}^{k}$ and $£_{it2}^{jk}$ are unobserved disturbances.

The dependant variable in equation (4.2) takes the value one if the household is insured and zero otherwise. In case of equation (4.3), the dependant variables are defined as per Table 4.8 provided in Section 5. F-tests and Sargan tests are conducted to check for the relevance and orthogonality of the instruments.

4.3 Exogeneity tests

Exogeneity tests form an important part of the econometric modeling for this Chapter. Durbin-Wu-Hausman test is conducted to check for exogeneity of insurance purchase and input allocation decisions. The two hypotheses tested here are: (i) Insurance is exogenous to input use and (ii) Input use is exogenous to insurance. In the case of (i) the original structural equation (4.3) is augmented by the inclusion of the residuals from the reduced form equation (4.2).

For case (ii), input use is considered endogenous to insurance. Inputs are modeled based on a set of explanatory variables and instruments in the first stage. The residuals from the reduced form equations are then included in a structural equations where the dependant variable is insurance purchase.

The Durbin-Wu-Hausman test is implemented as a Chi2 test respectively. If the null hypothesis of exogeneity is decisively rejected for both (i) and (ii), the specific input and insurance is considered simultaneously determined. If the null hypothesis is not rejected for both (i) and (ii), these decisions are considered exogeneous to each other. If the null hypothesis is only rejected for case (i) and not for case (ii), then only insurance is endogenous to input use and not vice versa.

4.4 Simultaneous equations modeling

If insurance and input decisions are found to be endogenous to each other, a simultaneous equations framework is used. Here, equation (4.4) and (4.5) are both referred to as the structural equations:

$$Insurance_{it}^{k} = \sim_{0} + \sim_{1} Input_{it}^{jk} + \ _{1}x_{it1}^{'} + \ _{2}z_{it1}^{'} + \pounds_{it1}^{k} \quad .... \quad (4.4)$$

$$Input_{it}^{jk} = \sim_{2} + \sim_{3} Insurance_{it}^{k} + \ _{3}x_{it2}^{'} + \ _{4}z_{it2}^{'} + \pounds_{it2}^{jk} \quad .... \quad (4.5)$$

where i denotes cross section, t denotes time period, j refers to the j^{th} input (j= seeds, pesticides, fertilizers, irrigation, labour) and k refers to the k^{th} crop (k= Aman, Boro). $z_{it1}^{'}$ and $z_{it2}^{'}$ represent vectors of exogenous explanatory variables in each equation, $x_{it1}^{'}$ and $x_{it2}^{'}$ represent vectors of other explanatory variables, $\pounds_{it1}^{k}$ and $\pounds_{it2}^{jk}$ are unobserved disturbances that are assumed to be normally distributed with constant variances.

Simultaneous equations are solved by first estimating the reduced form equations. Reduced form equations are the solution of endogenous variables in the model, in terms of exogenous variables and the errors. The predicted values are then substituted in the structural function to arrive at the final estimates. The reduced form of equations (4.4) and (4.5) can be expressed as follows:

$$Insurance_{it}^{k} = Z_{t}^{'}\Pi_{1} + \neg_{1t} \quad .... \quad (4.6)$$

$$Input_{it}^{jk} = Z_{t}^{'}\Pi_{2} + \neg_{2t} \quad .... \quad (4.7)$$

where, $Z_{t}^{'}$ is a vector representing the parameters of the reduced form equations. Equation (4.6) is estimated by probit model and equation (4.7) is estimated using an OLS or probit as the case may be. The structural equation (4.4) is then estimated by substituting $Z_{t}^{'}\hat{\Pi}_{2}$ for $Input_{it}^{jk}$ and equation (4.5) is estimated by substituting $Z_{t}^{'}\hat{\Pi}_{1}$ for $Insurance_{it}^{k}$.

While this two-stage procedure gives consistent estimates of model coefficients, the variance of the coefficients may be inconsistent because predicted values of endogenous variables are used in the second stage of estimation. In most literature, bootstrapping methods are used to derive consistent estimates of variances (Smith and Goodwin, 1996; Zhong et al., 2006). Nimon and Mishra (2001) suggest a jackknife procedure for correcting variances of structural equation. This Chapter uses bootstrapping methods for consistent variance estimates in the simultaneous equations analysis.

5. Analysis and results

The first step in the analysis is to define the input variables examined in the study. Since this study is based on a range of input that influence the level of output in specific ways, it is important to deliberate on what kind of change one wishes to observe in the usage of inputs. These possible changes could relate to if an input is used or not, amount of usage and/or timing of applications.

The first input allocation decision is made at the beginning of the season when insurance is also offered. This Chapter primarily aims to understand how initial purchase decisions change in the presence of *ex-ante* crop microinsurance. This original investment made using the available finances is more crucial that subsequent input purchases made. This is because the subsequent investment could be invariable due to pest attack or a specific crop disease that is normally not accounted for at the start of the season. These purchases are likely to be made irrespective of insurance interventions.

This Chapter prefers to focus on choices of input purchase at the start of the season, rather than the amount of total inputs purchased during a given season. The fact that the study analyses the investment preferences made *ex-ante* will also help study the endogeneity/simultaneity aspects of these decisions in a comprehensive manner. The dependant variable is defined as per Table 4.8.

Table 4.8: Definitions of the each input for the econometric analysis	
Name of the input	**Description**
Seed	1 = HVY seeds; 0 = otherwise
Pesticides	1 = if used; 0 = otherwise
Fertilizers	Aman: 1 = Traditional or Chemical fertilizers; 0 = otherwise
	Boro: 1 = Chemical fertilizers; 0 = Traditional fertilizers
Labour	Hired labour in man days
Irrigation	Bighas of cropped area under irrigation

As mentioned earlier, the analysis mainly focuses on Aman paddy. Aman is entirely rain-fed and requires a moderate level of fertilizers and pesticides. Following from the traditional input conventions, HYV seeds can be considered risk increasing for Aman paddy, as they need to be supplemented with adequate fertilizers and water for higher yield. Especially for a rain-fed crop such as Aman, sowing HYV seeds is indeed a risk. Fertilizers are also risk increasing as they increase the variability of low yield. Pesticides and hired labour are risk neutral (or risk decreasing), as while they assist in increasing the yield, they do not impact the variability of the yield.

Table 4.9 presents the description and summary statistics of the variables used in the analysis. The pooled OLS, two stage IV and simultaneous equations results for Aman paddy are provided in the following sections.

Table 4.9: Description and summary statistics of variables used in the regressions					
Variable name	Description	2011		2012	
		Obs	Mean	Obs	Mean
Aman insurance	1=insured; 0= otherwise	422	0.43	402	0.34
Aman seed type	1= HYV; 0= Traditional	419	0.13	337	0.56
Aman pesticide usage	1=Pesticides used; 0=Not used	419	0.53	337	0.07
Aman fertilizer usage	1=Fertilizer used; 0=Not used	419	0.92	337	0.26
Aman hired labour	in man days	419	29.69	337	15.75
Boro insurance	1=insured; 0= otherwise	422	0.21	402	0.19
Boro seed type	1= HYV; 0= Traditional	316	0.24	281	0.73
Boro pesticide usage	1=Pesticides used; 0=Not used	316	0.97	281	1.00
Boro fertilizer usage	1=Chemical Fertilizer used; 0=Traditional or Not used	316	0.96	281	1.00
Boro irrigated area	In bighas	316	2.47	281	2.53
Boro hired labour	in man days	316	42.58	281	17.73
No of crops grown	Number of crops produced in a year	422	1.90	402	1.84
Household size	No. of members in the household	422	4.81	402	4.54
Livestock	1= if a households own poultry or cow or goat; 0= otherwise	422	0.33	402	0.31
Risk aversion	Calculation described in Chapter II	422	0.82	402	0.49
Diversification	1= if the household has multiple sources of income; 0= otherwise	422	0.64	402	0.64
Land under crops	Bighas of land under all crops	422	2.78	402	2.39
SHG membership	1= if the household is an SHG member; 0= otherwise	422	0.25	402	0.35
Cooperative affiliation	1= if the household is affiliated to a cooperative; 0= otherwise	422	0.05	402	0.06
Day of sowing: Aman	Time of sowing the crop within the sowing month[38]	419	1.80	337	2.15
Input distance	Distance from the village to the nearest input source in kilometres	422	4.13	402	4.15
Aman fertilizer lag cost[39]	Lagged costs per bigha aggregated at block level	-	924.02	-	401.55
Aman pesticide lag cost	Lagged costs per bigha aggregated at block level	-	69.22	-	149.10
MNREGA participation	1= if the household participates in MNREGA; 0= otherwise	422	0.46	402	0.31
Trust insurer	1= if the household trusts the insurance provider; 0= otherwise	422	0.48	402	0.21
Basis risk understand	1= if the household understands basis risk; 0= otherwise	422	0.04	402	0.30
Savings to finance inputs: Boro	1= if Boro inputs are financed using savings; 0= otherwise	316	0.24	281	0.75
Water pump	1= if the household uses own a water pump; 0= otherwise	422	0.15	402	0.2
Labour hiring	1= if the households is able to hire labour easily; 0= otherwise	422	0.18	367	0.26

Note: The total Aman producers are 756 (419+337) and total Boro producers are 597 (316+281). However, out of this 597, only 588 (316+272) grow both Aman and Boro.

[38] In this case, the sowing period is divided into three phases within the sowing month as follows: 1= if seeds are sown in the first ten days of the sowing month i.e. days 1-10, 2= if seeds are sown in the middle ten days of the sowing month i.e. days 11-20 and 3= if seeds are sown in the last ten days of the sowing month i.e. days 21-31.

[39] A baseline (area profiling) survey was conducted in 2010 prior to the launch of the product. This survey covered similar households across the same blocks as the 2011 and 2012 surveys. The per bigha costs of fertilizers and pesticides aggregated at the block level from the 2010 and 2011 surveys are used as lagged fertilizer/pesticide costs in the analysis.

5.1 Pooled OLS results for Aman paddy

The analysis begins with pooled OLS framework. Insurance and input decisions are considered independent to each other and the impact of insurance is measured using the coefficient of insurance in a pooled OLS regression. Table 4.10 presents the results.

Seed type: The dependant variable takes the value 1 if the farmer uses high yielding variety (HYV) seeds and 0 if s/he uses traditional seeds. Results indicate that Aman insurance does not have a significant impact on Aman seed use.

Among other covariates, a farmer who has a diversified income portfolio is 12.8 percentage points more likely to invest in HYV seeds *on average and ceteris paribus*. A farmer who is more risk averse is 24.6 percentage points less likely to adopt HYV seeds in Aman production *on average and ceteris paribus*. SHG membership reduces the use of HYV seeds by 5.6 percentage points *on average and ceteris paribus*. Use of HYV seeds is also negatively related to the time of planting. In other words, the later a farmer plants her/his crops in the sowing month, the more likely s/he is to use traditional seeds. There is a 40 percentage points increase in the use of HYV seeds in the second year *on average and ceteris paribus*.

Fertilizer: The dependant variable in this case takes the value 1 if the farmer uses chemical or traditional fertilizers and 0 if they do not use fertilizers. Aman insurance does not have a significant impact on fertilizer use in the pooled OLS case.

A risk averse farmer is 9.67 percentage points less likely to use fertilizer *on average and ceteris paribus*, possibly because fertilizer is a risk increasing input. A farmer who is affiliated to an input cooperative is 15.8 percentage points more likely to invest in fertilizers *on average and ceteris paribus*. Distance of the private markets from the village is a deterrent for fertilizer use. Household size is positively correlated with fertilizer use and the year dummy is significant indicating a 58 percentage points decrease in the use of fertilizers in the second year *on average and ceteris paribus*. Lagged block level aggregate costs have a positive impact of fertilizer purchase.

Pesticides: The dependant variable in this case takes the value 1 if the farmer uses pesticides in Aman production and 0 if they do not. Aman insurance has a positive and significant impact on pesticide usage in this case. Insurance increases use of pesticides by 6 percentage points *on average and ceteris paribus.*

Farmers who own livestock (a proxy for wealth) are 9 percentage points more likely to invest in pesticides *on average and ceteris paribus*. However, farmers who derive income from multiple sources, i.e. those who diversify, are 12.05 percentage points less likely to invest in pesticides *on average and ceteris paribus*. Year dummy is significant indicating that pesticide use reduced by 53 percentage points in 2012 *on average and ceteris paribus*.

Hired labour: The dependant variable is continuous and represents the average man-days of hired labour. Aman insurance has a positive and significant effect on the units of labour hired. An insured farmer is likely to hire 4.93 additional man-days of hired labour when compared to the uninsured *on average and ceteris paribus.*

An increase in the number of crops grown increases hired labour by 4.28 man-days *on average and ceteris paribus*. Diversification encourages the use of labour probably because one can afford higher wages. A farmer who diversifies is likely to hire 4.92 additional man-days of labour *on average and ceteris paribus*. An increase in the bighas of land owned increases labour hired by approximately 7 man-days *on average and ceteris paribus.* Participation in the MNREGA reduces the units of labour hired by 6.62 man-days *on average and ceteris paribus.* Lesser units of labour were hired in 2012.

To summarise, Aman insurance has a positive impact on pesticide and labour usage and there is no significant effect on seed or fertilizer usage. However, these results do not account for the possibility endogeneity or simultaneity of insurance and input decisions. The next sections discuss these issues in detail.

Table 4.10: Pooled OLS to determine the impact of Aman insurance on Aman input use where both decisions are exogenous to each other				
Variable (1)	**Seed (2)**	**Fertilizers (3)**	**Pesticides (4)**	**Hired labour (5)**
Aman insurance	0.0164	0.0061	0.0614**	4.9362**
	0.0305	0.0248	0.0305	1.9819
No. of crops grown	0.0158	0.0350	0.0392	4.2840
	0.0278	0.0226	0.0294	2.9152
Household size	0.0096*	0.0151***	0.0052	-0.3701
	0.0057	0.0054	0.0074	0.5142
Livestock owned	-0.0226	-0.0472*	0.0901***	-1.0784
	0.0312	0.0268	0.0339	2.4372
Risk aversion	-0.2457***	-0.0967*	-0.0960*	-0.0100
	0.0679	0.0583	0.0521	4.1856
Diversification	0.1284***	-0.0386	-0.1205***	4.9276**
	0.0302	0.0275	0.0333	1.9719
Land under crops	0.0002	0.0042	0.0104	6.9967***
	0.0057	0.0046	0.0068	1.5260
Year dummy (2012)	0.3995***	-0.5850***	-0.5337***	-15.0263***
	0.0368	0.0406	0.0456	2.6577
SHG membership	-0.0563*	-0.0058	0.0444	-0.1580
	0.0333	0.0291	0.0322	2.1469
Cooperative affiliation	-0.0901	0.1582***	0.0200	-0.3363
	0.0768	0.0573	0.0590	4.2616
Day of sowing	-0.1246***			
	0.0175			
Input distance		-0.0369***		
		0.0058		
Lag costs: Fertilizers		0.0002***		
		0.0000		
Lag costs: Pesticides			0.0006	
			0.0004	
MNREGA participation				-6.6208***
				2.1061
Constant	0.4118***	0.8343***	0.4534***	1.9431
	0.0890	0.0860	0.0915	5.5879
No. of observations	756	756	756	756
F value	35.37	101.24	35.88	6.76
R-squared	0.30	0.51	0.29	0.33

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust Standard errors appear below coefficients.

5.2 IV regression results for Aman paddy

Though both insurance and input decisions are made *ex-ante*, they could precede one another. For instance, insurance could be offered first, following which input allocations are made by a farmer. In this case, insurance decisions could affect input investments, i.e. insurance is endogeneous to input.

Here, a two-stage IV regression is used to determine the impact of insurance on input allocations. Insurance is modeled in the first stage using a set of instruments and inputs are modeled in the second stage. The exogeneous determinants of Aman insurance purchase include trust in the insurance provider and insurance purchased for other crops (Boro). Both these variables are likely to affect the Aman insurance purchase decision but not the input purchase decisions. These variables were also used as exogeneous determinants of insurance in Chapter III.

Table 4.11 represents the two stage IV results. In all regressions, the coefficients of most explanatory variables are similar to the pooled OLS case in terms of significance, direction and magnitude. However, there are critical differences in the coefficients of the insurance variable. These effects are highlighted below.

Seed type: In line with the pooled OLS results, Aman insurance does not have a significant impact on Aman seed use.

Fertilizer: Contrary to the pooled OLS case, Aman insurance has a positive and significant impact on fertilizer usage in the two-step IV estimation. Insurance increases use of fertilizers by 16.9 percentage points *on average and ceteris paribus.*

Pesticides: Results concur with the pooled OLS case here. Aman insurance has a positive and significant impact on pesticide usage. In this case, Aman insurance increases use of pesticides by 14.41 percentage points *on average and ceteris paribus.*

Hired labour: When Aman insurance is considered endogenous, it does not have a significant impact on units of labour hired.

In all cases, the use of instruments for insurance in the first stage is both relevant (F-test) and orthogonal (Sargan test). [40]

The next steps are to check for the endogeneity/simultaneity of insurance and input decisions. As mentioned in the earlier section, checking for simultaneity involves tests for the exogeneity of insurance to input decisions as well as the exogeneity of input decisions to insurance. The former case can be tested using the findings of Table 4.11.

Testing the exogeneity of input decisions to insurance requires modeling another two stage IV case wherein inputs are modeled in the first stage and insurance is modeled in the second stage. The results of this model are presented in Annexure A4.2. The instruments used to exogeneously determine input investments are also highlighted below the results in the Annexure.

[40] Tests are based on the Stata command *ivreg2*

Table 4.11: Two-step IV to determine the impact of Aman insurance on Aman input use where insurance is considered endogenous								
	Seed use		Fertilizer use		Pesticide use		Hired labour	
Variable (1)	Stage 1 – insurance (2)	Stage II (3)	Stage 1 – insurance (4)	Stage II (5)	Stage 1 – insurance (6)	Stage II (7)	Stage 1 – insurance (8)	Stage II (9)
Insurer trust	0.7053***		0.6827***		0.6852***		0.6828***	
	0.0295		0.0290		0.0303		0.0308	
Insurance for the other crop (Boro)	-0.1662***		-0.1359***		-0.1367***		-0.1467***	
	0.0483		0.0433		0.0491		0.0491	
Aman insurance		0.0294		0.1685***		0.1441***		3.7367
		0.0471		0.0443		0.0502		3.4258
No. of crops grown	0.1206***	0.0132	0.0915***	0.0078	0.1266***	0.0225	0.1259***	4.5270
	0.0230	0.0286	0.0209	0.0239	0.0231	0.0301	0.0229	2.9061
Household size	-0.0065	0.0099*	-0.0108**	0.0197***	-0.0068	0.0073	-0.0073	-0.4005
	0.0056	0.0057	0.0054	0.0056	0.0057	0.0075	0.0057	0.5348
Livestock owned	0.0056	-0.0224	-0.0120	-0.0406	0.0095	0.0916***	0.0088	-1.0995
	0.0297	0.0310	0.0286	0.0272	0.0299	0.0338	0.0300	2.4173
Risk aversion	0.0499	-0.2473***	0.0456	-0.1170**	0.0402	-0.1058**	0.0470	0.1419
	0.0659	0.0675	0.0644	0.0588	0.0661	0.0523	0.0666	4.1737
Diversification	-0.0339	0.1288***	0.0222	-0.0430	-0.0421	-0.1175***	-0.0333	4.8912**
	0.0288	0.0299	0.0277	0.0278	0.0288	0.0333	0.0291	1.9405
Land under crops	-0.0065	0.0001	0.0036	0.0014	-0.0055	0.0097	-0.0060	7.0059***
	0.0072	0.0057	0.0076	0.0050	0.0075	0.0070	0.0075	1.5268
Year dummy (2012)	0.1546***	0.3999***	0.1478***	-0.5858***	0.0244	-0.5245***	0.1142***	-15.0858***
	0.0348	0.0365	0.0401	0.0409	0.0443	0.0469	0.0348	2.6357
SHG membership	0.1062***	-0.0584*	0.1218***	-0.0335	0.1153***	0.0309	0.1204***	0.0470
	0.0325	0.0339	0.0310	0.0303	0.0325	0.0324	0.0332	2.0720
Cooperative affiliation	-0.0135	-0.0906	-0.0330	0.1533**	-0.0402	0.0177	-0.0298	-0.2960
	0.0615	0.0758	0.0589	0.0596	0.0628	0.0603	0.0617	4.2007
Day of sowing	-0.0753***	-0.1244***						
	0.0170	0.0174						

Table 4.11 continued**: Two-step IV to determine the impact of Aman insurance on Aman input use where insurance is considered endogenous**								
	Seed use		**Fertilizer use**		**Pesticide use**		**Hired labour**	
Variable (1)	**Stage 1 – insurance (2)**	**Stage II (3)**	**Stage 1 – insurance (4)**	**Stage II (5)**	**Stage 1 – insurance (6)**	**Stage II (7)**	**Stage 1 – insurance (8)**	**Stage II (9)**
Input distance			0.0417***	-0.0431***				
			0.0060	0.0062				
Lag costs: Fertilizers			0.0001	0.0002***				
			0.0000	0.0000				
Lag costs: Pesticides					0.0012***	0.0005		
					0.0004	0.0004		
MNREGA participation							-0.0413	-6.6769***
							0.0284	2.1219
Constant	0.0384	0.4109***	-0.2964***	0.8655***	-0.1805**	0.4557***	-0.0819	1.9935
	0.0780	0.0883	0.0743	0.0866	0.0775	0.0912	0.0717	5.5218
Number of observations	756	756	756	756	756	756	756	756
F value	99.22	35.60	138.39	102.75	102.46	34.98	89.31	6.76
Prob >F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centered R2	0.4487	0.2967	0.4897	0.4872	0.4430	0.2786	0.4372	0.3262
Uncentered R2	0.6784	0.5228	0.7023	0.8067	0.6751	0.5152	0.6717	0.5440
Instruments validation								
Cragg-Donald Wald F statistic	294.4000		293.6130		269.0040		255.7850	
Underidentification test								
Anderson canon. corr. LM statistic								
Chi2 value/P-value	232.8450	0.0000	242.9040	0.0000	230.7050	0.0000	225.1520	0.0000
Over identification/validity of all instruments								
Hansen's J statistic								
Chi2 value/ P-value	0.1920	0.6614	3.0050*	0.0830	1.8020	0.1795	0.3040	0.5813

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust Standard errors appear below coefficients. Exogeneous determinants of insurance include trust in the insurance provider and purchase of insurance for other crops (Boro). Instrument validation tests confirm the relevance and orthogonality of the instruments.

5.3 Exogeneity test for Aman paddy

Following the framework set by Smith and Goodwin (1996), there are two hypotheses under test: (i) Insurance purchase decision is exogenous to the input purchase decision and (ii) Input use is exogenous to insurance purchase.

For case (i), the structural and reduced form equations are drawn from the IV estimation elaborated in Section 5.2. For case (ii), each input is modeled in the first stage reduced form equation and the structural equation analyses the factors affecting insurance purchase. As mentioned earlier, detailed regressions for this case are provided in Annexure A4.2.

For both cases, Durbin-Wu-Hausman test is conducted to check for endogeneity. Results are elaborated in Table 4.12

Table 4.12: Durbin-Wu-Hausman test for exogeneity of insurance and inputs for Aman

Case (i) Insurance is considered endogenous				
Particulars	**Insurance on Seed use**	**Insurance on Fertilizer use**	**Insurance on Pesticide use**	**Insurance on Hired labour**
Durbin-Wu-Hausman				
Chi2 value	0.09	15.08***	5.69**	0.09
P-value	0.76	0.00	0.02	0.76
Case (ii) Input is considered endogenous				
Particulars	**Seed use on insurance**	**Fertilizer use on insurance**	**Pesticide use on insurance**	**Hired labour on insurance**
Durbin-Wu-Hausman				
Chi2 value	1.46	11.99***	3.85**	16.57***
P-value	0.23	0.00	0.05	0.00

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10.

Table 4.12 displays the results. The relationship between each input and insurance and the subsequent estimation procedure in each case is detailed below:

Seed use and insurance: Seed use and insurance are exogenous to each other. For Aman paddy, farmers tend to use a combination of new seeds and their own seeds. At the beginning of the cropping seasons, a farmer assess the amount of own seeds and is thus aware of how much seeds s/he needs to purchase for the season. This decision is independent of the insurance purchase decision. The impact of insurance on seeds can be measured using the coefficient of insurance in the pooled OLS regression found in columns (2) in Table 4.10. Results indicate that insurance does not have a significant impact on seed use for Aman paddy.

Fertilizer use and insurance: Both insurance purchase and input allocation decisions are endogenous to each other in this case. Clearly, these decisions are simultaneously made at the beginning of the season and can be estimated using a simultaneous equations framework.

Pesticide use and insurance: This is similar to the fertilizer case. It is also consistent with the real world scenario as the first set of fertilizers and pesticides are purchased at the beginning of the season.[41] Insurance sales also happen at the start of the cropping cycle.

Hired labour and insurance: It is interesting to note that hired labour is endogenous to insurance purchase. A closer study of the MNREGA scheme indicates that the work demand for the scheme in Howrah district is high during April-Nov (See Annexure A4.4). This period coincides with the Aman cultivation period. To hire labour for Aman means competition from MNREGA and thus, the need to pay high wages to lure labour. Thus, a farmer is likely to set aside money at the beginning of the season in anticipation of these expenses.

Based on these findings, the next section develops and examines the associations between insurance and inputs in a simultaneous equations framework.

5.4 System of equations to determine impact of insurance on inputs for Aman

Based on the Wu-Hausman tests, a simultaneous equations framework is used to study the impact of insurance on input use. A *seemingly unrelated regressions framework* is used to account for contemporaneous correlation.

Specifically, fertilizer, pesticide and insurance purchase decisions are modeled in a simultaneous framework. Also, since hired labour is endogenous to insurance, hired

[41] It must be reiterated here that pesticide and fertilizers purchases are also made mid-season in case of unexpected pest attacks or crop deficiencies. However, an initial investment is made both at the beginning of the cropping season and this Chapter only considers the simultaneity of this first investment with the insurance purchase decision.

labour is estimated within the system using instruments and other explanatory variables. Thus, the final regression involves the estimation for a four-system equation that takes the following form:

$$Insurance_{it}^{Aman} = \sim_0 + \ _1Seed_{it}^{Aman} + \ _2Fert_{it}^{Aman} + \ _3Pest_{it}^{Aman} + \ _4Labour_{it}^{Aman} + \text{¢}_1 x_{it1}^{'} + \text{¥}_1 z_{it1}^{'} + \text{£}_{it1}^{Aman}$$
$$Fert_{it}^{Aman} = \sim_1 + \ _5Insurance_{it}^{k} + \text{¢}_2 x_{it2}^{'} + \text{¥}_2 z_{it2}^{'} + \text{£}_{it2}^{Aman}$$
$$Pest_{it}^{Aman} = \sim_2 + \ _6Insurance_{it}^{k} + \text{¢}_3 x_{it3}^{'} + \text{¥}_3 z_{it3}^{'} + \text{£}_{it3}^{Aman}$$
$$Labour_{it}^{Aman} = \sim_3 + \text{¥}_4 z_{it4}^{'} + \text{¢}_4 x_{it4}^{'} + \text{£}_{it4}^{Aman} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.8)$$

where, $z_{it1}^{'} - z_{it3}^{'}$ represents the exogenous determinants of the respective dependant variables, $z_{it4}^{'}$ represent the instruments that are correlated with hired labour and not with insurance. $x_{it1}^{'} - x_{it4}^{'}$ represent other explanatory variables and $\text{£}_{it1}^{Aman} - \text{£}_{it4}^{Aman}$ represent the residuals in each equation.

Table 4.13 provides the results. Column (2) in Table 4.13 provides the regression estimates for hired labour. MNREGA participation is used an instrument in this case. The key inferences with respect to the relationship between inputs and insurance as per Table 4.13 is summarised below.

Table 4.13: Simultaneous equation model to model the relationship between inputs and insurance for Aman paddy				
Variable (1)	**Hired labour (2)**	**Fertilizer use (3)**	**Pesticide use (4)**	**Insurance (5)**
Insurance Aman		-0.0189	0.0910*	
		0.0369	0.0470	
Aman seed type				0.0493
				0.0359
Aman fertilizer				-0.2399***
				0.0645
Aman pesticide				0.1213**
				0.0533
Aman hired labour				0.0012***
				0.0004
MNREGA participation	-6.4152***			
	2.3160			
Input distance		-0.0295***		
		0.0058		
Lag costs: Fertilizers		0.0001***		
		0.0000		
Lag costs: Pesticides			0.0009**	
			0.0004	
Insurer trust				0.6904***
				0.0315
Boro insurance				-0.1360***
				0.0480
No. of crops grown	5.2569*	0.0406*	0.0342	0.1169***
	2.8668	0.0238	0.0291	0.0235
Household size	-0.4956	0.0141**	0.0061	-0.0043
	0.5431	0.0058	0.0076	0.0060
Livestock owned	-1.1641	-0.0452	0.0906***	-0.0093
	2.4039	0.0283	0.0338	0.0312
Risk aversion	0.5361	-0.0965	-0.0995	0.0393
	3.9374	0.0597	0.0523	0.0690
Diversification	4.7924**	-0.0415	-0.1223***	-0.0374
	2.0692	0.0282	0.0335	0.0332
Land under crops	7.0346***	0.0045	0.0104	-0.0144
	1.6050	0.0048	0.0070	0.0089
SHG membership	0.5927	-0.0004	0.0407	0.1084***
	2.2905	0.0312	0.0326	0.0305
Cooperative affiliation	-0.1618	0.1625***	0.0167	0.0113
	4.4028	0.0570	0.0628	0.0584
Year dummy (2012)	-15.2282***	-0.6207***	-0.5568***	0.0123
	2.7007	0.0378	0.0455	0.0607
Constant	2.0802	0.8665***	0.4293***	0.0506
	5.8324	0.0883	0.0910	0.0922
No. of observations	756	756	756	756
Parameters	10	12	11	15
RMSE	27.97	0.34	0.39	0.37
R- squared	0.32	0.51	0.28	0.45
Chi2	357.58	774.67	310.25	645.16
P value	0.00	0.00	0.00	0.00

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Bootstrapped Standard errors appear below coefficients. Exogeneous determinants of fertilizers include distance to the nearest input source and lagged fertilizer costs aggregated at the block level. MNREGS participation is used to exogeneously account for hired labour, while lagged pesticides costs are used as instruments in the pesticide equation. Instrument validation tests confirm the relevance and orthogonality of the instruments.

Determinants of fertilizer use: The dependant variable in this case takes the value 1 if the farmer uses chemical or traditional fertilizers and 0 if they do not use fertilizers. Distance to the nearest input source and lagged (one-year) aggregate costs of fertilizers at the block level are used as exogenous determinants of fertilizer use. Both these factors impact the purchase of inputs but not insurance.

Column (3) provides the results. Aman insurance reduces the purchase of fertilizers in the simultaneous equations case, though this is not significant.

In the two-step IV case where only the endogeneity of insurance was accounted for, insurance had a positive effect on fertilizer use. Failure to account for the simultaneity of insurance and fertilizer purchase decisions would have thus led to an erroneous conclusion that the impact of insurance on input is positive (a similar conclusion was made in Smith and Goodwin, 1996)

Input distance is a deterrent to fertilizer use. An increase in the distance to the nearest input source by one kilometer reduces the purchase of fertilizers by approximately 3 percentage points *on average and ceteris paribus*. Lagged aggregate costs of fertilizers have a positive albeit a very small effect on fertilizer use. An increase in the household composition increases the use of fertilizers by 1.41 percentage points *on average and ceteris paribus*. Affiliation to a local agricultural cooperative increases fertilizer purchase by 16.25 percentage points *on average and ceteris paribus*. This is consistent with the fact that fertilizers are primarily marketed through input cooperatives and these institutions provide subsided rates for inputs. There is a 62.07 percentage point reduction in the use of fertilizers in 2012 *on average and ceteris paribus.*

Determinants of pesticide use: The dependant variable in this case takes the value 1 if the farmer uses pesticides and 0 if s/he does not use them. Lagged (one-year) aggregate costs of pesticides at the block level are used as an exogenous determinant of pesticide use. Past season’s costs are likely to affect the total investment set aside for inputs in the current season. This factor will not impact the purchase of insurance in the current season.

Column (4) provides the results. Aman insurance has a significant and positive impact on pesticide use. Insurance increases the purchase of pesticides by approximately 9.10 percentage points *on average and ceteris paribus.*

Akin to the fertilizer case, lagged costs have a positive albeit a small effect on pesticide purchase. A diversified farmer is less likely to invest in pesticides to the extent of 12.23 percentage points *on average and ceteris paribus*. Livestock ownership increases pesticide use by 9.1 percentage points *on average and ceteris paribus.* There is a 55.7 percentage point reduction in the use of pesticides in 2012 *on average and ceteris paribus.*

Determinants of insurance purchase: The dependant variable in this case takes the value 1 if the farmer purchases insurance and 0 if s/he does not. Trust in the insurance provider and Boro insurance are used as exogenous determinants of Aman insurance purchase.

Column (5) provides the results. Farmers who use pesticides and hired labour are more likely to purchase insurance to the extent of 12.13 and 0.12 percentage points respectively *on average and ceteris paribus.* However, farmers who use fertilizers are less likely to invest in insurance to the extent of 23.99 percentage points *on average and ceteris paribus*. Choice of seeds has no impact on insurance purchase.

Trust in the insurance provider increases the likelihood of insurance purchase by 69.04 percentage points *on average and ceteris paribus*. The high magnitude is justified given the negative insurance experiences that farmers in this district have faced in the last two years (as outlined in Section 3).

Investing in Boro insurance reduces the likelihood of Aman insurance purchase by 13.6 percentage points *on average and ceteris paribus.* Membership in an SHG (which is a primary forum for insurance marketing) increases purchase of Aman insurance by 10.84 percentage points *on average and ceteris paribus.* Higher the number of crops cultivated in a year, the greater likelihood of purchasing Aman insurance.

A summary of the key results and possible reasons behind them are discussed in Section 6. The next section provides a brief summary of the Boro paddy regressions.

5.5 Insurance and Boro paddy

Unlike Aman, Boro is an intensive crop that requires heavy dosage of fertilizers, pesticides and irrigation. Especially with respect to fertilizers and pesticides, there is a specific heavy requirement that is mandatory. Thus, one is likely to see the Paulson and Babcock (2010) effect here where there is a significant chemical usage irrespective of insurance. A look at the descriptive statistics clearly indicates that almost all households in both rounds use chemical fertilizers and pesticides. Thus, it is not prudent to study these inputs for Boro.

Detailed regressions for Boro inputs such as seeds, irrigation[42] and hired labour are provided in Annexure A4.3. Exogeneity tests (Table A4.5) indicate that irrigation and labour decisions are exogenous to insurance purchase and vice-versa. This finding is in line with convention. Requirement of water is quite high for Boro paddy and nearly most farmers have irrigation facilities, sometimes provided by the Government. Similarly, the labour usage for Boro is quite high due to recurrent weed attacks. However, insurance is endogenous to seed choice. HYV seeds, which are costlier, are generally preferred for Boro. Thus, the insurance purchased is likely to lower the total amount of investment available for these inputs.

Boro seeds and insurance: An IV framework can be used to assess the effect of insurance on seed choice where insurance is modeled in the first stage using instruments such as trust in the insurance company and purchase of insurance for Aman. The dependant variable in the structural equation takes the value 1 if the farmer uses high yielding variety (HYV) seeds and 0 if s/he uses traditional variety seeds**.** Column (2) and (3) of Table A4.3 presents the results.

Results indicate that Boro insurance has a positive and significant impact of seed choice. An insured farmer is 21.30 percentage points more likely to invest in HYV seeds *on average and ceteris paribus*.

[42] Irrigation is not examined for Aman as it is a completely rain-fed crop

A farmer who has a diversified income portfolio is 12.32 percentage points more likely to invest in HYV seeds *on average and ceteris paribus*. A risk averse farmer is 24.68 percentage points more likely to purchase HYV seeds *on average and ceteris paribus*. One must bear in mind that HYV seeds are generally preferred in Boro production given the nature of the crop, high input requirements and subsequent high yields. Since it is the normal convention to use HYV seeds for Boro in the entire state, a farmer who wants to 'play safe' is likely to use HYV seeds rather than traditional seeds that are seldom preferred.

Higher the number of crops grown, higher the probability of using HYV seeds for Boro. There is a 49.62 percentage point increase in the use of HYV seeds in 2012 *on average and ceteris paribus.* Akin to the Aman case, the more time a farmer takes to plant her/his seeds, the less likely s/he is to use HYV. Farmers who finance inputs through own sources are 13.29 percentage points more likely to be able to invest in HYV seeds *on average and ceteris paribus.*

Boro irrigation and insurance: Pooled OLS is used to study the impact of insurance on this input. The dependant variable is continuous and represents bighas of cropped land under irrigation. Column (3) in Table A4.2 presents the results.

Boro insurance has a positive and significant effect on irrigation. An insured farmer is likely to irrigate 0.22 additional bighas of land *on average and ceteris paribus*.

An increase in unit of land under crops increases irrigation by 0.64 bighas *on average and ceteris paribus*. Farmers who own machinery such as water pumps are likely to be able to irrigate 0.38 additional bighas of land *on average and ceteris paribus*. SHG affiliation ensures more cooperation among farmers and thus more bighas of land come under irrigation. An increase in the number of crops grown reduces the irrigation available to Boro by 0.38 bighas *on average and ceteris paribus.* Household size is positively associated with the bighas of land under irrigation.

Boro hired labour and insurance: A pooled OLS model is used here. The dependant variable represents the average man-days of hired labour. Column (4) in Table A4.2 presents the results.

An insured farmer is likely to hire 9.58 additional units of labour when compared to the uninsured *on average and ceteris paribus.*

Diversification increases the units of labour hired by 14.39 man-days *on average and ceteris paribus*. An increase in the bighas of land under crops increases the units of labour hired by 8.19 man-days *on average and ceteris paribus.* Lesser units of labour were hired in 2012 as compared to 2011. Ownership of livestock reduces hired labour by 9.36 man-days *on average and ceteris paribus* indicating substitution of bullock labour for manual labour. Risk aversion increases hired labour by 18.30 man-days *on average and ceteris paribus* indicating that farmers prefer to invest in labour to ensure higher produce as Boro is highly vulnerable to weeds and labour is required to clear the fields.

The relevance of the findings for both Aman and Boro paddy are discussed in the next section. The results are also assessed alongside the findings of Chapter III.

6. Discussion

The last sections explored the relationship between insurance and inputs accounting for the *timing* of these *ex-ante* decisions. To start with, the Chapter establishes how inputs contribute to production risk. Some inputs such as pesticides, irrigation and hired labour can be considered risk neutral or risk decreasing inputs as they contribute to an increase in mean yield but do not affect the variability of the yield. Whereas, fertilizers and HYV seeds are risk increasing as they may adversely affect the variability of the output.

Insurance is offered on a voluntary basis to all farmers in the district. This means households that purchased insurance have reasonable insurance awareness and product specific knowledge. This is a significant assumption as insurance can affect other aspects of agriculture only if a farmer fully understands how insurance works. Inadequate or incorrect knowledge of insurance mechanisms will not motivate a farmer to consider this *ex-ante* risk management tool as a means to alter input use behaviour.

Another equally important aspect is trust in the insurance provider. If the farmer has any doubt in the credentials of the insurance company, especially when it comes to claim payments, s/he is not likely to purchase insurance in the first place. Even if a farmer, who does not trust the provider, invests in insurance due to other factors such as peer pressure, s/he may not be willing to change input allocation patterns in the presence of crop microinsurance.

The standard hypothesis on the relationship between inputs and insurance proposes that insurance could either lead to a risk reduction effect (higher use of risk increasing inputs) or a moral hazard effect (reduction in the use of all inputs). Adding to this hypothesis, this Chapter highlights that there could be a third possibility i.e. a *substitution effect*, which leads to an increase in the use of cheaper, risk neutral (or risk decreasing) inputs.

The results obtained under various models for Aman and Boro paddy are summarised in Table 4.14a and Table 4.14b respectively.

Table 4.14a : Impact of insurance on input use for Aman paddy

Impact of insurance on	Seed	Fertilizers	Pesticides	Hired labour
Pooled OLS	0.0164	0.0061	0.0614**	4.9362**
IV estimation	0.0294	0.1685***	0.1441***	3.7367
Simultaneous equations	-	-0.0189	0.0910*	-

The Aman paddy findings are discussed first (see Table 4.14a). Based on the results of the Durbin-Wu-Hausman tests for Aman paddy, hired labour is endogeneous to insurance purchase. Seed use and insurance decisions are exogeneous to each other. Pesticides, fertilizers and insurance purchases are made simultaneously at the beginning of the cropping season. Drawing from these results, the impact of insurance on seeds are assessed under the pooled OLS model, while impacts of insurance on pesticide and fertilizer use are estimated within a simultaneous equation framework.

The results indicate that Aman insurance leads to an increase in the use of pesticides, which is a risk neutral input. The effect of insurance on fertilizers is negative under the simultaneous equations case, though the coefficient is not significant.

Recall that Aman insurance was found to have a risk reducing effect on output in Chapter III. A closer look at the individual components indicate the dominance of a *substitution effect* leading to an increase in the use of cheaper, risk neutral inputs such as pesticides and a reduction in fertilizer use.

To elaborate, a farmer has limited resources and investment in insurance means a reduction in the finances set aside for the cropping season. Since fertilizers are costlier than pesticides, farmers may be forced to purchase only pesticides due to shortage of funds. This is validated by the insurance regressions where farmers who use fertilizers have a lower probability of buying insurance. However, these dynamics do not seem to lower output in the short run as seen in Chapter III.

Table 4.14b: Impact of insurance on input use for Boro paddy

Impact of insurance on	Seed	Irrigation	Hired labour
Pooled OLS	0.0487	0.2240*	9.5804*
IV estimation	0.2130**	0.4437*	14.2088

In the case of Boro paddy (see Table 4.14b), irrigation and labour decisions are exogeneous to insurance purchase. Seed use decisions are endogeneous to insurance decisions. The findings show that insurance leads to an increase in the use of HYV seeds indicating a risk reduction effect, though there is also an increase in the use of irrigation and hired labour, which are risk neutral inputs.

Boro paddy insurance had a moral hazard effect on output in Chapter III. However, the inputs indicate an overall risk reduction effect that does not necessarily help increase output in the short run.

These results have several implications. First, the nature of endogeneity or simultaneity of insurance decisions varies across input and crop type. Failure to account for these associations may lead to an incorrect measurement of the impact of insurance on input usage. This is highlighted specifically in the case of Aman fertilizers, where failure to account for simultaneity leads to erroneous estimation of the impact of insurance on the input (see Table 4.14a).

It is prudent to note here that the effectiveness of pooled OLS, IV or simultaneous equation approach depends on the extent of such endogeneity issues, which could vary across crops, inputs or even geographies. It is important to acknowledge here that the assumptions underlying each of these methods are different and the econometric methodology adopted in the analysis of the association between inputs and insurance needs to be deliberated on for each specific case.

The assumptions here relate to the timing of the input and insurance purchase decisions. If there is clarity on when these decisions are made, the choice of the estimation methodology is fairly simple. For instance, if insurance is definitely offered prior to the cropping season, the two stage IV approach is sufficient to address associations between insurance and input use This means that all three estimation procedures used in this Chapter have their own stand-alone merit in determining the impact of insurance on input use.[43]

Similarly, the set-up of structural model for Aman paddy is also specific to this study only and cannot be generalised across crops, inputs or geographies. [44]

The risk reduction, substitution or moral hazard effects also vary across crop and input type. Also, insurance interventions have immediate, short-term impacts on inputs. However, insurance purchase decisions are likely to significantly impact output measures only in the medium or long term.

The fact that both crops under consideration are different lays a strong base for this analysis. Boro is a commercial crop that earns the farmer a larger share of income. Farmers are able to use insurance as an effective *ex-ante* hedge against low outputs and engage in better agricultural practices to maximise yields. However, since Aman is also used for self-consumption, insurance may not be an incentive to invest in better farming practices.

Note that all these effects are likely to be exhibited in the case of voluntary insurance schemes only. It is incorrect to assume that mandatory buyers of insurance have proper

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[43] Apart from the methods used in this Chapter, simulations or mathematical optimisation techniques are also used in such analyses in lieu of the endogeneity and/or simultaneity issues involved in an econometric analysis.

[44] Ideally, the structural model should account for the inherent endogeneity in input decision making. For example, the amount of pesticides purchased is related to the type of seeds purchased. The intention of this Chapter was to estimate a larger model wherein each input is estimated using insurance, a set of explanatory variables and the other inputs. Finding appropriate exogeneous variables for this case was challenging for this model and hence a simpler version is estimated in this Chapter. As an extension to this analysis, a full-form structural model can be estimated that accounts for not just the possible endogeneity between insurance and input decisions but also the endogeneity across different inputs.

awareness or trust in the provider because it is difficult to separate the demand for formal credit and the bundled insurance component for such policies as discussed in Chapter III.

7. Conclusion

This Chapter analyses the impact of insurance on input use for two different varieties of paddy i.e. Aman and Boro paddy using primary data collected in two phases from over 400 farmers in Howrah, West Bengal. The impact is measured for a range of inputs such as seed type, fertilizer use, pesticide use, irrigation (Boro only) and hired labour.

An important component of the analysis framework is that it covers voluntarily insured and uninsured farmers. Crop microinsurance coverage is a clear choice made by the households under study. This is important for several implicit assumptions made in the Chapter about crop microinsurance awareness, product specific knowledge and trust in local institutions. The fieldwork interactions support these assumptions.

The fact that Aman and Boro paddy are distinct from each other is also useful for the analysis. Aman is used for self-consumption and commercial purposes, yields lower when compared to Boro and it is more flexible in its input requirement mix. Boro is an intensive crop that is slowly emerging as the main commercial crop due to its high yields. It has very specific chemical requirements and nearly all farmers who grow this crop use high amounts of chemical fertilizers and pesticides.

After accounting for the endogeneity or simultaneity in the input and insurance purchase decisions, the study reveals that Aman insurance leads to a reduction in the use of risk increasing inputs, i.e. fertilizers and a rise in the use of risk decreasing/neutral inputs, i.e. pesticides. The Chapter defines this behaviour as a *substitution effect*, wherein insurance leads to an increase in the use of cheaper, risk neutral inputs in production. Boro insurance has a risk reduction effect on inputs as demonstrated by an increase in the use of HYV seeds by insured farmers.

The identification of *substitution effect* as a possible consequence in the relationship between inputs and insurance is an important contribution of this research. While Cole et al. (2013) find that insurance leads to a substitution in expenditures towards higher-risk, higher-return cash crops, this Chapter demonstrates a case of *intra-input* substitution effects for a given crop.

Clearly, the important inferences to be drawn here are that the effect of insurance on input use cannot be generalised. It depends on the type of the insurance, nature of the crop, its input requirement structure and the significance of the crop in the farm household's income portfolio.

As an additional contribution, the analysis shows how the endogeneity or simultaneity in input and insurance purchase decisions can be specific to both input and crop type. This is a significant finding as it demonstrates how each input is distinct in its requirement and contribution to output levels.

Among the other themes of the thesis, insurance trust is shown to significantly impact insurance purchases. The role of risk aversion is unclear in this case, as it does not significantly impact affect crop microinsurance purchases under most specifications.

As a policy recommendation, the use of better (risk increasing) inputs through insurance can be propagated by bundling insurance with the purchase of certain inputs based on a thorough understanding of the crop under consideration. For instance, if Boro crop insurance is bundled with the purchase of HYV Boro seeds, it will enable a higher percentage of farmers use HYV seeds and avail the benefits of insurance, leading to not just adoption of superior farming practices and higher output but also an increase in farmer's income and standard of living.

Stand-alone experiments such as the *Kilimo Salama*, Kenya and *Pioneer seeds*, India have already explored bundling insurance with inputs. This kind of bundling could probably work better than bundling insurance with credit for *loanee* farmers. This study lends credence to such efforts and recognizes the overall welfare implications of crop insurance as an *ex-ante* risk hedging mechanism.

Chapter V
Willingness to pay for index based crop microinsurance

1. Introduction

Microinsurance is a powerful tool that can help low income households transition out of poverty. The last two chapters on the impacts of crop microinsurance demonstrate how apart from providing a hedge against downside production risks, voluntary microinsurance can also promote use of superior quality inputs and advanced cropping techniques leading to increased productivity in the long term.

The awareness that insurance policies are an effective *ex-ante* source of risk coping has grown in the past decade. However, the demand for voluntary crop microinsurance continues to remain low globally. Poor households are wary of market-based solutions where they are required to make an upfront premium that will not be reimbursed to them, if the 'risk' does not occur (Dercon et al., 2008). Insurance companies, on the other hand, are keen to exploit this market base, but struggle both on product design and marketing aspects.

This Chapter examines the demand for index based crop microinsurance in India. Demand for any good has three components – the need for the product, the ability to buy and the willingness to pay. As a consumer, identifying the need for a certain product is not that difficult. It can be assumed that any rational farmer who is mindful of the several risks faced in agriculture will be able to appreciate the significance of *ex-ante* market based risk management strategies. However, merely recognising the importance of a particular product or service does not essentially convert into purchases.

There are many factors that can foster a gap between need and willingness to pay. Some of these include ability to pay, risk aversion, inadequate product knowledge and lack of trust in the institutions offering the product or service among others. Crop microinsurance demand is restricted due to some of the factors highlighted above. The additional themes explored in Chapter III and IV also substantiate this hypothesis.

This Chapter contributes to the existing literature by identifying the precise gaps between the ‘perceived’ and ‘actual’ demand for crop microinsurance policies. In order to achieve this, it is important to distinguish between the *willingness to join* (WTJ) and *willingness to pay* (WTP) for a product.

WTJ may be defined as an initial interest to understanding and adopting a particular product resulting from several tangible and intangible factors. The intention behind eliciting WTJ is to be able to capture the specific variables/attributes that affect a household’s interest in adopting formal ex-ante crop microinsurance. WTP refers as the amount of money an individual or household is prepared to pay for purchasing a product given her/his income, risk preferences and other background characteristics.

Clearly, WTJ may not necessarily translate into WTP. In other words, a household’s interest in participation may not lead into actual payment and purchase for reasons cited above or otherwise. This premise could explain why the uptake of insurance is low despite the apparent need for such products. The underlying hypothesis here is that while there is sufficient WTJ displayed in literature and field experiences, this is not always followed by an actual purchase and therefore, the need to study the gap between WTJ and WTP.

The Indian case where insurance is offered both on a mandatory (bundled with formal credit) and voluntary basis presents an ideal scenario for analysis. The crop insurance penetration in India currently stands at 25 percent. However, as highlighted in Chapter I, a majority of this coverage pertains to *loanee* farmers or mandatory buyers of insurance only. The demand for crop microinsurance is low among the *non-loanee* or voluntary buyers of insurance despite the presence of subsidies. Thus, it is critical to examine potential voluntary buyers of crop microinsurance to understand the reasons driving their low demand for such products.

This study is one of the first attempts to delineate the *willingness to join* or WTJ from the amount of *willingness to pay* or WTP for weather index based crop microinsurance policies in any country. A contingent valuation bidding methodology is used to study the demand for rainfall microinsurance programmes among 400 small and marginal turmeric farmers in Tamil Nadu, India. Using a Heckman selection approach, ordered probit is used to model WTJ and interval regression is used to estimate the amount of WTP.

The Chapter also examines the usefulness of contingent valuation techniques in microinsurance demand analysis. As an additional contribution, the analysis iterates the existing bidding methods to incorporate both the WTJ and WTP for crop microinsurance schemes. Instead of following a simple yes/no approach to WTJ, the bidding experiment categorises potential customers into four possible categories ranging from complete unwillingness to participate to unsure clients to those who are ready to invest in these schemes.

Results indicate that while the willingness to join crop index microinsurance is influenced by household wealth, risk attitudes and product literacy, the amount a household is willing to pay is driven by a careful assessment of the other risk coping avenues available to a household and only the *residual risk* is passed on to insurance.

The rest of this paper has been organised as follows: Section 2 reviews the existing literature and Section 3 illustrates the survey design and contingent valuation methodology. Section 4 describes the dataset compiled using a purpose-designed survey instrument. Section 5 elaborates on econometric methodology, Section 6 provides the findings and Section 7 presents the conclusion.

2. Literature review

While the last two Chapters studied the impact of crop microinsurance on output and input, this Chapter delves into the demand for these products. As mentioned in the introduction, the demand for voluntary insurance products is low not just in India, but also in other developing countries.

This Chapter takes an experimental approach to analyse the demand for crop insurance products. A contingent valuation framework is used to elicit a household's willingness to participate in and pay for crop microinsurance programmes. Contingent valuation has been used intensively in literature to assess the demand for intangible goods. There are a sizeable number of studies that use contingent valuation to assess demand for health microinsurance schemes. However, there is very little work in this space relating to crop microinsurance.

Most of the existing articles on microinsurance demand tend to directly estimate demand by eliciting willingness to pay for a particular product at a specific pre-determined price or use randomised control trials, where insurance is offered only to the treatment group.

The literature section needs to incorporate both articles on the factors affecting crop microinsurance demand as well as studies relating to contingent valuation methodology. This section is organised as follows – the first sub-section elaborates on crop microinsurance demand literature and the second describes contingent valuation methodology. The final sub-section analyses the gaps in literature and presents the contributions of this Chapter.

2.1 Demand for crop microinsurance

The first sub-section traces the literature on the demand for microinsurance schemes. Various economic theories have been put forward to summarise the uptake of low premium based insurance products. According to Ito and Kono (2009), the low take up of insurance can be understood using the prospect theory proposed by Kahneman and Tversky in 1979. Prospect theory presumes that people behave in a risk-averse way in evaluating gains but in a risk-loving way in evaluating losses. Since insurance covers losses, those who are risk-loving in evaluating losses are less likely to purchase the insurance.

Dror et al. (2006) suggest that insurance uptake can be explained using the regret theory. It holds that people want to replicate good feelings and lessen feelings of regret. When deciding whether or not to buy insurance, people usually act at the beginning of a period but assess their choice at the end, based on the outcome (Loomes and Sugden 1982, as cited in Dror et al., 2006).

Though there are a handful of studies on crop microinsurance demand, there is a much larger pool of literature on demand for health microinsurance products. Churchill et al.

(2012) present an elaborate list of health based *willingness to pay* (WTP) literature. Some of the health insurance demand studies that employ a contingent valuation framework include Mathiyazhagan (1998), Asenso-Okyere et al. (1997), Dong et al. (2003), Dror et al. (2006), Gustafsson-Wright et al. (2009) and Donfouet and Makaudze among others. The major findings indicate that demand for health microinsurance and nominal income levels are positively correlated, while household income and WTP as a percentage of household income is negatively correlated (Dror et al., 2006). WTP for health microinsurance also varies with the time and nature of the payment procedures and number of people covered per household in a group policy (Asenso-Okyere et al., 1997). Most of these studies directly estimate WTP using a contingent valuation based bidding methods.

However, it is important to distinguish the WTP from the willingness to participate or join (WTJ) an insurance programme. A household may be willing to join microinsurance programmes for several reasons that may not translate to actual purchase. In such cases, estimating WTP values from respondents who are only willing to join the scheme can lead to biased and inconsistent results if respondents who are willing to join and pay for the scheme have different observable and unobservable characteristics when compared to those who are only willing to join (Mattsson & Li, 1994; Whitehead, Blomquist, Hoban, & Clifford, 1995, as cited in Gustafsson-Wright et al., 2009).

Under this framework, Mathiyazhagan (1998) studies both WTJ and WTP for health microinsurance in India to report that the probability of willingness to join was greater than the probability of willingness to pay. This is the only known work that demarcates WTJ from WTP for health microinsurance.

The rest of this sub-section highlights the major findings relating to crop insurance demand. The literature on demand for crop microinsurance is fairly recent. Most of this work focuses on weather indexed insurance schemes, where demand is directly assessed based on assessing insurance buyers and non-buyers over a period of time.

Factors affecting demand for crop insurance include premium amounts and household wealth. Demand for rainfall insurance is shown to be highly dependent on price and sensitive to cash on hand (Cole et al., 2008) based on a study in India.

Insurance demand is shown to be increasing in household wealth (Gine et al., 2008; Cole et al., 2009). However, recent findings by Clark and Kalani (2011) provide evidence for a hump-shaped relationship between weather index insurance demand and wealth based on a study in rural Ethiopia. In other words, insurance demand is lower in the poorest and richest households and is highest in households with intermediate wealth. In this case the total livestock units are used as a proxy for wealth.

Households which assume that they are more vulnerable to risk opt not to use any financial services at all and are especially unlikely to use insurance on top of other services (Bendig et al., 2009). Similarly Gine et al. (2008) identify that households that face credit constraints are less likely to take up crop insurance. However, households that belong to social networks and/or have access to savings and borrowings are likely to have more knowledge of insurance products and are thus exhibit higher demand for such products (Clarke and Kalani, 2011).

Though the proximity to the financial institution seems to play a role in the demand for financial services, trust in this institution and their staffs is even more important. On these lines, McGuinness and Tounytsky (2006) identify that while clients have a high level of trust in their microfinance institution, they have no interest or faith in the insurance companies based on a study in Pakistan. Gine et al. (2008) show that demand for crop microinsurance is higher among households who were familiar with the insurance vendor in India.

Another factor that affects the willingness to participate in index based microinsurance programmes is basis risk. Basis risk is the difference between the rainfall on a farmer's field and rainfall recorded in a weather station situated *x* kilometres away from the field. It represents the potential mismatch between insurance payout and actual losses. Micro-climates and uneven topography may affect yields greatly and these aspects are not measured in weather based products.

Gine et al. (2008) show that insurance take-up is decreasing in basis risk. The fact that very few farmers have access to weather information through radio, television or friends reduces their demand considerably (McCarthy, 2003). Hill, Hoddinott and Kumar (2011) identify that willingness to continue purchasing microinsurance in the subsequent years is also affected by basis risk as 30 percent of their respondents refused to continue with the product if there was no pay-out when rains failed their farm based on a study in Ethiopia.

Insurance demand is also affected by product marketing (Gaurav et al., 2011; Dalal and Morduch, 2010). Negative framing of insurance advertisements are more powerful than positive framing. For instance, Johnson, Hershey, Meszaros and Kunrether (1993) conduct a survey in which willingness to pay for flight insurance, covering a single airline flight, is elicited. The mean willingness to pay for a policy covering —any act of terrorism' is $14.12, compared to $12.03 for a policy covering an accident for 'any reason' (as cited in Cole et al., 2009).

Finally, past insurance experiences (Link and Wirz, 2008) and risk aversion (Gine et al, 2008; Cole et al, 2009) are also important determinants of crop microinsurance demand.

The next section explores contingent valuation methodology in detail.

2.2 Contingent valuation methodology

In general, WTP is analysed using the contingent valuation method (CVM). This methodology helps estimate the value an individual places on a product, usually an intangible good. Pioneered by Davis in 1963, CVMs were mainly used to evaluate environment and health care programmes. However, CVM are now being increasingly used to evaluate private market goods and services.

Broadly, there are two approaches to studying WTP under CVM. The first is a close ended format called referendum or the 'take-it-or-leave-it' approach. Here, the product is offered to the individual at a pre-determined price. The individual provides his/her preference to accept or not accept the product at that price. Hanemann and Kanninen (1999) suggest that the close ended format as a good way to elicit individuals' preferences as it closely mimics real market situations and reduces strategic bias. However, it is considered a rather ad-hoc approach to understanding an individual's preferences. It is also difficult to use these estimations to draw aggregate demand curves for the product under study.

The other method, which is more widely used, follows an open-ended format and is called the 'interactive bidding' (IB) method. Under the IB method, an individual is offered the product at a starting price. If s/he accepts the price, a higher price is offered and the process goes on until s/he rejects the bid. Alternatively, if s/he rejects the price, a lower bid is offered and the process goes on until s/he accepts the bid.

Hanemann (1991) suggests the use of 'double bounded dictomous choice' or DBDC response models for WTP elicitation. He shows that the 'double-bounded' approach is asymptotically more efficient than the conventional 'single- bounded' approach. This method is also preferable to triple or higher biddings as literature validates based on Monte Carlo simulations that that the additional statistical efficiency gains in estimating mean WTP from adding third or fourth follow-up bids is relatively small and it can increase the chance of inducing response effects (Cooper & Hanemann, 1995; Yoo & Yang, 2001). Interval regressions (parametric) or survival regression (non-parametric) models are generally used to estimate WTP under DBDC methods. More information on the econometric modeling is provided in Section five of this Chapter.

While the IB method helps identify a more precise estimate of WTP, it also suffers from certain limitations including starting point bias and hypothetical bias. Starting bias arises when respondents interpret the starting value in the bidding game as being indicative of market information, or as representing a typical bid. For instance, Kartman et al. (1996) find that individuals in the highest starting-bid group are willing to pay double that of those in the lowest (as cited in Dong et al., 2004, pg 124).

Starting point bias can be reduced by using a range of starting point bids (i.e. different starting values for different respondents) and comparing the effect of each of those starting points on the final WTP value elicited. For example, to study WTP for community based health microinsurance in Burkina Faso, Dong et al (2004) use as many as thirteen starting bids.

Hypothetical bias arises when an individual responding to a survey fails to take into account the additional information s/he possesses in terms of her/his budgetary constraints, preferences, available substitutes etc. (Slovic, 1972 as cited in Bateman, 1993). Thus, in order to make results more accurate, it is important to explicitly introduce 'mental accounting' into CVMs by asking some initial questions about the respondent's total yearly budget etc. (Bateman, 1993). Hypothetical bias can be dealt with using a *cheap talk script* or respondent certainty method (Blumenschein et al., 2008).

Under the *cheap talk script* method, the respondents are asked to read a note prior to the survey describing the issue of hypothetical bias and advising them to do some mental accounting while participating in the bidding process. This method was first used by Cummings and Taylor in experimental referenda about donations to public goods.

The response certainty method uses a follow-up question at the end of survey requesting the respondent to validate his/her choice of the final bid. This is done in two possible ways: (i) a scale is used to assess degree of certainty where the respondents ranks their chosen WTP on a one to ten scale (ten being the most certain) or (ii) where only two degrees of certainty are provided in the follow-up question- probably sure and definitely sure. The former was first used by Champ et al. in 1997 in experimental referenda about donations to public goods and the latter by Johannesson et al. in 1998.

Blumenschein et al. (2008) compare the *cheap talk script* and response certainty methods. They report that WTP can be accurately estimated by adding a simple follow-up question about the certainty of responses and that cheap talk is not a generally effective approach. Blomquist et al. (2009) compare the two methods of recording certainty – the ten point scale method versus the definitely/probably sure method. They assess results across three independent studies to conclude that aggregate demand curves plotted using the 'definitely sure' responses are closest to the real world scenario.

Most studies that estimate WTP using a bidding process conclude the analysis with the estimation of mean and median WTP. Though the initial studies estimate only mean WTP, Cawley (2008) cites that the mean WTP is more biased than median WTP associated with the follow-up responses. Thus, there is now greater reliance on the median values obtained from bidding games.

Aggregate demand curves are also constructed using the final responses to the bidding game to determine the nature of the product. A downward sloping curve indicates that product under study is a 'normal good'.

In terms of variables used in the analysis of contingent valuation based bidding games, Clinch and Murphy (2001) suggest the use of dummies for income/wealth bands rather than incorporate them directly as it will help get a better sense of WTP across income/wealth groups.

CVMs have been used extensively in assessing demand for intangible goods. The limitations and drawbacks of using this methodology have also been addressed and corrected over the years. The next sub-section highlights the key aspects of literature that will affect this Chapter's framework and analysis.

2.3 Observations from the literature

The above sub-sections presented literature on demand for crop microinsurance as well as contingent valuation. Contrary to the impact literature that largely focused on US federal insurance, demand studies are concentrated in developing countries specifically in India, Pakistan and Ethiopia.

A number of factors such as household wealth, access to financial institutions, trust in the provider, insurance marketing, household's perception of poverty status, basis risk and risk aversion are shown to affect crop microinsurance demand.

The research on factors contributing to the demand for crop insurance across developing countries is slow-growing. Often, in these studies, a sizeable portion of the sample agrees to purchase the product but the numbers fall short when the actual sale happens. In other cases, while the response is good in the pilot phase, the product does not achieve scale subsequently.

The demarcation of WTP from the WTJ for microinsurance programmes could help explain this gap. Mathiyazhagan's (1998) pioneering work in health microinsurance may be adapted to crop index insurance to evaluate the *actual* WTP for such policies. Addressing demand through a two-step approach can help account for those households who are not decisive on insurance purchase decisions at the time of the survey/pilot. Thus allows a realistic assessment of demand and helps identify the reasons for indecisiveness among participating households. This Chapter delineates the WTJ and WTP schemes to assess the gaps between survey responses and follow-up purchases.

The literature on CVM cites not only the elicitation methodology, but also the possible limitations to overcome certain biases that may impede the process. These corrective measures such as multiple starting bids, cheap talk script and response certainty need to be incorporated effectively into the contingent valuation experiment conducted in this Chapter.

Another important aspect that emerges from the CVM literature is that the questionnaire structure can significantly affect elicitation responses of the survey. It is important to place the questions relating to 'mental accounting', hypothetical product, cheap talk script, response certainty in a logical format so that the respondent is able to overcome biases and provide realistic estimates of his/her willingness to pay.

The literature reviewed above does not delve fully into the econometric estimation methodologies relating to contingent valuation experiments. The econometric modeling largely depends on the bidding methodology adopted by the study. The subsequent aggregate demand curves are estimated based on the nature of the WTP estimation. These methods could be parametric or non-parametric approaches.

This Chapter estimates both the WTJ and WTP in a two-step framework. The specific bidding process and econometric modeling are detailed in the later section of the document.

The next sections describe the contingent valuation process and hypothetical product offered to respondents. This is followed by descriptive statistics relating to the household dataset.

3. Survey design and bidding methodology

This study elicits the WTJ and WTP for a crop microinsurance scheme using a contingent valuation game. Primary level data collection using a pre-defined survey instrument is crucial for a comprehensive analysis. This Chapter uses the primary data collected from Erode, Tamil Nadu. Some basic information relating to this dataset is provided in Section 4 of Chapter II.

To recall, data is collected from 400 small and marginal turmeric farmers from two blocks in Erode district, namely Andhiyur and TN Palayam. Institutional support is provided by a local NGO named Myrada. A purpose-designed questionnaire is used to elicit the WTJ and WTP for a hypothetical rainfall index based crop microinsurance scheme.

The product under study needs to be address the major risks faced in crop production in the study areas. Chapter II highlights that the Erode belt is known for its turmeric production. Other crops cultivated in this area include sugarcane, banana and vegetables.

A sub-tropical crop, turmeric requires warm and humid climate. It is typically a ten-month crop consisting of four growth phases – sowing, rhizome vegetation, rhizome maturation and harvesting. Average rainfall requirement is 1500 mm and temperature range preferred is 20°–30°C. Turmeric grows up to 1200 meters above mean sea level. It is a root crop and grows well in loamy soils that have natural drainage systems. Both Andhiyur and TN Palayam, the blocks under study, provide a favourable atmosphere for high tonnes of turmeric production. Both these blocks are also well irrigated due to the existence of a dam at the sub-district level.

Major risks in turmeric cultivation in these regions include low average rainfall, crop diseases and high rainfall for consecutive days. Low rainfall leads to low maturation of the root nodule, so the final product is of low quality. This is not a major issue in the study areas as they are well irrigated. Similarly, crop pests and diseases are dealt with using pesticides recommended by local universities. However, this crop is particularly averse to water stagnation and alkalinity. Though the overall rainfall requirement of turmeric is high, consecutive daily heavy rainfall and water stagnation can completely corrode the root crop. Sample households face the risk of heavy losses when heavy rainfall is combined with water released from the dam.

This section provides more insight on the contingent valuation experiment conducted to elicit demand. The contingent valuation experiment has three main components – the product under study, the bidding process and the manner in which these aspects are placed in the survey instrument i.e. questionnaire. These three elements have to be carefully constructed to elicit realistic values of WTJ and WTP.

3.1 Hypothetical insurance product

A hypothetical product is developed for the contingent valuation bidding game. The reason for using a hypothetical product rather than an actual product is outlined in Section 4 of Chapter II. To recall, the initial aim of this Chapter was to secure an insurance company partnership and offer a real-time product to respondents. Negotiations with several insurance companies were not successful. The hypothetical product was then developed with the help of an insurance actuary.

The use of a hypothetical product emerged as a significant advantage for the analysis. The locals in these geographic have little exposure to weather based policies. It was important to initiate them with a basic product, rather than offer a multiple trigger scheme that covers several weather risks. The product design needed to be simple and easy to understand as the idea is to sell the concept of weather index based insurance and not an actual product. The hypothetical scheme allowed the author and the actuary to design the crop microinsurance policy under study in a suitable manner. Since the product provided has a premium and sum assured similar to market standards for horticulture crops, our analysis remains unaffected.

Based on the risks in turmeric production as highlighted above, the hypothetical product offered to the sample households is an excess rainfall cover. It was developed with the help of an actuary in India. The product is straightforward and provides a full cover for rainfall beyond a certain level. It does not have a linear pay out structure.

The product makes a payout to the farmer if the rainfall for any two consecutive days is cumulative 85 mm or higher during the crop's vegetation phase i.e. between months two-five after sowing. The claim amount is at INR 25000,[45] which is the average cost of cultivation during this phase. The actuarial premium is estimated at INR 2000 approximately. Note that the premium rate for this product is 8 percent. The average premium for commercial and horticulture index insurance products in India ranges from 6-12 percent.

The product note also advises the respondent about the possible case of basis risk by highlighting that rainfall would be recorded using a weather station (rain gauge) that is 7-10 kilometres away from his/her farm.

The trigger level is set at 85 mm for a cumulative two-day period. The insurance payout automatically comes to play when the trigger is reached. Full payment is made to the farmer once the trigger level is attained in the vegetative phase. The product does not have a linear pay out structure.[46]

Rainfall at 85 mm or higher represents substantial water logging, which can completely erosion of the root crop. This means that the product is well aligned with the specific risks experienced historically in turmeric cultivation in this area. The actuarial premium is slightly higher when compared to the premium of food grains and oilseeds. However, it is on par with the premium chargeable for horticulture crops as discussed above.

The bidding game and questionnaire format are described in the following sub-sections.

3.2 Contingent valuation process

The bidding methodology is crucial to the analysis. The 'double bounded dictomous choice' or DBDC methodology highlighted in the literature review is used for this study. Some of the literature that employ DBDC models include Hanemann (1984), Alberini et al. (1997), Hagos et al. (2006), Cawley (2008), Kristom (1990), Hanemann

[45] £1 = INR 78 at the time of the survey
[46] Most weather index products have a linear payout structure. See Box 1.1 of Chapter I for an illustrative description.

(1991), Carson et al. (1994) and Carson et al. (2003), Gustafsson-Wright et al. (2009) and Donfouet and Makaudze (2010) among others.

Under this method, a starting bid is provided to each individual who has expressed willingness to join the crop microinsurance programme. If s/he accepts the first bid, a second higher bid is offered. If s/he accepts the higher bid, that value is considered as the WTP. If s/he rejects the higher bid, the original bid offered is considered as the WTP. If the respondent rejects the initial bid, then s/he is offered a second lower bid. If s/he accepts the lower bid, that value is considered as the WTP. If the respondent rejects the second lower bid, then s/he is asked to provide an estimate of the maximum amount s/he is willing to pay for the product.

In this process, each individual provides one of the four responses: yes-yes, yes-no, no-yes, no-no. Also note that the second bid is contingent on the first bid (Hanemann, 1991). Gustafsson-Wright et al. (2009) provide evidence on this in their study on health microinsurance.

The additional contribution of this Chapter is that only the respondents who expressed a willingness to join (WTJ) in such a scheme are subject to the bidding process. This iteration ensures that the bidding game distinguishes between respondents that are interested in participating in the scheme from those who are more ready to actually pay for and purchase the product.

The bidding game is set up as follows. The product structure is explained to the respondent using an initial starting bid (price) and s/he is first asked if they are willing to participate or WTJ this scheme.[47]

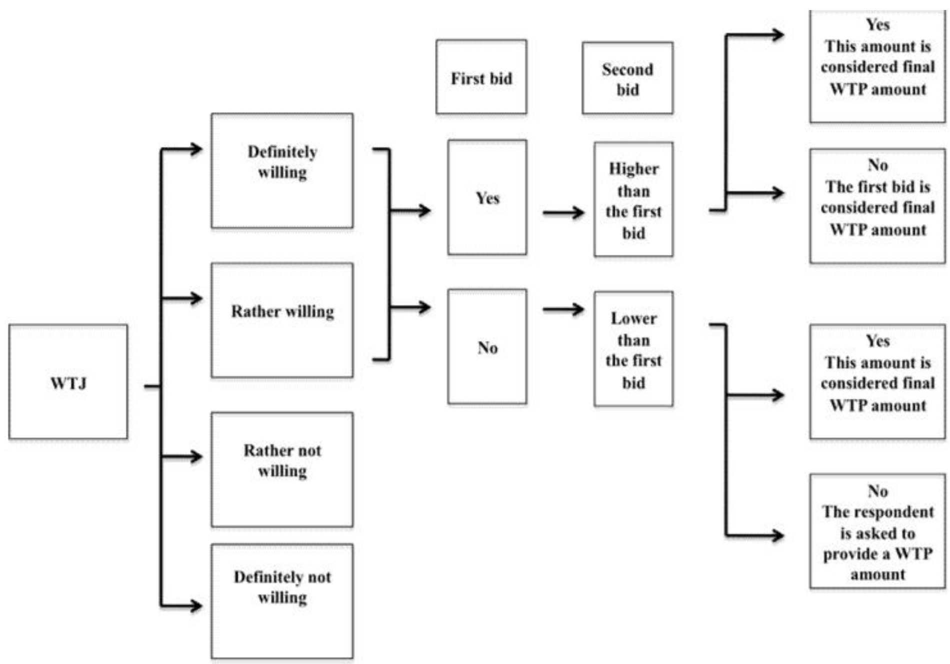
[47] It is important to reiterate here that WTJ refers to an initial interest in understanding and adopting the hypothetical weather index based crop insurance only. It does not represent the *willingness to pay* the first bid. In this case, ideally WTJ elicitation should not include the price of the product. However, initial field discussion and pilot testing of the questionnaire indicated that the product price is also an important determinant in assessing the WTJ of a household. Most participants were unwilling to express their WTJ without sufficient information on the approximate price of this policy. Thus, the first step in the two-stage bidding experiment used to elicit WTJ and WTP had to incorporate an initial price or start bid. Econometric measures have been undertaken to test the robustness of the non-price effects, especially in the WTJ analysis. Please see Section 6.1 for details.

For this, the respondent is asked to choose between four responses: *Definitely not willing to join, Rather not willing to join, Rather willing to join and Definitely willing to join*. Only respondents who are *rather willing* or *definitely willing to join* participate in the two-step bidding process.

The choice of four different responses to the WTJ question, rather than a simple Yes/No is designed to allow the respondent to evaluate his/her actual stance on the product. A direct Yes/No would be rather crude as the product is only introduced in an earlier stage. Offering four possible responses to the client enables them to process the information and assess their potential demand for the same. It also allows the analysis to capture the ‘doubtful’ households who represent those households that may respond positively to a survey but not follow through after the pilot phase.

A detailed illustration of the bidding game followed in this study is provided in Figure 5.1

Figure 5.1: Contingent valuation methodology used to elicit WTJ and WTP



Source: Author

Contingent valuation models are subject to starting point and hypothetical bias. In order to control for *starting bias,* a range of the starting bids are used. The starting bids are: INR 1000, 1500, 2000, 2500 and 3000. The subsequent bids vary by INR 500, e.g. for the questionnaires in which the first bid is INR 2000, the second higher bid is INR 2500 and the second lower bid is INR 1500. The starting bids are varied per 80 questionnaires and equally distributed among the executors of the survey to reduce enumerator specific biases.

Hypothetical bias is also controlled for using both a *cheap talk script* prior to the bidding and a response certainty question at the end of the survey. The certainty factor is assessed using two measures- probably sure and definitely sure. The respondent is not informed that the product is hypothetical until the end of the survey. The manner in which the *cheap talk script* and response certainty are placed in the questionnaire is described in the next section.

3.3 Questionnaire scheme and field interviews

In view of the possible biases that arise in contingent valuation processes, the questionnaire structure and the pattern of questioning become as crucial as the underlying product and the bidding game.

The positioning of information relating to household socio-economic variables, cheap talk scrip and product note can also influence the responses to the bidding game and post elicitation response certainty assessments as highlighted in the literature. The questionnaire contained four sections, which are described below:

i. Section A - Mental Accounting (Bateman, 1993; Diamond and Hausman, 1994): The questionnaire begins with questions relating to basic socio-economic and agricultural profiles of the household. These questions help remind the respondent of his/her own well-being and build a base for realistic WTJ and WTP elicitation.

ii. Section B – Perceptions, risk attitudes and insurance: This section explores the risk attitudes of the respondent using a Binswanger (1980) lottery game. It also records the recent agricultural risks faced by the household and measures taken to cope with these shocks and resulting losses. A household's self-perception of its poverty status is also assessed along with insurance attitudes, trust and experiences in this section.

iii. Section C -Willingness to pay and willingness to join: A *cheap talk script* is first read out to the respondent. Following this, a hypothetical product with an initial start bid price (premium) is presented. A few questions on the product described and basis risk considerations are also posed at this stage. After this, a household's WTJ is elicited using the four possible responses highlighted in the earlier sub-section. Households that are *rather willing* or *definitely willing to join* are then subject to a two-stage bidding process. Their final WTP values are recorded at the end of the bidding game.

iv. Section D - Post elicitation enquiries: The respondent is asked to elaborate on his/her WTJ and WTP choices in this section. Respondent certainty of the type 'probably/definitely sure' is assessed at the end of the questionnaire to check for hypothetical bias (Blumenschein et al., 2008; Blomquist et al., 2009)

The questionnaire structure ensures that the respondent is clear about the product and the experiment. The enumerators were trained over a two-day period to ensure that they fully understood the product and the requirements of the study. They were also advised to not prompt the participants in any manner or share the responses of other households of the survey. The latter is to ensure that a respondent is not influenced by the choices of his/her peers or neighbours in the elicitation process.

Apart from demand elicitation using a survey questionnaire, qualitative data is also collected through focussed group discussions with NGOs as well as farmers in Andhiyur and TN Palayam. Discussions reveal that the only *ex-ante* strategies adopted to deal with turmeric weather shocks were savings and multiple cropping.[48] Most households preferred to borrow from friends, relatives or moneylenders to manage

[48] Farmers also employ some interesting strategies to deal with some risks of banana and sugarcane production. For instance, they install electric fences around sugarcane to prevent elephant attacks to sugarcane near hilly areas. Also, they use twines to ensure the banana trees are not fully uprooted by heavy winds. There are no such strategies for turmeric

shocks *ex-post*. Formal bank borrowing is considered tedious, as it requires heavy documentation. Few people in the area have past experiences with agriculture insurance (as per the survey only 12 households in Andhiyur). Individuals were not aware of area yield insurance or weather index based insurance.

Small and marginal farmers in TN Palayam and Andhiyur realise the importance of formal risk management mechanisms to deal with production and price shocks. They have a clear sense of the risks in their production process – the extent to which they can handle losses themselves and their need for external solutions. Their main motivation to participate in the household survey was to educate themselves on market-based risk management strategies. This meant that the respondents provided their WTJ and WTP estimates in an unbiased environment by matching their requirements against the product features.

4. Descriptive statistics

Section 4 of Chapter II provides the averages of relevant socio-economic variables collected from the households under survey. To reiterate, 200 households are interviewed in each of Andhiyur and TN Palayam. 80 percent of the respondents are male with an average age of 44 years. Agriculture is the primary source of income for nearly all households in both blocks. Annual income levels are higher in Andhiyur when compared to TN Palayam.

In addition, Andhiyur's sample has more exposure to beneficiary programmes. At least 45 percent of households participate in the MNREGA, 56 percent households are members of the cooperative society and 48 percent are members of SHGs. In comparison, only 11 percent households in TN Palayam are members of SHGs, less than one percent is aware of the MNREGA and 20 percent of the households are members of cooperatives. Both blocks have less exposure to MFIs.

This section provides further information on the agricultural profiles, production techniques, risk attitudes, insurance experiences and highlights the findings from the demand elicitation processes.

4.1 Agricultural profile

This sub-section highlights land ownership and agricultural profiles of the households under study. Around 75 percent of the respondents in Andhiyur operate on their own lands and the average land holdings are around 3 acres. 95 percent of farmers in TN Palayam have own lands and the average land size per farmer is around 5 acres.

Every household surveyed cultivates turmeric on at least one acre of their total planted area; other crops grown include sugarcane, banana, cotton, maize, paddy or others. On average farmers grow turmeric on at least 1.5 acres of their land in Andhiyur and 2.1 acres of their land in TN Palayam.

Though TN Palayam has more acres of turmeric under cultivation on average, the production of turmeric per acre is statistically higher in Andhiyur. Andhiyur produces 1900 kg of turmeric per acre and TN Palayam produces 1700 kg of turmeric per acre. The cost of cultivation per acre of turmeric is significantly lower in TN Palayam (INR 40000 approx.) compared to Andhiyur (INR 44000 approx.).

Around 15 percent of the respondents cite heavy rains as a major source of losses for their crops. On average, it takes the households around a year to recover from shocks irrespective of land size or income level. The common risk coping mechanisms and attitudes towards risk are highlighted in the next sub-section.

4.2 Risk attitudes and past insurance experience

In view of the multiple shocks faced in agriculture, households tend grow multiple crops on their land and earn profits on average in both blocks. Major risk coping mechanisms include savings or borrowings from both formal and informal sources. The details are provided in Table 5.1.

Table 5.1: Risk coping strategies		
Technique	**Primary strategy (In %)**	**Secondary strategy (in %)**
Do nothing	21.11	
Multiple cropping per season	41.71	21.71
Savings	20.35	49.22
Formal borrowing	4.52	11.63
Informal borrowing	12.06	12.79
Have other sources of income	0.25	2.33

Source: Author's calculations

A study on loan preferences indicates that 32 percent of the respondents prefer to borrow from relatives, friends or neighbours during emergencies. The next preferred sources are moneylenders (28 percent) and local cooperative banks (15 percent). These results are in line with inferences from the FGDs. This suggests that there are some forms of informal insurance arrangements in the community. While these arrangements do help manage sudden cash crunches, the situation is different when systemic shocks affect the communities – especially in case of heavy winds and rainfall vagaries- where most of the farmers suffer losses.

Results of the Binswanger game on risk preferences (described in Section 5 of Chapter II) indicate that around 49 percent of the respondents are extremely risk averse and 27 percent are risk preferring. Households at low levels of income in TN Palayam exhibit higher risk preference. 43 percent of the households in the lower income quintiles chose the 0-200 lottery in this block.

Households in both blocks do not have a lot of exposure to non-life microinsurance policies. Around 92 percent of the total sample has purchased life insurance policies. Around seven percent of the total sample has exposure to health insurance and less than one percent has agriculture (sugarcane area yield) insurance experiences. These experiences have not been satisfactory especially in relation to claim settlements. Households that have not invested insurance in the past indicate that insurance is not necessary (39 percent) and that the policies are expensive (24 percent).

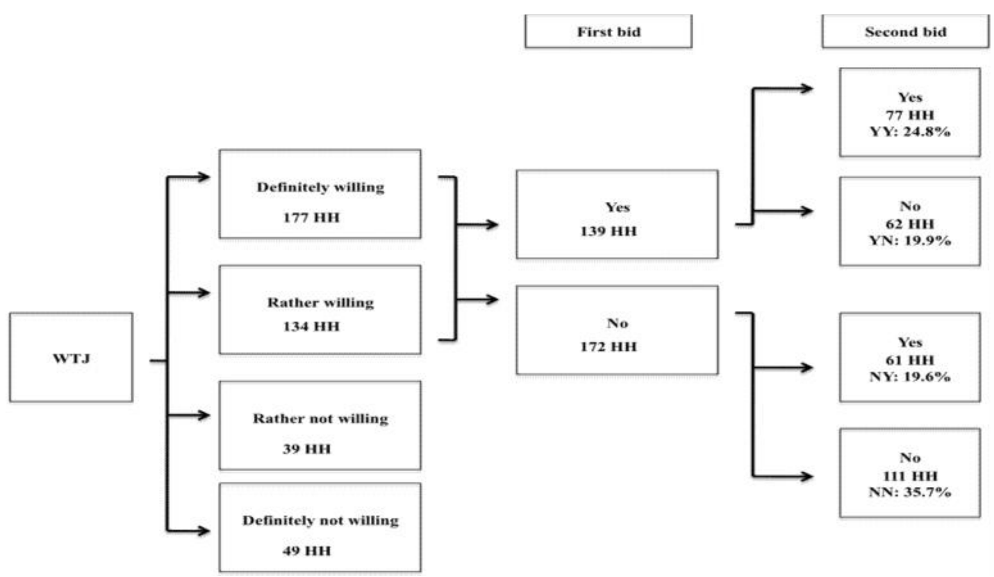
The next section presents the results of the demand elicitation game.

4.3 Demand elicitation results

Demand for crop microinsurance is elicited using a DBDC bidding game. As an additional contribution, the DBDC elicitation is preceded by a WTJ option. Only households that express a willingness to participate are subject to the bidding process.

Out of the total sample of 400 households, 88 expressed unwillingness to join the hypothetical crop microinsurance programme. 311 households expressed a willingness to participate in the scheme - 56 percent are *definitely willing* and 43 percent are *rather willing to join*. The households that participate in the bidding process could respond in four possible ways: yes-yes, yes-no, no-yes, no-no. Around 36 percent of the households preferred the no-no bid indicating that irrespective of the starting bid values, insurance seems to be expensive for the study group. The responses to the WTJ and WTP bidding are illustrated in Figure 5.2.

Figure 5.2: Results of the bidding game used to elicit WTJ and WTP



Source: Author's calculations; HH refers to number of households

59 percent of the respondents who are *not rather* or *definitely willing to join* cited basis risk as the primary reason for the same. 12 percent expressed a lack of trust in the insurance provider. Other reasons cited for non-participation include bad past

experiences (7.4 percent), inadequate claim amounts (7 percent) and non-requirement of insurance to manage risks (6.2 percent).

The choice of final bid amount in the two stage DBDC game is based on affordability (36 percent) and the respondent’s assessment of the actual price of the product (35 percent). Additionally, 81 percent of the households that participated in the bidding fame prefer to pay the premium in a one-time lump sum at the beginning of the crop season. 25 percent of these households prefer not to renew the policy if pay-outs are not made in the current season due to basis risk issues (similar to Kumar et al., 2011).

The next step is to examine the factors that influence a household’s bidding framework- their reasons for participating in the scheme i.e. WTJ and the dynamics that affect the amount of WTP. The next sections describe the econometric framework and the analysis.

5. Econometric methodology

This Chapter aims to examine factors that affect the WTJ and WTP for crop microinsurance programmes. The paper uses a DBDC bidding framework with iteration to account for the household’s willingness to participate in the insurance scheme.

WTP values elicited using DBDC framework is generally analysed using maximum likelihood methods. While Alberini et al. (1997), Hagos et al. (2006) Cawley (2008) and others model WTP under a parametric approach; Kristom (1990) Hanemann (1991) Carson et al. (1994), Carson et al. (2003) and others use non-parametric models such as survival functions to estimate WTP.

The parametric approach estimates the factors affecting WTP using interval regression techniques to account for the four possible responses to the bidding game: yes-yes, yes-no, no-yes and no-no.

In the non-parametric framework, survival is defined with respect to the cost variable rather than time. A respondent willing to pay a specific amount ‘survives’ that amount and a respondent who is not willing to pay a specified amount ‘fails’ that amount

(Carson et al., 2003). For example, a yes-no response indicates that the respondent's maximum WTP amount lies between the first bid and second higher bid. In survival analysis terms, the failure occurred between the first bid and second higher bid cost amounts

The model also needs to account for the selection effects that may arise from eliciting WTP from only those households that are willing to join the crop insurance scheme. The parametric model incorporating both WTJ and WTP is described in the next sub-section.

5.1 Modeling WTJ and WTP

This chapter mainly employs a parametric approach to study WTP as well as estimate aggregate demand curves based on household's responses.

Assuming a linear functional form for WTP equation, it can be defined as:

$$
\begin{aligned}
&wtp_{\mathrm{i}}^{*} = x_i' \quad + \neg_{\mathrm{i}} \\
&v_i \sim N(0, \pm^2) \text{ ....(5.1)}
\end{aligned}
$$

where, is a vector of parameters and $\neg_{\mathrm{i}}$ is the random error term with mean zero and variance $\pm^2$.

If t^0 is the first bid, t^h is the second higher bid and t^l is the second lower bid, wtp_{i}^{*} can be expressed in terms of the following intervals:

$$
\begin{array}{ll}
wtp \geq t^h & \textit{for the yes} - \textit{yes responses} \\
t^0 \leq wtp < t^h & \textit{for the yes} - \textit{no responses} \\
t^o > wtp \geq t^l & \textit{for the no} - \textit{yes responses} \\
wtp < t^l & \textit{for the no} - \textit{no responses}
\end{array}
$$

For the 'yes-yes' responses, the lower limit is the second higher bid and the upper limit is positive infinity; for the 'yes-no' responses, the lower limit is the first bid and the upper limit is the second higher bid; for the ‘no-yes’ responses, the lower limit is the second lower bid and the upper limit is the first bid; for the ‘no-no’ responses, the upper limit is the second lower bid and the lower limit is zero or negative infinity.

The log likelihood function for this model can be written as (Alberini et al., 1997; Hagos et al., 2006; Cawley, 2008; Haab, 1998):

$$L = \sum_{i=1}^{n} \left\{ \begin{array}{l} I_i^{yy} \ln\left[1 - \Phi\left(\frac{t_i^h - x_i^{'}}{\pm}\right)\right] + I_i^{yn} \ln\left[\Phi\left(\frac{t_i^h - x_i^{'}}{\pm}\right) - \Phi\left(\frac{t_i^o - x_i^{'}}{\pm}\right)\right] + \\ I_i^{ny} \ln\left[\Phi\left(\frac{t_i^o - x_i^{'}}{\pm}\right) - \Phi\left(\frac{t_i^l - x_i^{'}}{\pm}\right)\right] + I_i^{nn} \ln\left[\Phi\left(\frac{t_i^l - x_i^{'}}{\pm}\right)\right] \end{array} \right\} \ldots\ldots\ldots\ldots\ldots\ldots(5.2)$$

where $I(.)$ is an indicator function that takes the value 1 if the individual i belongs to the particular bidding argument and zero otherwise.

An important aspect to be considered is the additional iteration made to the DBDC bidding in this Chapter. WTP can only be observed if an individual is willing to join the microinsurance programme. WTJ can be defined as follows:

$$\begin{array}{l} wtj_i^* = x_i^{'}\sim + £_{\mathrm{i}} \\ £_i \sim N(0,1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5.3) \end{array}$$

where $\sim$ is a vector of parameters and $£_{\mathrm{i}}$ is the random error term with mean zero and variance one. The latent variable wtj_i^* is defined as follows:

$$\begin{array}{l} wtj_i = 0 \ [\textit{definitely not willing}]\ \textit{if} \ wtj_i^* < ¯_0 \\ wtj_i = 1 \ [\textit{rather not willing}]\ \textit{if} \ ¯_0 \le wtj_i^* < ¯_1 \\ wtj_i = 2 \ [\textit{rather willing}]\ \textit{if} \ ¯_1 \le wtj_i^* < ¯_2 \\ wtj_i = 3 \ [\textit{definitely willing}]\ \textit{if} \ ¯_2 \le wtj_i^* \end{array}$$

WTP is only observed when $wtj_i \geq 2$, i.e. if the individual is either *rather willing* or *definitely willing* to join the programme. This model can be estimated using an ordered probit approach.

Evaluating WTP from only those who express WTJ may lead to biased estimates if the sample that chooses to not participate is not random. This selection bias resulting from estimating demand using only those households that express WTJ can be modeled using a Heckman selection approach. The Heckman procedure attempts to solve the selection problem by using an inverse mills ratio, which captures the selection effects. If the inverse mills ratio is found to be statistically significant in the WTP equation, this suggests that the unobservable factors determining WTJ and WTP are correlated.

The use of Heckman's selection model with a first stage ordered probit and second stage interval regression is not common in literature, one of the few articles being Chantarat et al. (2009) to estimate the willingness to pay for livestock index insurance.

If A_i^L and A_i^U are the lower and upper bounds of WTP, the final likelihood function (L) is defined as per Yoo and Yang (2001):

$$L = \prod_{wtj_i=0}^{1} \Pr(wtj_i \leq 1) \prod_{wtj_i=2}^{3} \Pr(wtj_i \geq 2, A_i^L < wtp_i^* < A_i^U) \text{.............}(5.4)$$

Assuming that ε_i and v_{ij} follow bivariate normal distribution with correlation coefficient ρ, the mean WTP conditional on WTJ for the i^{th} individual in the j^{th} category now takes the form:

$$E\left[wtp_{ij}^* / wtj_i \geq 2\right] = x_i' \quad + \rho \sigma_v \lambda_{ij}$$
$$\varepsilon_i, \nu_{ij} : BVN\left(0, 0, 1, \sigma_v^2, \rho_{\varepsilon\nu}\right) \qquad \text{..............................}(5.5)$$

for each case where WTP is observed i.e. if $wtj = 2, 3$. The selection correction term, λ_{ij}, for each category is given by (Iwai et al., 2005):

$$\lambda_{ij} = \frac{\phi(\mu_j - x_i'\beta) - \phi(\mu_{j-1} - x_i'\beta)}{\Phi(\mu_j - x_i'\beta) - \Phi(\mu_{j-1} - x_i'\beta)} \qquad (5.6)$$

The predicted values from the second stage regressions are used to construct aggregate demand curves for both the *rather willing* and *definitely willing to join* categories. The mean and median amount of WTP is also estimated using bootstrapping (Cawley, 2008).

In case of the non-parametric approach, the first stage of the Heckman model is estimated using ordered probit and the second stage is modeled using survival regression models. Several distributions are used in the survival analysis including weibull, lognormal, loglogistic, gamma and exponential distribution. The best fitting distribution is assessed using AIC/BIC criterion. The main text of this Chapter provides the parametric results only. The second stage non-parametric results are provided in Annexure A5.1.

5.2 Validation checks

Validation checks are required in relation to two issues – to test the exclusion restriction in the Heckman selection model and to check for hypothetical bias in the DBDC bidding game. These tests are described below.

This Chapter uses a Heckman selection model for its analysis. In this case, WTJ is modeled in the first stage using an ordered probit model. Inverse mills ratios are then generated using the predicted values of the first stage. The second stage i.e. WTP is modeled using interval regressions. The exogeneous variables used in the first stage regression to model WTJ need to be valid, i.e. correlated with WTJ but not with WTP. This is referred to as exclusion restriction.

A simple method to check for this is to include the exogeneous variables in the second stage WTP equation and check for their statistical significance. The exclusion restriction is satisfied if the exogeneous variables are not significant in the second stage regression.

DBDC bidding process is used for demand elicitation. As mentioned in Section 2, hypothetical bias occurs when a respondent fails to indulge in ‘mental accounting’ before participating in the elicitation process. A *cheap talk script* and response certainty of the type *probably/definitely sure* are used to correct hypothetical bias in the WTJ/WTP elicitation game.

Interval regressions are estimated using only those respondents who are *definitely sure* of purchasing the product at the agreed price. These results are compared to the interval regressions estimated using the entire sample that expressed WTJ to check for hypothetical bias. If both results are similar, then it can be assumed that the elicitation process is close to real life behaviour.

The next section presents the results of the Heckman’s selection model on the factors affecting the WTJ and WTP for crop microinsurance programmes.

6. Analysis and results

This section presents the findings from the WTJ and WTP elicitation. A description of the explanatory variables used in Heckman selection model is presented in Table 5.2

Three different specifications are used in Heckman selection analysis to confirm the robustness of the results. These specifications are described below:

i. Specification 1 does not include risk aversion or household demographic variables in the model
ii. Specification 2 includes household demographic factors such as respondent age and household size
iii. Specification 3 includes household demographic factors and a risk aversion term calculated using the Binswanger game described in Section 5 of Chapter II

Table 5.2: Sample averages of the explanatory variables used in the two stage estimation model				
Variable (1)	**Description (2)**	**Sample average**		
		Full sample (3)	**WTJ=2 (4)**	**WTJ=3 (5)**
Product literacy	1= correct responses for product related questions; 0= otherwise	0.84	0.82	0.90
Think poor	Calculation described in Chapter II	0.61	0.71	0.42
Household size	1= more than three members; 0= three members or less	0.70	0.78	0.62
Age	in years	44.42	45.11	44.07
Risk aversion	Calculation described in Chapter II	0.76	0.77	0.72
Start bid	Starting bid values of the CVM	1999	1993	1927
Land quintiles:				
Land 2 (2 to 3.49 acres)	1= belongs to that quintile; 0= otherwise	0.22	0.27	0.14
Land 3 (3.5 to 4.9 acres)	1= belongs to that quintile; 0= otherwise	0.26	0.22	0.33
Land 4 (5 to 7.49 acres)	1= belongs to that quintile; 0= otherwise	0.07	0.04	0.12
Land 5 (over 7.5 acres)	1= belongs to that quintile; 0= otherwise	0.11	0.10	0.18
Acres of planted area	No of acres of land under crops	4.13	3.86	5.12
Savings	1= if savings is a means of risk coping; 0= if not	0.54	0.68	0.45
Borrowings	1= if borrowings is a means of risk coping; 0= if not	0.40	0.49	0.33
Diversification (income)	1= if households has multiple income sources; 0= if not	0.64	0.76	0.60
Mathematical literacy	1= higher literacy (score >3); 0= lower literacy	0.74	0.54	0.95
Multiple crops	1= if household grows more than one crop; 0= if not	0.89	0.93	0.91
SHG/MFI member	1= if household is SHG/MFI/NGO member; 0= if not	0.44	0.67	0.23
Andhiyur	1=if respondent belongs to Andhiyur; 0= if not	0.50	0.71	0.21
Basis risk	1= understand basis risk; 0 = otherwise	0.97	0.96	0.99
Sample size	Number of observations	399	134	177

Note: Sample averages for the full sample as well as for the rather willing (WTJ=2) and the definitely willing (WTJ=3) households are provided in the above table in columns (3), (4) and (5) respectively. Land quintiles are based on the acres of planted area. The base category for the land quintiles is 0-1.99 acres.

Another important consideration for the Heckman selection model are the exogeneous variables used to determine WTJ in the first stage. The exclusion restriction is addressed using two variables – think poor and product literacy.

'Think poor' refers to the term used to capture the household's perception of its poverty status (details in Section 5 of Chapter II). Households that assume they are more vulnerable to risk opt not to use any financial services at all (Bendig et al., 2009). To elaborate, if a household thinks it is poor and has a limited source of income, it will think twice before investing in a scheme that promises to pay only if a certain event occurs. Such households are likely to express lower/zero WTJ level irrespective of the bid levels.

Product literacy is also a key determinant of WTJ. If a household doesn't understand or appreciate the product, it is not likely to participate in the scheme irrespective of bid levels. Such households would prefer to use informal risk coping strategies or avail Government support, rather than trust market-based schemes that they don't fully comprehend. Similarly, if a household fully understands the insurance product, it may be keen to immediately join the scheme to secure an effective *ex-ante* means of risk hedging. Such households may not worry too much about the amount of premiums.

Both these variables will affect participation in the programme but may not necessarily affect the amount of money the household is willing to pay for the product. The following sub-sections describe the results.

6.1 Willingness to join

The results of the ordered probit model used to estimate WTJ are presented in Table 5.3. The results are similar across all specifications. Variables that significantly affect the willingness to join include socio-economic factors such as age and block, wealth indicators such as land size, risk attitudes and product features among others. The marginal effects obtained from specification 3, i.e. column (4) of Table 5.3 are described here. The marginal effects are provided in Table 5.4.

The area of planted land is used as a proxy for wealth in this analysis. In the WTJ regression, the planted area is divided in five quintiles (Clinch and Murphy, 2001) Results indicate that belonging to the third and fourth quintiles of land holdings has a significant impact on the WTJ. This is consistent with Hill et al. (2011) and Clarke (2011) indicating that farmers with very low or very high levels of land do not value insurance as much as farmers with intermediate land sizes. Also, growing more than one crop increases the likelihood of belonging to the *definitely willing* category by 19.8 percentage points *on average and ceteris paribus*.

The more risk averse an individual is, the less likely s/he is to be *definitely willing* to join (consistent with Cole et al., 2009). This indicates that insurance could be considered as a 'risk' by some sections of the community. It is also interesting that holding an SHG or an MFI membership decreases the willingness to join (which is not consistent with literature). Perhaps, individuals may choose to borrow from these institutions rather than invest in market based solutions to manage risks indicating a preference for existing *ex-post* risk coping strategies. It may also be the case that they are not satisfied with the services of these institutions and are thus wary of non-governmental entities.

Think poor and product literacy represent the exogenous determinants of WTJ. A farmer who thinks s/he is poor is less likely to be *definitely willing* to join by 14.01 percentage points *on average and ceteris paribus*. Product literacy increases the probability of the respondent belonging to the *definitely willing* category by 13.6 percentage points *on average and ceteris paribus*.

Starting bid has a negative effect of belonging to the *definitely willing* category indicating starting point bias and justifies the use of multiple starting bids in the contingent valuation process. A one-year increase in age decreases the probability of definitely *willing to join* by 0.5 percentage points *on average and ceteris paribus*. Similarly, mathematical literacy increases the probability of *definitely willing to join* by 13.04 percentage points *on average and ceteris paribus*. The block level dummy for Andhiyur is also significant.

80 percent of the non-willing households suggest that they would register for the policy if it is provided for free by the government.

Since the elicitation of WTJ involves a start price, the robustness of the non-price effects identified in the first stage of the Heckman model needs to be further investigated. For this purpose, the non-price effects are estimated by replacing the continuous price variable, i.e. ‘start bid’ with a set of starting price dummies that completely control for initial price at which the product is offered to estimate WTJ. The results in this case are similar to the estimates obtained in Table 5.3 indicating that our analysis remains unaffected by the inclusion of the product price in the WTJ elicitation. These results are presented in Annexure A5.1

Table 5.3: First stage ordered probit model to estimate the Willingness to Join the hypothetical crop microinsurance scheme			
Particulars (1)	**Specification 1 (2)**	**Specification 2 (3)**	**Specification 3 (4)**
Product literacy	0.3237**	0.3274**	0.3573**
	0.1569	0.1578	0.1607
Think poor	-0.3109*	-0.3105*	-0.3560**
	0.1620	0.1650	0.1619
Household size		-0.0964	-0.1139
		0.1577	0.1577
Age		-0.0118	-0.0137*
		0.0074	0.0075
Risk aversion			-0.4619**
			0.2331
Basis risk			
Risk aversion*Basis risk			
Start bid	-0.0002***	-0.0002***	-0.0003***
	0.0001	0.0001	0.0001
Land 2	-0.1232	-0.1349	-0.1620
	0.1622	0.1633	0.1634
Land 3	0.3520**	0.3583**	0.3284*
	0.1754	0.1779	0.1769
Land 4	0.7276**	0.7351**	0.6811**
	0.3017	0.3037	0.2966
Land 5	0.2695	0.3098	0.2827
	0.2718	0.2746	0.2789
Savings	0.0101	0.0307	-0.0162
	0.1295	0.1266	0.1280
Borrowings	-0.0567	-0.0455	-0.0767
	0.1206	0.1208	0.1214
Diversification (income)	0.0101	0.0306	0.0845
	0.1586	0.1621	0.1602
Multiple crops	0.5367**	0.5110**	0.5395**
	0.2301	0.2348	0.2328
SHG/MFI member	-0.2974*	-0.2932*	-0.2992*
	0.1554	0.1573	0.1578
Mathematical literacy	0.3294**	0.2763*	0.3386**
	0.1553	0.1573	0.1583
Andhiyur	-0.7271***	-0.7684***	-0.7153***
	0.1717	0.1794	0.1843
/cut1	-1.5183	-2.1357	-2.5952
/cut2	-1.0630	-1.6795	-2.1445
/cut3	0.1316	-0.4777	-0.9114
No. of observations	398	398	397
Log pseudo likelihood	-404.2728	-402.7767	-395.9618
Pseudo R2	0.1625	0.1656	0.1757
Chi2	179.6364	180.1493	185.7480

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust standard errors are provided below coefficients. Specification 1 does not include risk aversion or household demographic variables. Specification 2 includes age and household size, Specification 3 also includes risk aversion. The base category for the land quintiles is 0-1.99 acres. Think poor and product literacy represent the exogenous determinants of WTJ.

Table 5.4: Marginal effects of significant variables obtained from Specification (3) of the Willingness to Join estimation				
Particulars (1)	**Definitely not wiling (WTJ=0) (2)**	**Rather not willing (WTJ=1) (3)**	**Rather willing (WTJ=2) (4)**	**Definitely willing (WTJ=3) (5)**
Product literacy	-0.0543	-0.0371	-0.0446	0.1360
Think poor	0.0428	0.0346	0.0627	-0.1401
Age	0.0017	0.0014	0.0023	-0.0054
Risk aversion	0.0584	0.0461	0.0772	-0.1817
Start bid	0.0000	0.0000	0.0000	-0.0001
Land 3	-0.0370	-0.0312	-0.0617	0.1299
Land 4	-0.0553	-0.0546	-0.1547	0.2646
Multiple crops	-0.0928	-0.0563	-0.0490	0.1981
SHG/MFI member	0.0390	0.0299	0.0480	-0.1169
Mathematical literacy	-0.0484	-0.0347	-0.0473	0.1304
Andhiyur	0.0928	0.0693	0.1136	-0.2757

Note: The marginal effects for the significant variables of the ordered probit estimation of WTJ are provided here. These pertain to only results from Specification 3 or column (4) of Table 5.3

6.2 Willingness to pay

The interval regression model examines factors that affect the amount of WTP for individuals who are *rather willing* or *definitely willing* to participate in the programme. Table 5.5 provides the results.

Results are consistent across most specifications. The findings from Specification 3, presented in column (6) and (7) of Table 5.5 are discussed here. WTP is elicited from two categories of households – those that are *rather willing to join* and households that are *definitely willing to join* the hypothetical crop microinsurance scheme.

The *rather willing* category represents a section of respondents who appreciate the product but are not completely sure of investment.

The start bid has a positive impact on the amount a household is *rather willing* to pay for the scheme, indicating that once a respondent agrees to participate, s/he believe that it is worth paying a slightly higher amount, if required, for the product. The respondents from Andhiyur are *rather willing* to pay lower than TN Palayam. This is consistent for two reasons- the respondents of Andhiyur have had bad past experiences with agriculture insurance and the annual income of Andhiyur is lower than that of TN Palayam on average.

Interestingly, all the three variables representing risk coping mechanisms – savings, borrowings and other sources of income (diversification) - are significant and negative.

Households who use savings as a means of risk management are *rather willing* to pay an amount that is 20.1 percentage[49] lower than the base category *on average and ceteris paribus.* Similarly, household that generally borrow from formal or informal sources to meet shocks are *rather willing* to pay an amount that is 15.7 percentage lower than households who do not borrow to meet losses *on average and ceteris paribus.*

Respondents who earn income from multiple sources (including allied agriculture activities, other businesses and remittances) are also *rather willing* to pay 21.2 percentage lower than those with only one source of income *on average* and *ceteris paribus.*

This indicates that although these households already have established risk coping networks, they are still *rather willing* to pay a small amount towards microinsurance as an additional strategy to secure their 'residual' risk.

Risk aversion is positively related to the amount a respondent is *rather willing* to pay. Since these households are risk averse to production shocks, they do have other *effective* risk management mechanisms in place and even so, are willing to secure their residual risk through market based indemnity. The inverse mills ratio is not significant in this case and thus there are no selection effects of belonging to this category.

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[49] Since the dependant variable is in logs, marginal effects have been calculated as follows: $(e^{\beta}-1) \times 100$

Table 5.5: Second stage interval regression estimates for willingness to pay of respondents who are rather willing or definitely willing to join the programme						
Particulars (1)	**Specification 1**		**Specification 2**		**Specification 3**	
	WTJ=2 (2)	**WTJ=3 (3)**	**WTJ=2 (4)**	**WTJ=3 (5)**	**WTJ=2 (6)**	**WTJ=3 (7)**
Household size			-0.1696	-0.0215	-0.1702	-0.0101
			0.1213	0.0407	0.1202	0.0405
Age			0.0024	0.0006	0.0029	-0.0001
			0.0037	0.0023	0.0037	0.0023
Risk aversion					0.2314*	-0.1471**
					0.1364	0.0710
Start bid	0.0004***	0.0002***	0.0004***	0.0002***	0.0004***	0.0002***
	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000
Acres of planted area	0.0436***	0.0192***	0.0531***	0.0200***	0.0515***	0.0205***
	0.0155	0.0065	0.0182	0.0070	0.0185	0.0068
Savings	-0.2642***	-0.0419	-0.2300***	-0.0424	-0.2249***	-0.0516
	0.075	0.0359	0.0718	0.0368	0.0709	0.0376
Borrowings	-0.1861**	-0.0765*	-0.1914**	-0.0780*	-0.1705*	-0.0871**
	0.0929	0.0424	0.0947	0.0418	0.0957	0.0414
Diversification (income)	-0.2407**	0.0422	-0.2080*	0.0525	-0.2378**	0.0484
	0.1115	0.041	0.1140	0.0429	0.1114	0.0434
SHG/MFI member	-0.0295	-0.0068	-0.0002	-0.0146	0.0020	-0.0060
	0.0907	0.044	0.0945	0.0431	0.0967	0.0438
Multiple crops	-0.1279	0.1687**	-0.0838	0.1942**	-0.0217	0.1991***
	0.2326	0.0753	0.2482	0.0773	0.2508	0.0760
Andhiyur	-0.6387***	-0.6879***	-0.5727***	-0.6945***	-0.6479***	-0.6758***
	0.1707	0.0769	0.1491	0.0804	0.1456	0.0794
Mills ratio (WTJ=2)	-0.0379		-0.0434		0.0093	
	0.1589		0.1413		0.1387	
Mills ratio (WTJ=3)		0.1324		0.1719*		0.1539*
		0.1054		0.1043		0.0927
Constant term	7.0707***	6.9539***	6.8857***	6.8953***	6.7116***	7.0429***
	0.1961	0.109	0.2602	0.1726	0.2716	0.1629

Table 5.5 continued**: Second stage interval regression estimates for willingness to pay of respondents who are rather willing or definitely willing to join the programme**						
Particulars (1)	**Specification 1**		**Specification 2**		**Specification 3**	
	WTJ=2 (2)	**WTJ=3 (3)**	**WTJ=2 (4)**	**WTJ=3 (5)**	**WTJ=2 (6)**	**WTJ=3 (7)**
LnSigma	-1.1571***	-1.7099***	-1.1933***	-1.7172***	-1.2082***	-1.7362***
	0.1382	0.1152	0.1347	0.1112	0.1349	0.1070
No. of observations	134	176	134	176	134	176
Log pseudo likelihood	-82.1387	-141.1898	-80.6304	-140.4633	-79.5584	-138.8770
Chi2	273.6203	592.0574	294.3037	605.3887	297.8688	597.1557

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Dependant variable represents intervals of WTP amounts in logs. Robust standard errors appear below coefficients. WTJ=2 and WTJ=3 represent rather willing and definitely willing to join respectively. Specification 1 does not include risk aversion or household demographic variables. Specification 2 includes age and household size, Specification 3 also includes risk aversion.

The *definitely willing* category also shows similar results in terms of variables such as the start bid, block level effects and acres of planted area. In terms of other risk management solutions, only borrowings are significant in this case. A respondent's access to borrowings reduces the amount of money s/he is *definitel*y willing to pay for the microinsurance programme by 8.3 percentage *on average and ceteris paribus.*

The mean values for the three risk management variables for both the *rather willing* and *definitely willing* cases (Table 5.2) show that the number of households that have access to or use these risk coping mechanisms are higher on average in the *rather willing* category.[50] This builds a clear framework for the preference of households to belong to the *rather willing* or *definitely willing* categories. The households in the *definitely willing* category are more keen on microinsurance as they do not have many other 'significant' means of risk coping. This is discussed in detail under Section 6.5.

Risk aversion is significant, but negative, for the *definitely willing* category. This may represent aversion to insurance stemming from either low trust or bad past experiences with other institutions.

The inverse mills ratio is significant at 10 percentage indicating the presence of selection effects. These unobservable factors could relate to nature of the alternative crops grown by the farmer, past insurance experiences of their peers/relatives, cash in hand, famer's perception on the certainty of future income flows among others.

Among other findings, 81 percent of the households that participated in the bidding process prefer to pay the premium in a one-time lump sum at the beginning of the crop season. 25 percent prefer to not renew the policy if pay-outs are not made in the current season due to basis risk issues (similar to Hill et al., 2011).

The interval regression model is also estimated using survival analysis under weibull, lognormal, loglogistic, gamma and exponential distributions. These results are similar to the interval regressions and are presented in Annexure A5.2

[50] A two-tailed t-test is carried out to test the equality of means for savings, borrowings and other sources of income between the *rather willing* and *definitely willing* categories. The null hypothesis of equal means is rejected at 95% for all three categories.

6.3 Validation checks

As mentioned in Section 5.2, validation checks are required in relation to two aspects – exclusion restriction of the Heckman selection model and presence of hypothetical bias in the contingent valuation process.

The Heckman selection model is required to satisfy the exclusion restriction. Similarly, the contingent valuation process needs to be checked for hypothetical bias. The manner in which these tests are implemented is described in Section 5.2 above.

The exclusion restriction is verified by including exogenous variables of the first stage ordered probit analysis in the second stage interval regressions. The exogeneous determinants include product literacy and household's perception of its poverty status defined as "think poor". The exogenous variables are not significant in the second stage satisfying the exclusion restriction (Table 5.6).

The DBDC bidding process is subject to a hypothetical bias, which may lead to an overestimation of WTP for the product under study. Hypothetical bias is reduced using both a *cheap talk script* and a response certainty assessment. The effectiveness of *cheap talk scripts* is not tested in literature. However, the efficacy of the response certainty question can be verified. This test is implemented by estimating the second stage interval regression for only those households that expressed certainty of the type *definitely sure*.

The results, provided in Table 5.7, are similar to those estimated in Table 5.5. This indicates that the bidding game is not affected by hypothetical bias, though the selection effects are not significant here. Note that 67 percent of the respondents who participated in the bidding game are *definitely sure* to buy the product and 32 percent are *probably sure* of purchase.

Table 5.6: Validation checks for exclusion restriction by including the exogeneous determinants of WTJ in the second stage WTP interval regression model						
Particulars (1)	**Specification 1**		**Specification 2**		**Specification 3**	
	WTJ=2 (2)	**WTJ=3 (3)**	**WTJ=2 (4)**	**WTJ=3 (5)**	**WTJ=2 (6)**	**WTJ=3 (7)**
Product literacy	-0.1342	0.0723	-0.1361	0.0694	-0.1786	0.0751
	0.1239	0.0540	0.1168	0.0519	0.1133	0.0513
Think poor	0.1577	0.0123	0.1347	0.0149	0.1485	0.0105
	0.0978	0.0365	0.0935	0.0375	0.0975	0.0372
Household size			-0.1543	-0.0184	-0.1502	-0.0068
			0.1115	0.0404	0.1054	0.0399
Age			0.0025	0.0009	0.0039	0.0001
			0.0038	0.0023	0.0037	0.0023
Risk aversion					0.2834**	-0.1183*
					0.1310	0.0664
Start bid	0.0004***	0.0003***	0.0004***	0.0003***	0.0004***	0.0003***
	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000
Acres of planted area	0.0527***	0.0162***	0.0610***	0.0163***	0.0543***	0.0171***
	0.0162	0.0058	0.0177	0.0060	0.0175	0.0057
Savings	-0.2199***	-0.0493	-0.1926***	-0.0498	-0.1849***	-0.0535
	0.0756	0.0372	0.0732	0.0384	0.0688	0.0380
Borrowings	-0.2128**	-0.0564	-0.2191**	-0.0561	-0.1894**	-0.0616
	0.0922	0.0417	0.0962	0.0417	0.0954	0.0404
Diversification (income)	-0.2434**	0.0182	-0.2139*	0.0241	-0.2491**	0.0165
	0.1092	0.0405	0.1125	0.0424	0.1111	0.0426
SHG/MFI member	-0.0419	0.0220	-0.0113	0.0219	0.0052	0.0260
	0.1027	0.0473	0.1115	0.0472	0.1118	0.0467
Multiple crops	-0.1129	0.1222*	-0.0688	0.1302*	-0.0160	0.1459**
	0.2177	0.0679	0.2363	0.0701	0.2366	0.0732
Andhiyur	-0.7288***	-0.6330***	-0.6679***	-0.6208***	-0.7097***	-0.6177***
	0.1126	0.0688	0.1037	0.0754	0.0979	0.0741
Constant term	7.0785***	6.9605***	6.9189***	6.9179***	6.6571***	7.0240***
	0.2034	0.1224	0.2217	0.1861	0.2490	0.1795

Table 5.6 continued**: Validation checks for exclusion restriction by including the exogeneous determinants of WTJ in the second stage WTP interval regression model**						
Particulars (1)	**Specification 1**		**Specification 2**		**Specification 3**	
	WTJ=2 (2)	**WTJ=3 (3)**	**WTJ=2 (4)**	**WTJ=3 (5)**	**WTJ=2 (6)**	**WTJ=3 (7)**
LnSigma	-1.1875***	-1.7187***	-1.2180***	-1.7202***	-1.2469***	-1.7429***
	0.1382	0.1149	0.1398	0.1134	0.1439	0.1088
No. of observations	134	176	134	176	134	176
Log pseudo likelihood	-80.8556	-141.2243	-79.5029	-141.0058	-77.8547	-139.1427
Chi2	289.9957	616.6757	315.7735	623.0768	344.4637	621.4911

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust standard errors appear below coefficients. WTJ=2 and WTJ=3 represent rather willing and definitely willing to join respectively. The exogeneous determinants of WTJ, product literacy and think poor, are not significant across all restrictions satisfying the exclusion restriction.

Table 5.7: Validation checks for hypothetical bias by estimating WTP from only household that express certainty of the type *definitely sure*						
Particulars (1)	**Specification 1**		**Specification 2**		**Specification 3**	
	WTJ=2 (2)	**WTJ=3 (3)**	**WTJ=2 (4)**	**WTJ=3 (5)**	**WTJ=2 (6)**	**WTJ=3 (7)**
Household size			-0.1615	-0.0193	-0.1715	-0.0061
			0.1184	0.0423	0.1176	0.0418
Age			0.0011	0.0013	0.0020	0.0004
			0.0036	0.0023	0.0034	0.0023
Risk aversion					0.3049**	-0.1641**
					0.1389	0.0758
Start bid	0.0004***	0.0003***	0.0004***	0.0003***	0.0004***	0.0002***
	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000
Acres of planted area	0.0457***	0.0211***	0.0553***	0.0216***	0.0568***	0.0228***
	0.0163	0.0069	0.0189	0.0074	0.0195	0.0072
Savings	-0.2898***	-0.0374	-0.2566***	-0.0399	-0.2571***	-0.0471
	0.0763	0.0363	0.0726	0.0370	0.0698	0.0377
Borrowings	-0.1615*	-0.0717*	-0.1637*	-0.0738*	-0.1271	-0.0833**
	0.0933	0.0433	0.0939	0.0427	0.0939	0.0419

Table 5.7 continued**: Validation checks for hypothetical bias by estimating WTP from only household that express certainty of the type *definitely sure***						
Particulars	**Specification 1**		**Specification 2**		**Specification 3**	
	WTJ=2	**WTJ=3**	**WTJ=2**	**WTJ=3**	**WTJ=2**	**WTJ=3**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Diversification (income)	-0.2042*	0.0361	-0.1786	0.0482	-0.2226**	0.0422
	0.1095	0.0417	0.1143	0.0445	0.1103	0.0447
SHG/MFI member	-0.0806	0.0035	-0.0443	-0.0047	-0.0331	0.0077
	0.0898	0.0445	0.0943	0.0441	0.0916	0.0453
Multiple crops	-0.0671	0.1594**	-0.0436	0.1901**	0.0423	0.1965**
	0.2328	0.0779	0.2432	0.0784	0.2534	0.0765
Andhiyur	-0.5734***	-0.6729***	-0.5162***	-0.6757***	-0.6029***	-0.6545***
	0.1630	0.0776	0.1462	0.0814	0.1432	0.0806
Mills ratio (WTJ=2)	-0.0446		-0.0509		0.0205	
	0.1540		0.1384		0.1371	
Mills ratio (WTJ=3)		0.1273		0.1698		0.1513
		0.1141		0.1117		0.0981
Constant term	6.9386***	6.9404***	6.8296***	6.8412***	6.5797***	7.0096***
	0.1891	0.1175	0.2572	0.1753	0.2671	0.1660
LnSigma	-1.1720***	-1.7065***	-1.2022***	-1.7175***	-1.2252***	-1.7409***
	0.1347	0.1150	0.1333	0.1106	0.1365	0.1064
No. of observations	130	168	130	168	130	168
Log pseudo likelihood	-78.2236	-134.4243	-77.0224	-133.4643	-75.3803	-131.4953
Chi2	264.6054	541.8406	280.2861	553.2726	282.6427	560.3528

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust standard errors appear below coefficients. WTJ=2 and WTJ=3 represent rather willing and definitely willing to join respectively. Results are similar to Table 5.5 indicating that the analysis is not affected by hypothetical bias.

6.4 Demand curve estimation

Contingent valuation studies are generally supplemented by the calculation of mean WTP for the product under study. It is useful to estimate the mean WTP as it presents the average price the consumer prefers to pay for the product under study.

To recall from Section 2, Cawley (2008) states that median WTP measures are preferred since mean WTP could be biased due to the follow-up responses. Thus, both mean and median measures are calculated using the predicted values of the parametric interval regression model. These results are based on specification 3 of Table 5.5 presented above.

Table 5.8 presents the parametric mean and median WTP measures for the *rather willing* and *definitely willing to join* households. These measures are calculated for all households in the relevant categories as well as only households that are *definitely sure* under the response certainty elicitation in each case. A comparison of the findings across these categories will help identify the extent to which the bidding is affected by hypothetical bias.

Table 5.8: Mean and Median estimates of WTP

Category	**Mean WTP (in INR)**		**Median WTP (in INR)**	
(1)	**All households (2)**	***Definitely sure* (3)**	**All households (4)**	***Definitely sure* (5)**
Rather willing to join	1073.63	1072.31	957.01	953.92
	0.0501	0.0413	0.0843	0.0709
Definitely willing to join	1998.63	2001.25	2104.50	2098.58
	0.0263	0.0253	0.0331	0.0355

Note: Bootstrapped standard errors are provided below mean and median measures. Column (2) and (4) represent all participants who expressed WTJ under the relevant categories. Column (3) and (5) represent only households that expressed response certainty of the type *definitely sure*. Note that average annual income for the *rather willing to join* is INR 146769 and *definitely willing to join* is INR 240438 approx.

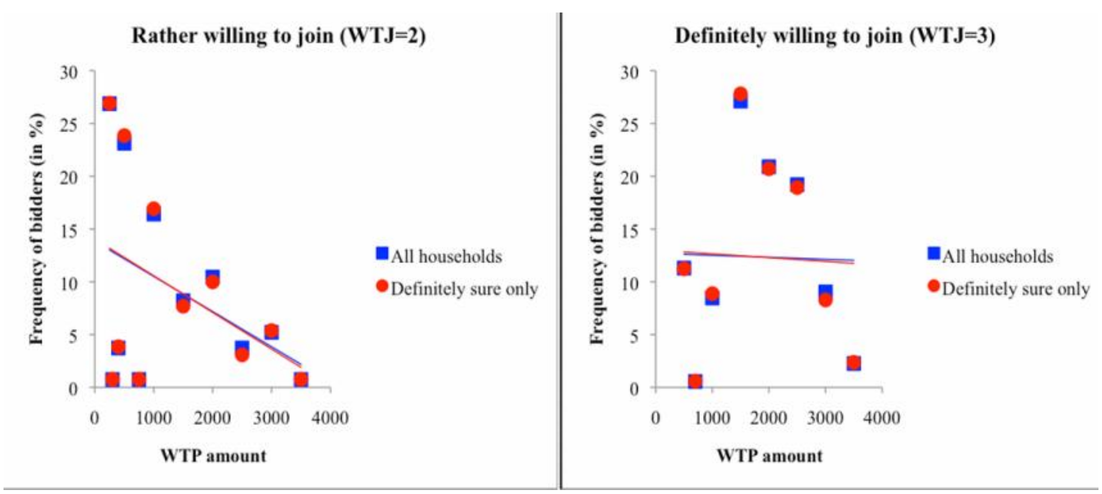
The mean and median WTP for the *rather willing* households are INR 1074 and INR 957 respectively. Both these numbers are roughly one percent of the annual income for this category. For the *definitely willing* households, mean and median WTP are higher at INR 1998 and INR 2105 respectively. Note that the annual income is also higher for this category and the mean and median WTP values are around one percent of their annual income. The mean and median measures of the *definitely sure* category are similar to the above indicating that the results are free from hypothetical bias.

The WTP analysis finds that a household's selection into the *rather willing* or *definitely willing* categories is based on its assessment of the existing risk coping mechanisms and its perception of the importance and use of insurance as a potential source of risk management. The *definitely willing* emerges as a group that are fully aware of the benefits of *ex-ante* crop microinsurance. This is corroborated by the fact that they are willing to pay higher amount on average towards premium when compared to the *rather willing* category.

Estimation of aggregate demand curves using the final values of the bidding game is also an important component of contingent valuation. Demand curves are constructed for the *rather willing* and *definitely willing* categories based on their final responses to the DBDC bidding process.

Akin to the mean/median estimations, the curves are plotted for all households as well as only those that are *definitely sure* of purchasing crop microinsurance at the agreed bid value.

Figure 5.3: Demand for index based crop microinsurance based on the DBDC bidding game



Source: Author's calculations

In both cases, the demand for index based crop microinsurance is downward sloping indicating that crop microinsurance is a normal good (Hanemann, 1991; Kumar et al., 2011). The curve for the *definitely willing* category is more elastic which is consistent with our findings. The *rather willing* category is more inelastic towards the price of the microinsurance policy. Aggregate demand curves can also be plotted by non-parametric methods using Kaplan Meier survival functions. These results are not presented in this Chapter.

The findings from the analysis and the limitations of this study are discussed in the next sub-section.

6.5 Discussion

This Chapter critically examines the factors that impede the demand for crop microinsurance policies using a hypothetical insurance product offered through a contingent valuation game. One of the limitations of the demand literature is that the households that consent to purchase do not always follow through post the pilot phase. There is a tangible gap between the intention to participate and the willingness to pay premiums. This study is able to address this gap by delineating the WTJ from the amount of WTP for crop microinsurance policies.

Participation in crop microinsurance programmes or WTJ is governed by socio-economic factors, wealth measured using land size, risk attitudes, household's perception of its poverty status and product literacy. Interestingly, risk aversion negatively affects participation in crop microinsurance programmes. Investments in *ex-ante* sources of shock management are considered 'risky'. This clearly indicates lack of knowledge in insurance mechanisms and/or lack of trust in the institutions providing such services.

A household's self-perception of its poverty status is also a significant impediment to demand. Insurance, especially, index-based policies are considered as contemporary 'fancy' interventions that the households would prefer to stay away from. This was also reflected in the FGDs in Erode. Most households felt that index based policies are complicated solutions offered to confuse buyers. There is a lack of clarity on general product types and claim triggers.

The reasons behind a household's non-willingness to invest in insurance are quite patent. However, the factors that prevent households that express willingness from following through is unclear. The bidding game places participating households in four different categories. Under normal convention, *rather not* and *definitely not willing* category represents non-participants and *rather willing* and *definitely willing* represent insurance buyers. By clubbing the *rather willing* and *definitely willing*, most of the existing studies tend to overestimate demand.

The findings of this study clearly show that even among the households that are willing to join i.e. purchase the insurance product, not all of these are fully confident of purchase. The *rather willing* households seem to represent a reasonably progressive group that appreciates *ex-ante* insurance policies but is not willing to pay a high premium. These households prefer to tap into traditionally used measures of risk management and attribute only the residual risks to insurance.

On the other hand, *definitely willing* households fully understand the benefits of crop microinsurance and are ready to invest to secure their harvest. Another reason driving their willingness is the lack of effective alternative risk coping mechanisms in place. It is possibly for this reason that the selection effects are only valid for the *definitely willing* households.

The use of contingent valuation models is also validated by employing numerous checks against the possible biases exhibited by such models. Starting point bias is controlled for by using the starting bid value in the regression analysis. The starting bid value is significant in all specifications indicating that bidding game is affected by the first bid price quoted to a consumer.

Hypothetical bias is corrected using both a cheap talk script and a response certainty assessment. The regressions estimated using those only those households that are 'definitely sure' of purchase are similar to the main results indicating that the analysis is not affected by hypothetical bias.

However, it must be noted that the findings are based on a hypothetical product that was not actually offered to the participants at the end of the survey. Though the questionnaire was designed specifically to address all possible biases generated from using contingent valuation methods for demand elicitation, the fact that the product is not real is a limitation.

7. Conclusion

This Chapter examines the demand for crop microinsurance policies using primary data collected by the author from a sample of 400 small and marginal turmeric farmers in Erode, India.

The study uses a two-step decision process to effectively capture the gaps between the *willingness to join* or WTJ and *willingness to pay* or WTP for a hypothetical crop insurance product. For this purpose, households are classified into four categories based on their responses to WTJ - *Definitely not willing to join, Rather not willing to join, Rather willing to join and Definitely willing to join*

A double bound dictomous choice or DBDC bidding model is iterated to account for both WTJ and WTP in a two-step process. This iteration along with categorising WTJ under four heads are important methodological contributions of this Chapter.

Since farmers in this area have limited exposure to weather based insurance policies, a simple hypothetical product is developed for turmeric crop. The product provides a hedge against excess rainfall risks in turmeric production.

A Heckman selection model is used wherein WTJ is modeled in the first stage using ordered probit and amount of WTP is modeled in the second stage using both parametric interval regression and non-parametric survival regression models. The use of ordered probit and interval/survival regression approaches is not common in traditional Heckman selection models.

Findings indicate that there is a difference between the WTJ and WTP for index based crop microinsurance schemes. WTJ is governed by wealth status, risk attitudes and product knowledge among others.

On the other hand, the amount of WTP elicited for only the *rather willing* and the *definitely willing* households, is determined based on the other risk coping measures available to a household. Households that have lesser access to informal coping strategies are *definitely willing to join* and households that tap into other coping strategies are *rather willing to join.*

There is greater reliance on existing informal risk coping that farm households have tapped into for generations. Only the *residual risk* is passed on to insurance. In other words, there is a crowding-in of alternative risk coping measures such as savings, borrowings and income diversification against *ex-ante* crop insurance schemes.

Informal mechanisms such as savings, borrowings, diversification etc. may help transition out of smaller losses. However, such measures tend to fail in the event of catastrophic shocks (Azam and Imai, 2009; Heltberg and Lund, 2009; Dercon, 2001). Microinsurance, being a market-based solution, is designed in a manner that it can effectively cater to both small and large scale shocks.

Microinsurance education could play a significant role here. Extension services via awareness programmes on the long term impacts of the existing informal risk coping strategies and how these measures may fail in certain circumstances could help households re-think their risk coping portfolio. Enlightening households on how formal insurance works and how they can cater to catastrophic shocks by pooling risks across larger geographies may encourage them to invest in market-based formal risk management techniques such as microinsurance to deal with shocks in the long run.

It must also be noted that insurance providers and institutions are not evaluated as stand-alone entities by households. Rather, they are put on the same pedestal as all other institutions serving these populations. Thus, bad experiences with local institutions such as NGOs, MFIs or cooperatives operating in the area may translate into poor demand for microinsurance products and vice-versa.

More transparency from the insurer and agents and clarity on the product features and claims processing can encourage uptake. Installing weather stations across smaller aggregated units, which minimises basis risk to a certain extent, can also encourage farmers to participate in and pay for crop microinsurance.

Crop microinsurance can play a vital role in responding to some of the risks faced by farmers in developing countries. This study plays a significant role in demystifying the reasons driving low demand for insurance products and presents some actionable feedback on how the existing gap can be bridged.

Chapter VI
Conclusion

This thesis analyses the demand and impact of crop microinsurance in India. Specifically, the thesis examines the impact of insurance on output (productivity) and input use and factors affecting demand for crop microinsurance products. The fact that microinsurance is relatively less researched provides a broad scope for analysis. The empirical analysis uses a combination of secondary district level and primary household level data collected through fieldwork in India.

A brief description of the research work, contributions to existing literature, policy implication and limitations of the empirical research undertaken are described here. Though these findings cannot be generalised, it is definitely a starting point to think about some of the challenges faced by the crop microinsurance sector in developing countries.

The first empirical analysis, presented in Chapter III, examines the impact of crop microinsurance on agricultural output measured by productivity or yield using both aggregate and farm level data. The initial analysis is based on district level data on mandatory paddy insurance provided under the National Agriculture Insurance Scheme or NAIS. To recall, mandatory crop insurance is *bundled* with formal credit for *loanee* farmers in India. A two-step IV model is used to account for the endogeneity of insurance purchase decisions. Though insurance has a positive impact on output, this result is not significant. Since the underlying insurance scheme is bundled with formal credit on a mandatory basis, it is difficult to separate the impact of the insurance component from the impact of the loan advanced. The district level analysis also fails to account for individual perceptions, risk attitudes and behaviour that affect insurance and output related decision-making.

The second part of this Chapter uses primary household level data collected in two consecutive years from Howrah, West Bengal. Insurance is provided on a voluntary basis under the Weather Based Crop Insurance Scheme or WBCIS for two varieties of paddy- Aman and Boro. Using a two-stage IV approach, the household level analysis finds that the impact of insurance interventions on productivity is largely determined by the nature of input-requirement structures of crops under study. Despite the fact that both Aman and Boro are essentially paddy varieties, the differences in their cultivation processes have a bearing on how productivity responds to an insurance intervention. Aman paddy, which is both a subsistence and commercial crop, responds positively to an insurance intervention. Boro is an intensive commercial crop with a fixed input requirement structure. Boro yield has a negative association with crop microinsurance.

The analysis contributes to the existing literature in several ways. The use of both district and household level datasets present a unique framework to promote an understanding of how individual effects average out at the aggregate level. The empirical modeling also demonstrates how the endogeneity of insurance purchase decision can be different for different crops. The findings from the analysis show how the effect of insurance on productivity is not homogeneous and varies by crop and input type.

The second empirical study, presented in Chapter IV, uses the primary dataset collected in Howrah, West Bengal to explore the associations between insurance and use of inputs. Impact of crop microinsurance on inputs such as seeds, fertilizers, pesticides, irrigation and labour are examined for two varieties of paddy crops- Aman and Boro. Literature hypothesises that the presence of *ex-ante* crop microinsurance could encourage the use of better quality inputs in production (risk reduction effect). Alternatively, it could also foster a moral hazard effect reducing the use of all inputs (Ramaswami, 1993).

The study uses a simultaneous equations model to account for the possible endogeneity and/or simultaneity of insurance and input purchase decisions. Results indicate that crop microinsurance has a risk reduction effect on the usage of inputs such as seeds, irrigation and labour for commercial crops like Boro paddy. In the case of subsistence crops such as Aman paddy, findings show an input substitution, where Aman crop microinsurance is substituted for fertilizers, a risk increasing input.

The presence of input substitution in relation to weather index based insurance policies for subsistence crops such as Aman paddy is an important contribution of this Chapter.

While inter-crop substitution has been suggested in the microinsurance literature (Cole et al., 2008), this is possibly one of the first studies to suggest intra-input substitution in relation to input use and insurance.

Apart from this, the analysis demonstrates that inputs cannot be combined as a unit to estimate insurance effects. Each input has its specific contribution to output, which varies by crop type. The analysis also demonstrates how the endogeneity or simultaneity of inputs and insurance purchase decisions are different across input and crop types.

The final empirical study, presented in Chapter V, uses a contingent valuation experiment to examine crop microinsurance demand for small and marginal farmers in Erode, Tamil Nadu using primary data. A double bound dictomous choice (DBDC) bidding game is used to study both the *willingness to join* or WTJ and *willingness to pay* or WTP for a hypothetical crop microinsurance product. A Heckman selection model is used where WTJ is modeled using ordered probit and WTP is assessed using interval regressions.

Results indicate that WTJ is influenced by household wealth, risk attitudes and product literacy. The amount of WTP is primarily affected by the informal risk management strategies available to a household such as savings, borrowings and diversification. There is a greater reliance on these measures as they are easily accessible within communities resulting in a *crowding-out* of crop insurance policies.

This study contributes to existing literature in three ways. As a methodological contribution, the contingent valuation experiment accounts for both the *willingness to join* (WTJ) and *willingness to pay* (WTP) for crop microinsurance policies, which is one of the firsts in relation to crop microinsurance. The only other article that uses this approach is Mathiyazhagan (1998) for an analysis of health microinsurance demand in India. WTJ is assessed using four different responses rather than a simple yes/no to incorporate households that do not have a strong opinion for or against such policies. This ensures that the analysis duly accounts for the psychological implications relating to investments in complex market-based solutions such as microinsurance.

The use of ordered probit and interval/survival regression models in a Heckman selection framework is an econometric contribution. Though this is not the first time this combination has been used in literature, the analysis adds to a very small pool of work based on such models as outlined in Chapter V.

The third and most significant contribution relates to the findings of the analysis. Demand is low due to dependence on informal mechanisms such as savings, borrowings and income diversification. It seems that insurance, while duly recognised as a potential source of risk management, continues to be rated low in the risk profiling strategy of the household.

While each chapter presents a unique set of results, there are some common themes and findings that emerge from the overall analysis. For instance, microinsurance education and product literacy have a significant effect on both the impact and demand for crop microinsurance policies. In the impact studies, it is an implicit assumption and in the demand analysis, it is an important policy implication as discussed in Chapters IV and V respectively. Other common aspects that emerge are the roles of household risk preferences and support of local institutions in microinsurance markets. These issues and other policy implications of the findings are now discussed.

With respect to the impact of insurance on input and output, the fact that insurance could foster different effects based on crop and input type is a critical consideration in evaluating crop microinsurance policies. The product design and outreach models should ensure that insurance is offered for the relevant crop against actual risks faced by households in a particular area. It is imperative to duly incorporate the local agricultural customs and dynamics in the broader framework.

The evidence that the presence of crop microinsurance could influence input use behaviour opens avenues for improving input marketing and sales in rural areas. Consider for instance bundling insurance with the purchase of a high yielding variety seeds (HYV) for a commercial crop. A risk averse farmer may now feel motivated to invest in HYV seeds, given the insurance component. The farmer now has opportunities to secure higher output through use of better quality seeds as well as an *ex-ante* hedge against possible losses incurred due to unanticipated risks that may occur during the season. The suggestion relates to the use of an additional channel for crop microinsurance outreach that could be help increase voluntary insurance participation.

An important caveat here is that only a well-informed farmer can effectively tap into insurance to make improved input investment decisions. Building microinsurance awareness and providing product specific knowledge can play a vital role in motivating farmers to invest in better production techniques in the presence of *ex-ante* insurance.

The demand study demonstrates that informal risk coping measures are preferred by households and microinsurance is only used to address residual risks. While there is a well-researched and well-documented literature on the shortcomings of informal mechanisms in the event of possible catastrophic shocks, this knowledge has not really reached poor communities in rural areas. Microinsurance education can play a significant role here. It is important to educate low-income farmers on the usefulness and potential role of private markets in responding to their risk coping needs. A comprehensive safety net strategy requires proactive coping measures that are not affected by the extent of the shock or losses- microinsurance clearly fits the bill.

In both Howrah and Erode, the presence of local institutions who act as agents for microinsurance had a huge effect on insurance purchase and renewals. The negative experiences of dealing with local NGOs, SHGs and MFIs adversely impacted demand in Erode. Similarly, poor claim experiences of the insured in Howrah led to some violent reactions towards local institutions working in the area as described in Chapter IV. Positive experiences with such agents can play a significant role in encouraging uptake and renewals (Clark and Kalani, 2011).

As a policy implication, it is important to recognise the potential role of these local institutions or agents in establishing the credibility of microinsurance policies and the insurance provider. Local institutions can be encouraged to offer microinsurance education via awareness programmes and facilitate active interactions between insurance providers and farmers. This can potentially build a low-income household’s trust in market-based risk management solutions and increase uptake of microinsurance products.

Another important theme explored by the thesis is the role of risk aversion in microinsurance. The main finding that emerges is that insurance by itself is considered risky and not an effective risk management solution by sample households. This relates mostly to the poor understanding of microinsurance mechanisms and low trust in local institutions and insurance providers as observed both in the empirical analysis and fieldwork interactions. As noted throughout this thesis, microinsurance can play an effective role in catering to both small-scale and large-scale shocks. For this reason, it would be worth focussing efforts towards making insurance a more appealing risk management option to farmers when compared to informal mechanisms. It is important to invest in better product design and outreach models, timely claims processing and establish formal channels for addressing clarifications and grievances. This could encourage farmers to purchase *ex-ante* formal risk coping techniques such as microinsurance to manage both idiosyncratic and systemic shocks effectively.

While the thesis contributes to literature in several ways, there are some limitations to the analysis. Some of these limitations present opportunities for future extensions to research in microinsurance. An ideal impact analysis relating to input use and output levels requires a longer time frame and a higher number of observations in the analysis. Another limitation of impact studies is the fact that the household analysis in both the input and output case focuses on voluntary buyers of insurance only. In the light of the significance of individual specific behaviour, risk attitudes and perceptions in enabling any kind of impact, it will be useful to study both mandatory and voluntary insurance coverage at the household level to identify if and how the responses and behaviour vary at the individual unit across these groups.

A useful extension to the input analysis could be a study of how the amount of investments made both in terms of financial expenditures and units of inputs purchased are affected by insurance interventions. It would also be helpful to examine how the timing of subsequent input applications change within a particular season in the presence of insurance.

The demand study is limited due to the use of a hypothetical insurance product. Securing an insurance partnership and conducting this experiment with an actual insurance policy over time to understand how WTJ and WTP change with respect to both first time purchase and renewals could be an interesting extension to this analysis. In line with the other empirical chapters, the inclusion of more sample households could make the findings more robust.

The problems encountered by small and marginal farmers in India are complex and transcend much beyond the absence of effective risk management solutions. Roadblocks are encountered at each stage of the production process due to poor facilitating infrastructure, inadequate government assistance and poor quality of inputs, irrigation and storage facilities. This thesis is a small step towards understanding some of these issues and providing action oriented guidelines for this sector.

We are seeing the tip of an iceberg in so far as crop microinsurance market in India is concerned. Conscious and consistent efforts towards planning, designing and implementation of relevant crop insurance programmes at the grass root level are an immediate requirement. The very fact that this will transform the life of the common man is reason enough for sustained work in this area.

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Appendices

Appendix for Chapter I

A1.1 Crop microinsurance schemes in India

This section describes the guidelines provided by the Government of India on the currently operational crop insurance schemes – NAIS, WBCIS and MNAIS.

A1.1.1 National Agriculture Insurance Scheme (NAIS)

The Government of India launched National Agriculture Insurance Scheme (NAIS) or the Rashtriya Krishi Bima Yojana (RKBY) in Rabi 1999-2000. NAIS is a comprehensive insurance programme that covers yield losses due to non-preventable risks such as landslides, storms, cyclones, hailstorms, floods, typhoons and pest diseases among others. The product is based on a combination of an area yield index as well as individual losses in case of localized events such as natural calamities.

While the policy is mandatory for *loanee* farmers, it is also offered on a voluntary basis to *non-loanee* farmers. AIC is the sole provider of NAIS in India. The AIC, with the consensus of the respective State Government, declares crops to be insured in each district in advance of the cropping season. The premium is deducted from the loan advanced for all *loanee* farmers. *Non-loanee* farmers are offered the product through banks and other individual/institutional agents.

The sum insured is the value of the threshold or average yield of the insured crop. For loanee farmers, it could extend up to the value of the loan advanced.[51] Premium rates range from 1.5 percent to 3.5 percent for food crops and oil seeds. The premium rates for commercial and horticulture crops are actuarial based. Small and marginal farmers receive a 10 percent subsidy on insurance premiums, shared equally by the Centre and State Governments.

The risks in insurance are shared by the insurance provider i.e. AIC and the Government. However, the proportion of the risk sharing varies across crops. The financial burden of the Centre and State Governments also differ.[52] In other words, NAIS receives both premium (*ex-ante*) and claim (*ex-post*) subsidies from the Government.

The claim assessment in NAIS has two components. Area yield claims are assessed through crop cutting experiments conducted at the Block, Taluk or Gram Panchayat level based on the discretion of the

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[51] Farmers are also provided the option of buying higher cover by paying additional premium

[52] Financial liabilities towards claims beyond 100 percent of premium in case of food crops and oilseeds and 150 percent of premium in case of annual horticultural and commercial crops is borne by the Government and are shared on 50:50 basis by the Centre and State Governments.

respective State Government. Individual plots are assessed in case of localised calamities. Claim amounts are then transferred to banks, who in turn credit the accounts of insured farmers.

A1.1.2 Weather Based Crop Insurance Scheme (WBCIS)

The first pilot weather index insurance scheme was launched in Mahbubnagar district, Andhra Pradesh in 2003. Funded by the World Bank, this experiment was implemented by a private insurance company for ground and castor farmers with the help of a local agency.

Weather Based Crop Insurance Scheme or WBCIS was formally launched only in Kharif 2007. WBCIS provides insurance against adverse weather incidences such as deficit & excess rainfall, frost, heat (temperature), relative humidity, etc.

Akin to NAIS, WBCIS is also mandatory for *loanee* farmers and voluntary for *non-loanee* farmers in districts/states that choose to adopt this scheme. AIC as well as some private insurance companies offer WBCIS policies in India. Selected crops and districts to be covered by WBCIS are declared in advance of the cropping season. Since there are multiple providers of insurance in this case, several extensive marketing and insurance literacy campaign are undertaken to attract *non-loanee* farmers.

The sum insured in broad terms is equal to the cost of cultivation or 'expected loss', which in turn depends on the patterns of weather parameters of historical period ranging from 25 to 100 years. The farmer is required to declare the 'area under cultivation' at the time of purchasing the insurance contract and the claim received are based on the notified sum insured (cost of cultivation) per unit of area declared. Typically, the contract also pre-determines the 'trigger values' and payments are due only if there are deviations between the trigger weather and actual weather parameters.

Premium rates are calculated on an actuarial basis using historical data of selected weather parameters to be covered at the district level. WBCIS also receives *ex-ante* premium subsidies that vary across crop type ranging from 25 to 50 percent, subject to a minimum premium amount payable by the client in each case.[53] All subsidies are jointly funded on a 50:50 basis by the Centre and State Governments. WBCIS does not receive *ex-post* claim subsidies.

Claim assessments are made using data from pre-determined weather stations located at the block or district level. Payments are made when the actual weather deviates from the 'trigger values' set in the insurance contract. Contrary to NAIS, the turn-around time for claim assessments and payouts is much

[53] For food crops and oil seeds, premium payable by the farmer is capped at 1-2 percent. For Annual Commercial/ Horticultural Crops, subsidies are available based on premium slabs. For instance, there is no subsidy for premium rates up to 2 percent. Premium rates between 2-5 percent receive a 25 percent subsididy, provided that the premium rates payable by the farmer after subsidies is at least 2 percent. Premium rates between 5-8 percent are subsidised at 40 percent, suject to a minimum net premium of 3.75 percent payable by the farmer. Premiums above 8 percent receive a 50 percent subsidy, subject to minimum net premium of 4.8 percent and maximum net premium of 6 percent payable by farmer.

smaller as the weather data is made available on an immediate basis from the Indian Meteorological Department (IMD) and other sources.

Evidently, WBCIS has both theoretical as well as administrative advantages over the NAIS and other traditional crop insurance programmes in India. Premium rates and sum insured are more location specific and administrative costs of claim assessment procedures are much lower. Also, since claims are assessed using data from an independent source, instances of moral hazard and adverse selection are minimized. Participation of private insurance companies has also helped in encouraging voluntary insurance participation.

A1.1.3 Modified National Agricultural Insurance Scheme (MNAIS)

The Modified National Agricultural Insurance Scheme (MNAIS) was introduced for Rabi 2010-11. MNAIS combines the merits of both NAIS and WBCIS. Some of its features include actuarial premium with premium subsidy at different rates, reduction in the unit area level for claims assessment, introduction of more proficient basis for calculation of threshold-yield, coverage of post-harvest losses due to localized calamities and allowing more private sector insurance participation among others. Both AIC as well as private insurance companies in the country offer MNAIS products.

Akin to NAIS and WBCIS, it is offered on a mandatory basis to *loanee* farmers and on a vountary basis to *non-loanee* farmers for selected crops/districts/seasons.

The sum insured can extend to the value of the threshold yield of the specific crop Premium rates are calculated on an actuarial basis. The nature of the *ex-ante* premium subsidies received by MNAIS is similar to that of the WBCIS scheme

Appendix for Chapter III

A3.1 Paddy cultivation in India

Table A3.1: Annual paddy cultivation in India during the period 2007-08 to 2009-10									
State/ UT	Area (‘000 Hectares)			Production (' 000 Tonnes)			Yield (Kg./Hectare)		
	2007-08	2008-09	2009-10	2007-08	2008-09	2009-10	2007-08	2008-09	2009-10
Andhra Pradesh	3984.0	4387.0	3441.0	13324.0	14241.0	10538.0	3344	3246	3062
Assam	2324.0	2484.2	2495.8	3319.0	4008.5	4335.9	1428	1614	1737
Bihar	3572.6	3496.0	3213.7	4418.1	5590.3	3599.3	1237	1599	1120
Chhattisgarh	3752.4	3734.0	3670.7	5426.6	4391.8	4110.4	1446	1176	1120
Goa	52.2	50.0	47.1	121.6	123.3	100.6	2330	2466	2138
Gujarat	759.0	747.0	679.0	1474.0	1303.0	1292.0	1942	1744	1903
Haryana	1075.0	1210.0	1205.0	3613.0	3298.0	3625.0	3361	2726	3008
Himachal Pradesh	78.6	77.7	76.7	121.5	118.3	105.9	1546	1523	1381
Jammu & Kashmir	263.2	257.6	259.9	561.3	563.1	497.4	2133	2186	1914
Jharkhand	1653.7	1683.6	995.0	3336.4	3420.2	1538.4	2018	2031	1546
Karnataka	1416.0	1514.0	1487.0	3717.0	3802.0	3691.0	2625	2511	2482
Kerala	228.8	234.3	234.0	528.5	590.3	598.3	2310	2519	2557
Madhya Pradesh	1558.9	1682.3	1445.7	1461.9	1559.7	1260.6	938	927	872
Maharashtra	1574.0	1522.0	1470.0	2996.0	2284.0	2183.0	1903	1501	1485
Orissa	4451.8	4454.7	4365.1	7540.7	6812.7	6917.5	1694	1529	1585
Punjab	2610.0	2735.0	2802.0	10489.0	11000.0	11236.0	4019	4022	4010
Rajasthan	127.8	133.4	150.7	259.6	241.1	228.3	2031	1807	1515
Tamil Nadu	1789.2	1931.8	1845.5	5040.2	5182.7	5665.2	2817	2683	3070
Tripura	237.2	242.5	245.6	624.6	627.1	640.0	2633	2586	2606
Uttar Pradesh	5709.0	6034.0	5186.7	11780.0	13097.0	10807.1	2063	2171	2084
Uttarakhand	289.0	296.0	294.0	593.0	582.0	608.0	2052	1966	2068
West Bengal	5719.7	5935.7	5630.1	14719.5	15037.3	14340.7	2573	2533	2547

Source: Ministry of Agriculture, Government of India

A3.2 District level boundaries

The district level boundary maps are presented here. This will help understand the Chloropeth maps better.

Andhra Pradesh

Gujarat

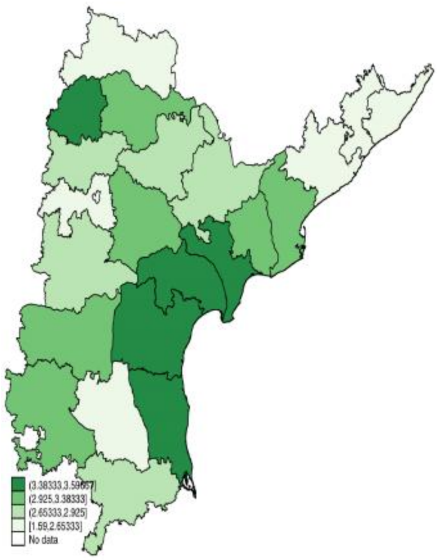
Tamil Nadu

A3.3 Season-wise insurance coverage

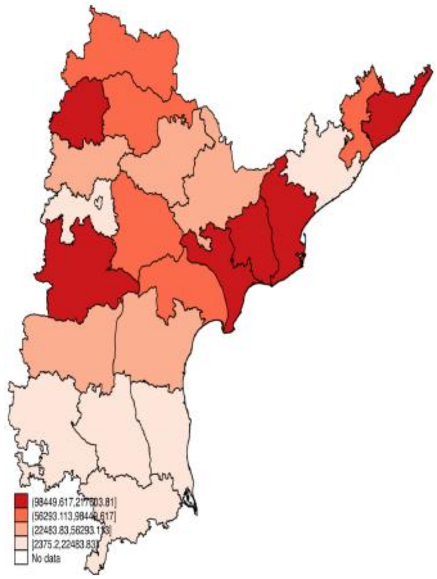
This section traces the area under insurance of paddy (in thousand hectares) over the three years under study. As mentioned in Chapter III, there insurance coverage within districts across states does not change significantly during the study period.

a. Andhra Pradesh

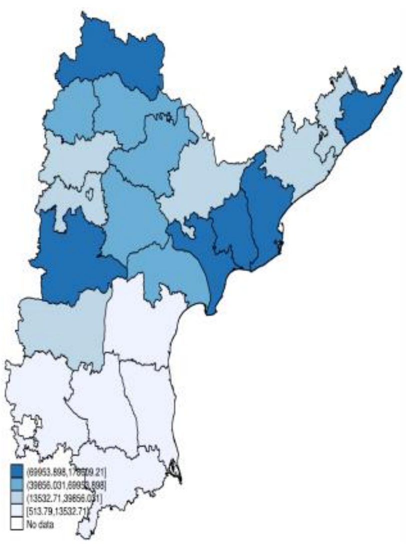
Kharif



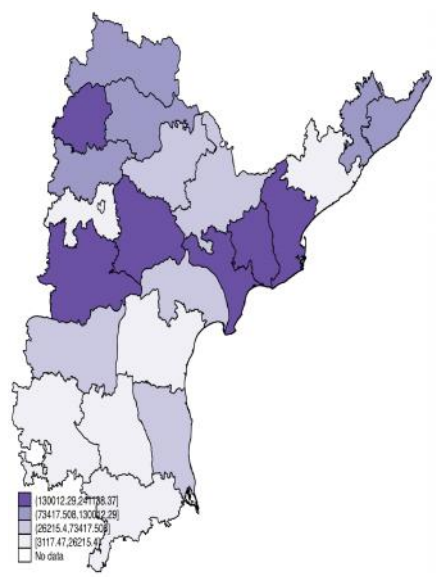
Average Yield



Area under insurance: 2007-08

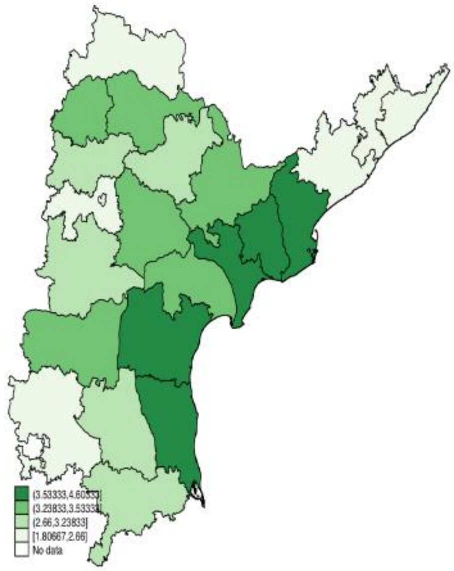


Area under insurance: 2008-09

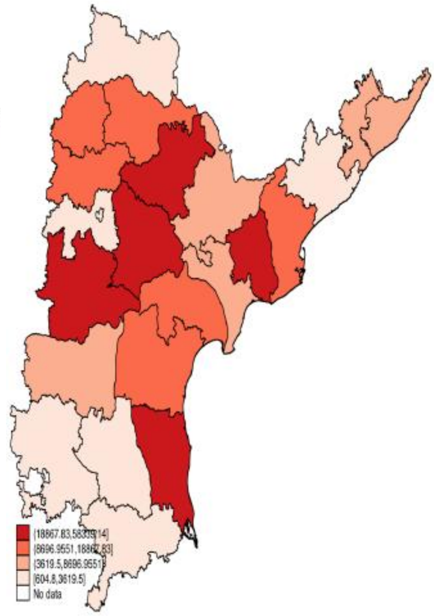


Area under insurance: 2009-10

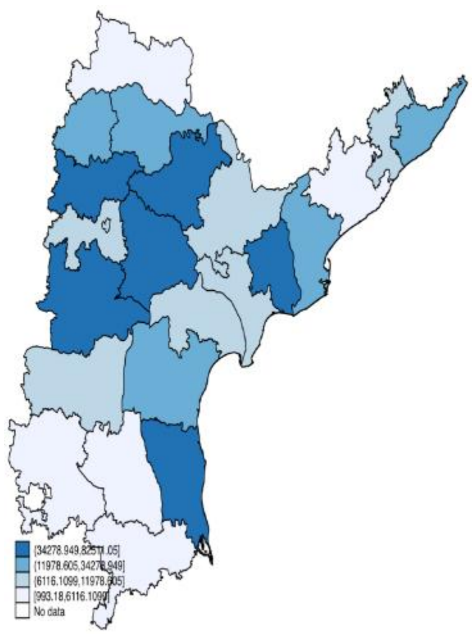
Rabi



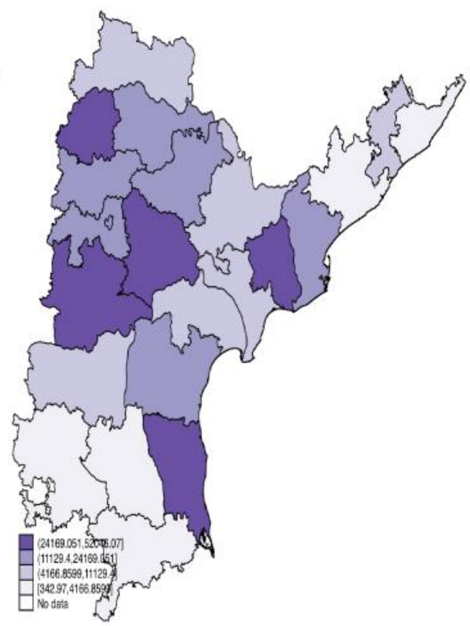
Average Yield



Area under insurance: 2007-08



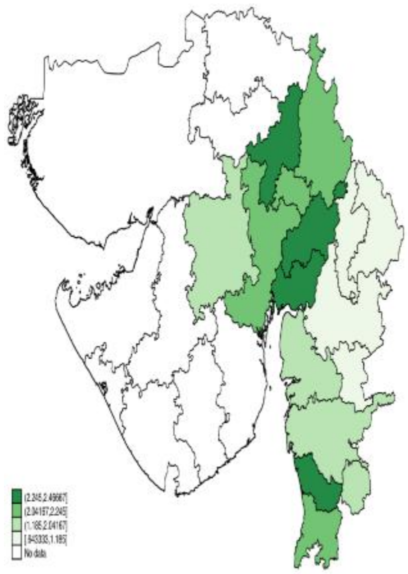
Area under insurance: 2008-09



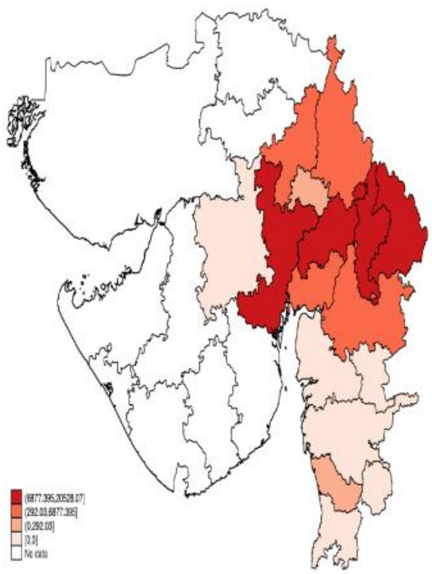
Area under insurance: 2009-10

b. Gujarat

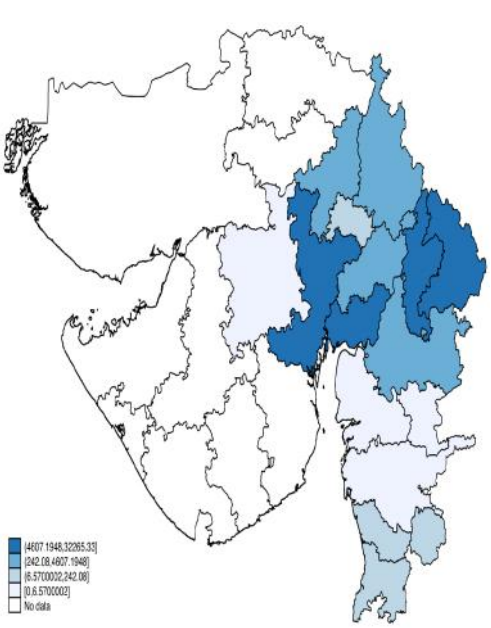
Kharif



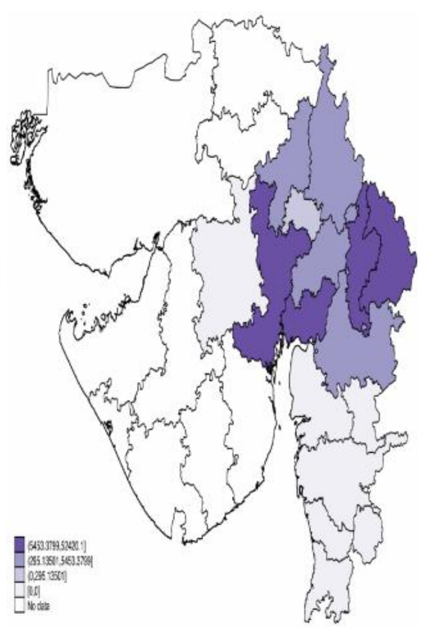
Average Yield



Area under insurance: 2007-08



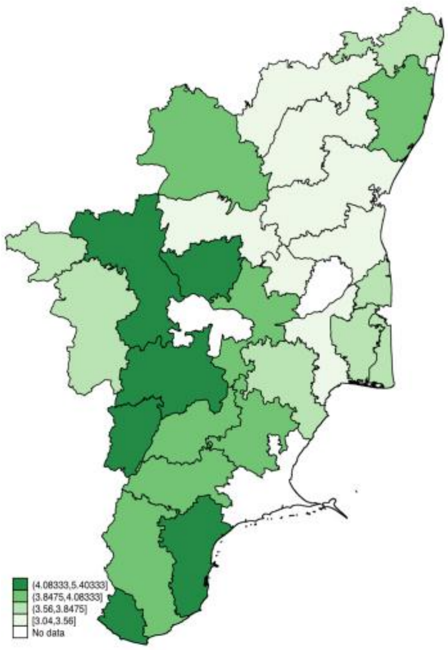
Area under insurance: 2008-09



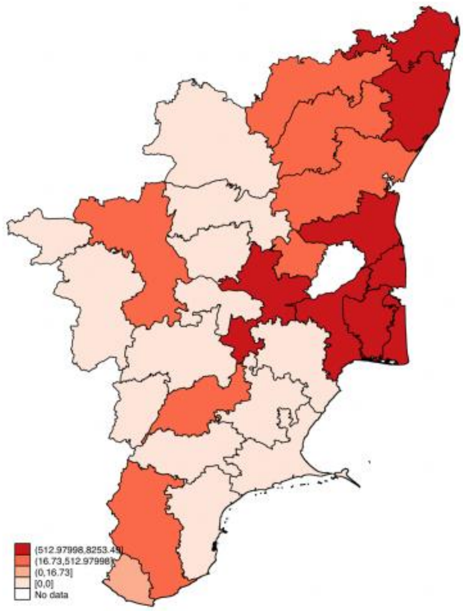
Area under insurance: 2009-10

c. Tamil Nadu

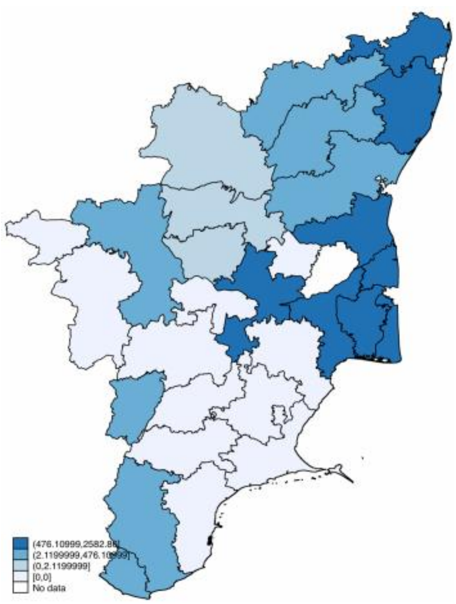
Kharif



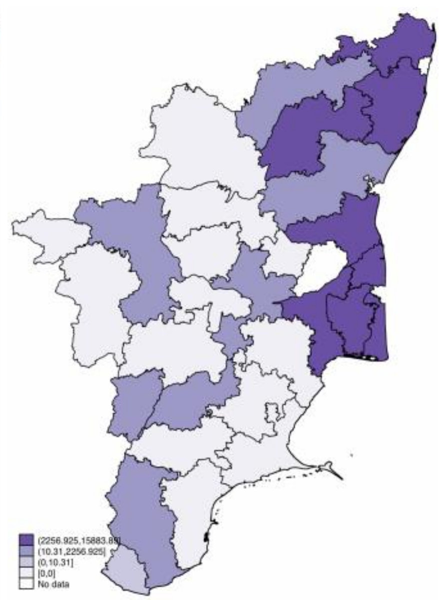
Average Yield



Area under insurance: 2007-08

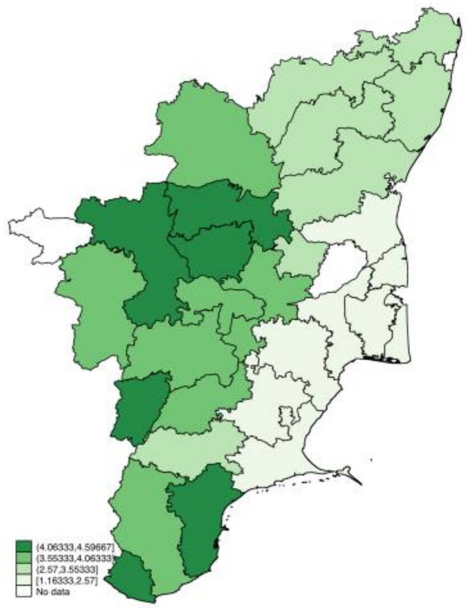


Area under insurance: 2008-09

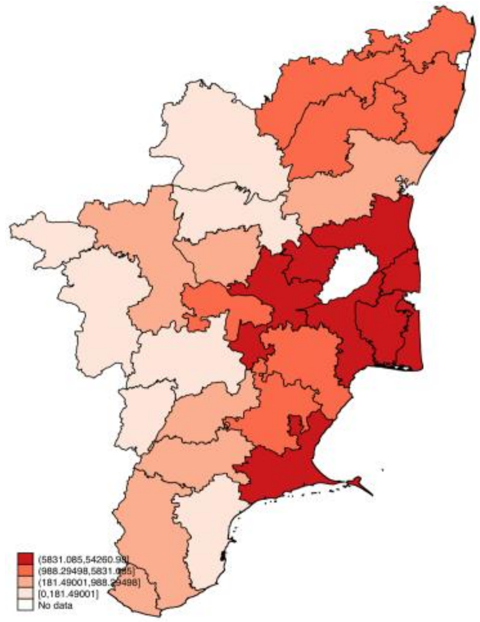


Area under insurance: 2009-10

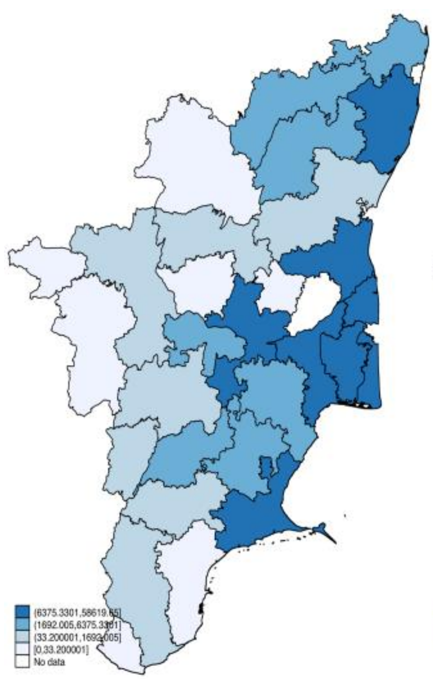
Rabi



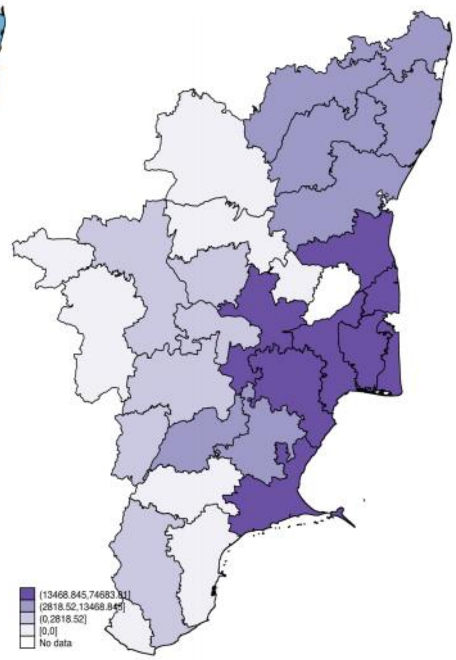
Average Yield



Area under insurance: 2007-08

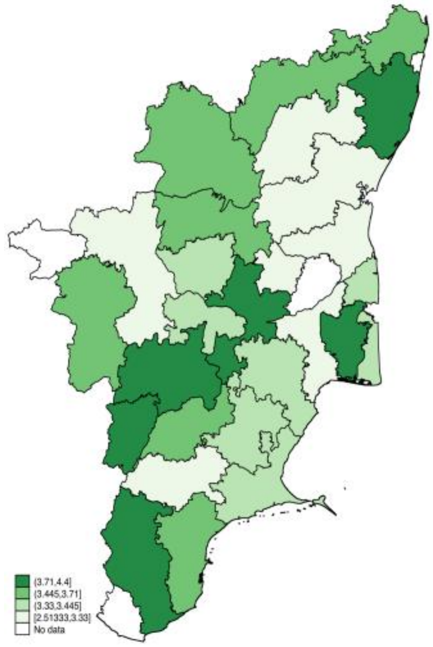


Area under insurance: 2008-09

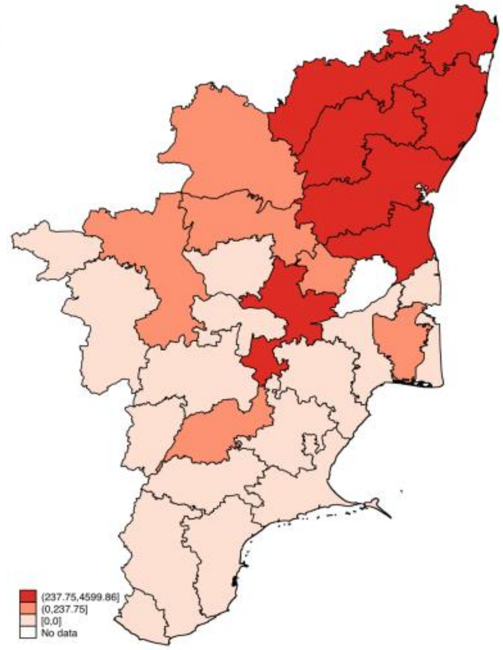


Area under insurance: 2009-10

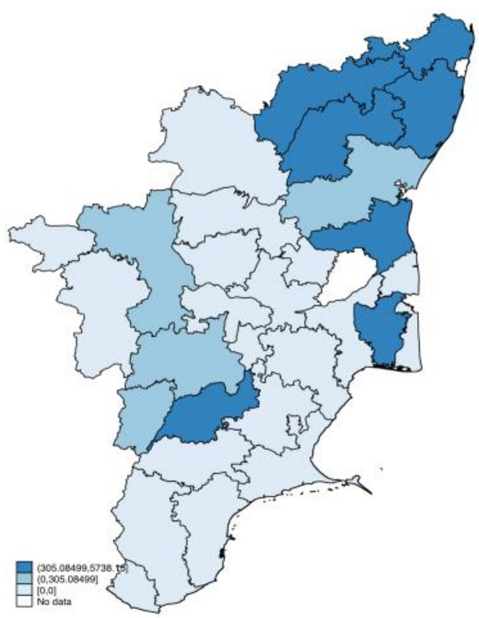
Summer



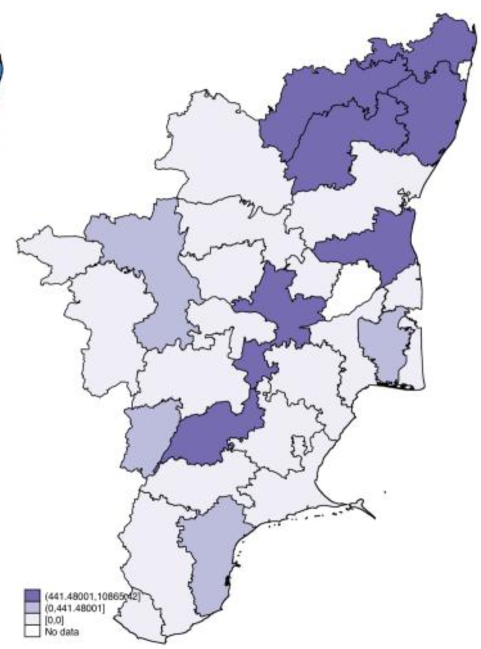
Average Yield



Area under insurance: 2007-08



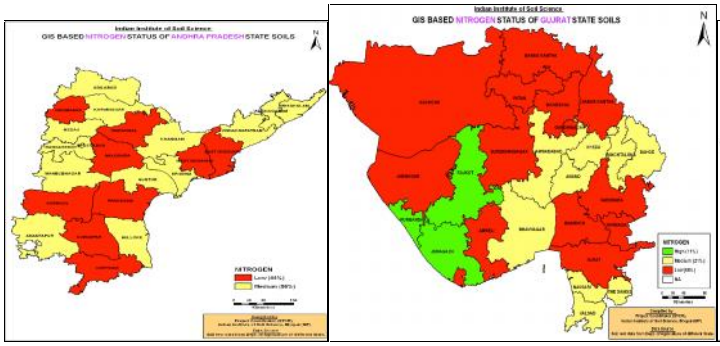
Area under insurance: 2008-09



Area under insurance: 2009-10

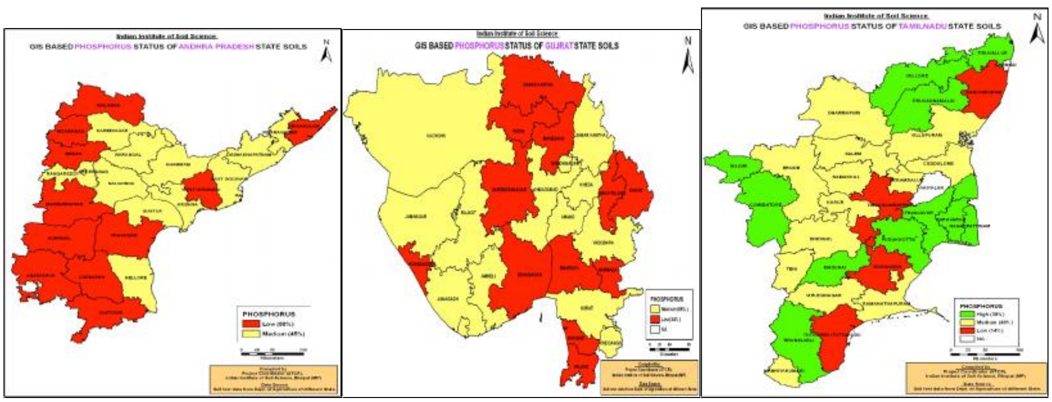
A3.4 Soil fertility measures

a. Nitrogen (N) content



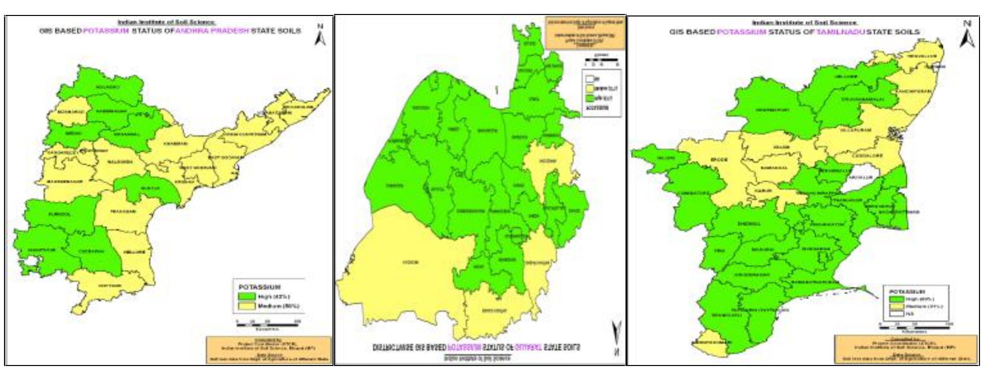
AP Gujarat TN

b. Phosphorous (P) content



AP Gujarat TN

c. Potassium (P) content



AP Gujarat TN

Source: Indian Institute of Social Sciences (IISS)

A3.5 National Food Security Mission or NFSM

The National Development Council (NDC) launched the NFSM scheme in 2007-08 aiming to increase the production of rice by 10 million tons, wheat by 8 million tons and pulses by 2 million tons by the end of the Eleventh Plan (2011-12).

Components of the NFSM scheme (as of 2012-13)

S.No	Components	Patterns of assistance
1	Demonstration of improved practices and packages	
	i. Cluster demonstrations by state in collaboration with ICAR/SAUs/IRRI on direct seed rice/line transplanting/SRI (target 1.5% of area of district)	Rs. 7500 per hectare
	ii. Cluster demonstrations on hybrid rice (one cluster of 100 ha. target 0.5% of the district)	Rs. 7500 per hectare
	iii. Cluster demonstrations on Swarna Sub-1/Sahbhagi Dhan of 100 ha each	Rs. 7500 per hectare
	iv. Frontline demonstration by ICAR/SAUs on hybrid/varieties (cluster of min 10 ha each)	Rs. 7500 per hectare
2	Support from promotion of hybrid rice seed	Rs. 1000 per quintal or 50% of the costs, whichever is less
3	Assistance for distribution of HYV seeds	Rs 5 per kg or 50% of the costs, whichever is less
4	Incentive for macro nutrients	Rs 500 per hectare or 50% of the costs, whichever is less
5	Incentive for liming in acid soils	Rs 500 per hectare or 50% of the costs, whichever is less
6	Assistance for plant protection chemicals and bio-pesticides	Rs 500 per hectare or 50% of the costs, whichever is less
7	Incentive for weeder and other farm implements	Rs 3000 per farmer or 50% of the costs, whichever is less
8	Zero seed till drill	5% of the costs limited to Rs. 15000 per machine
9	Rotavator	5% of the costs limited to Rs. 30000 per machine
10	Distribution of power weeder	5% of the costs limited to Rs. 15
11	Incentives on zero till multi crop planter	5% of the costs limited to Rs. 15
12	Incentives for laser land levelers	5% of the costs limited to Rs. 15
13	Incentive for ridge farrow planter	5% of the costs limited to Rs. 15
14	Knap sack sprayer	5% of the costs limited to Rs. 3000 per machine
15	Incentive for pump sets	5% of the costs limited to Rs. 10000 per machine
16	Farmer's training	Rs. 3500 per session; Rs 17000 per training

Source: http://farmer.gov.in/imagedefault/pestanddiseasescrops/rice.pdf

Table A3: Districts under NFSM in AP, Gujarat and TN

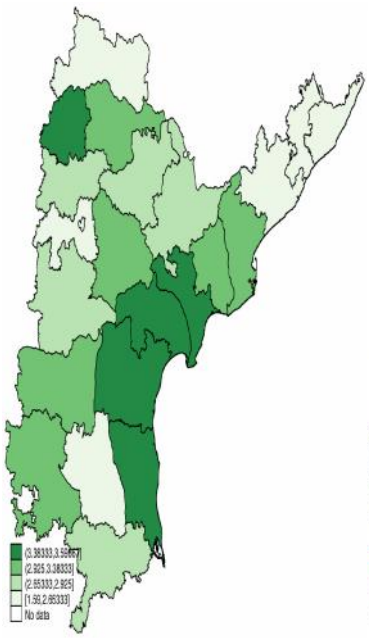
AP	Adilabad	GUJARAT	Dahod
	Guntur		Panchmahal
	Khammam	TN	Nagapattinam
	Krishna		Pudukkottai
	Mahaboobnagar		Ramanathapuram
	Medak		Sivagangai
	Nalgonda		Thiruvarur
	Nellore		
	Srikakulam		
	Visakhapatnam		
	Vizianagarm		

Source: Ministry of Agriculture, Government of India

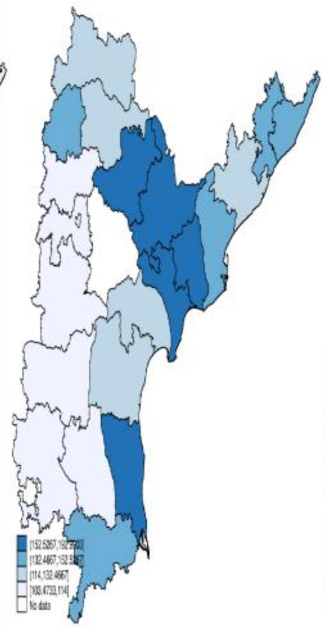
A3.6 Season-wise associations among yield, insurance and rainfall

a. Andhra Pradesh

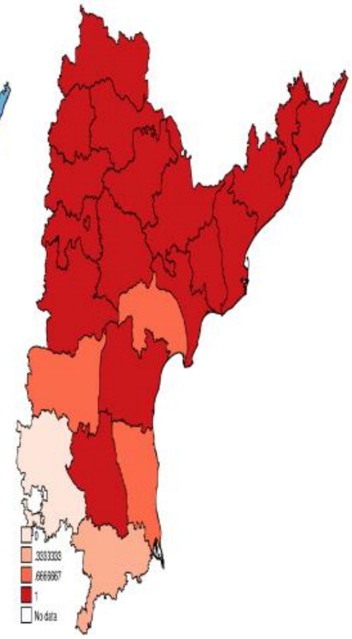
Kharif



Average yield

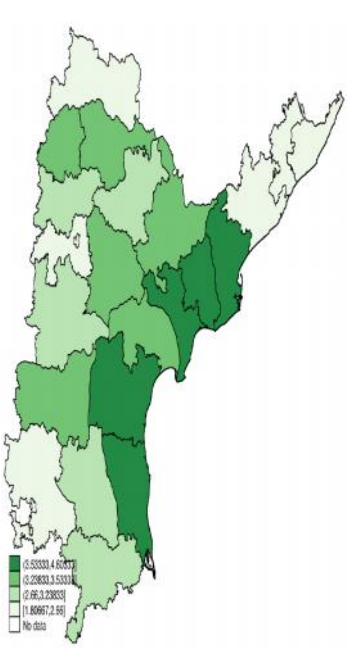


Total rainfall

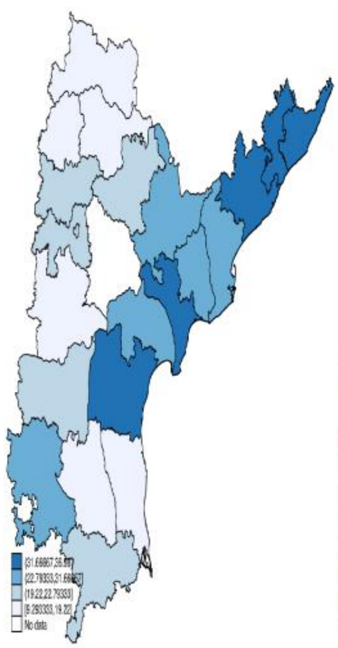


District dummy for insurance cover (20%)

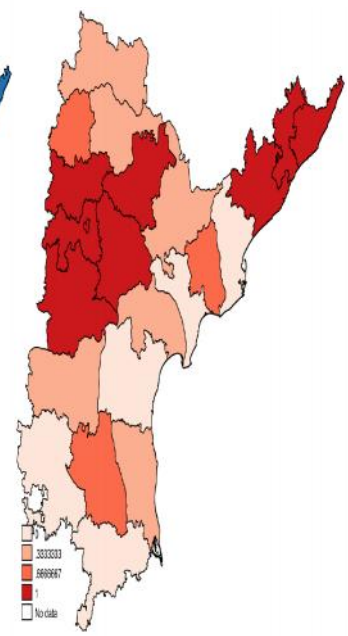
Rabi



Average yield



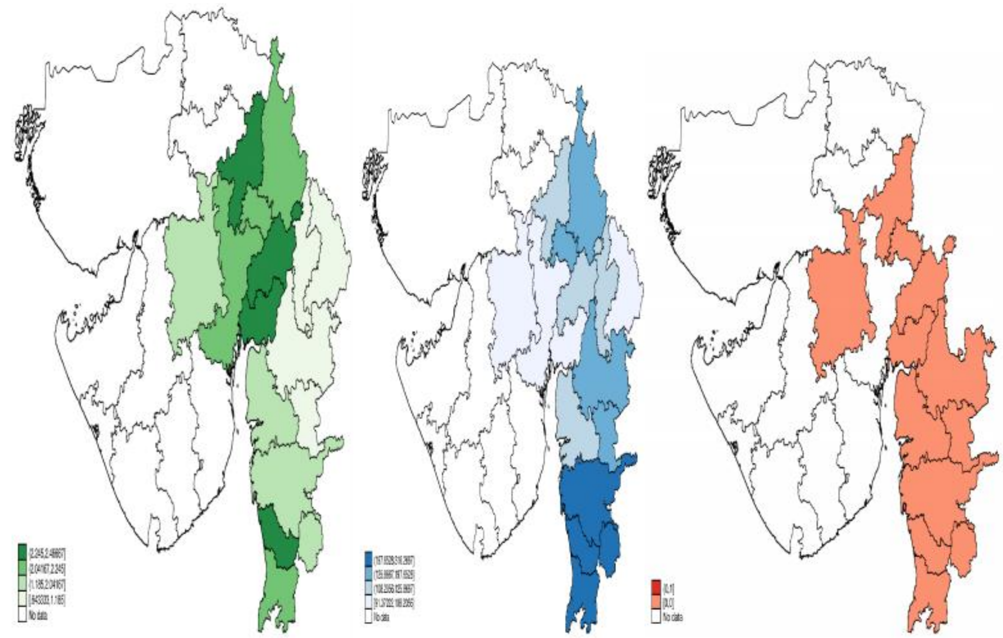
Total rainfall



District dummy for insurance cover (20%)

b. Gujarat

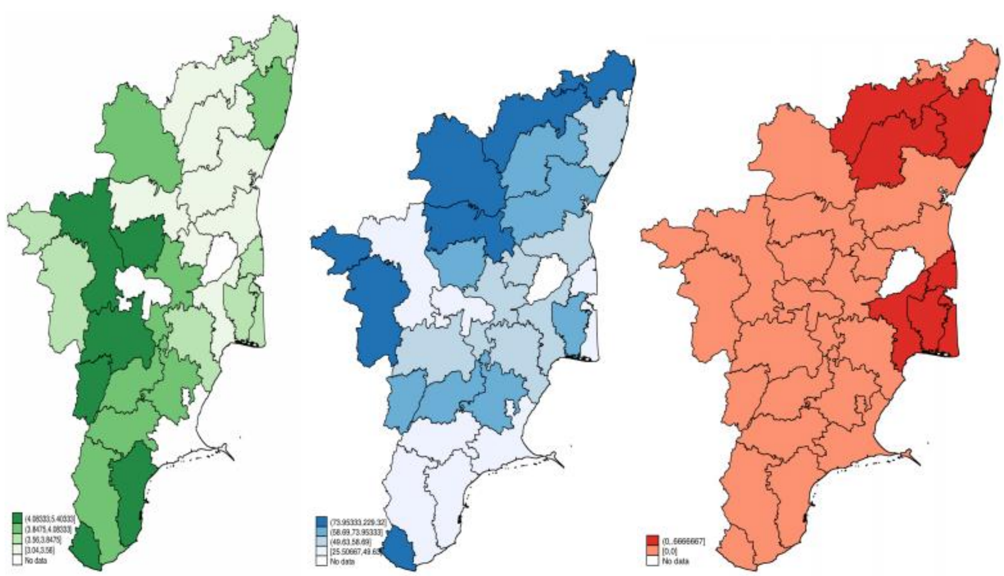
Kharif



Average yield **Total rainfall** **District dummy for insurance cover (20%)**

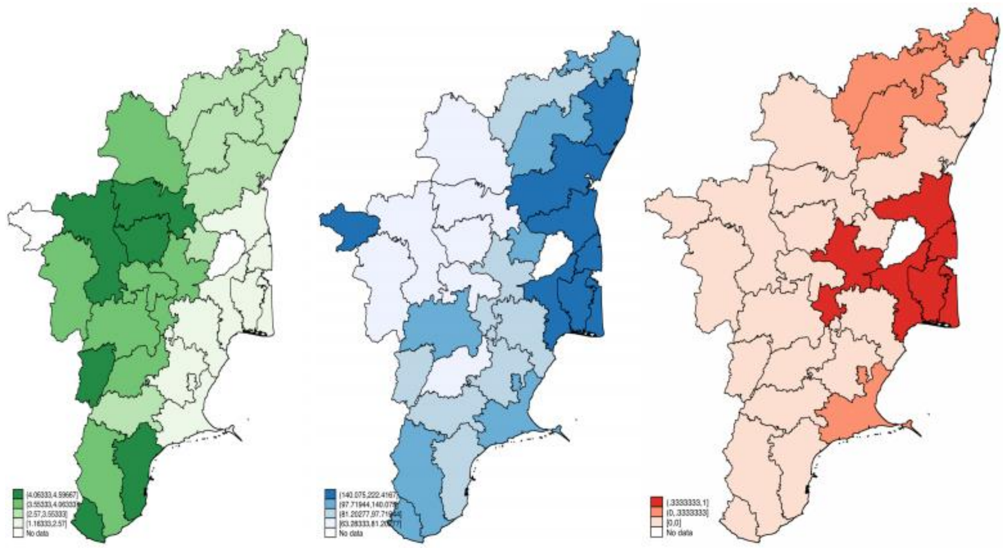
c. Tamil Nadu

Kharif



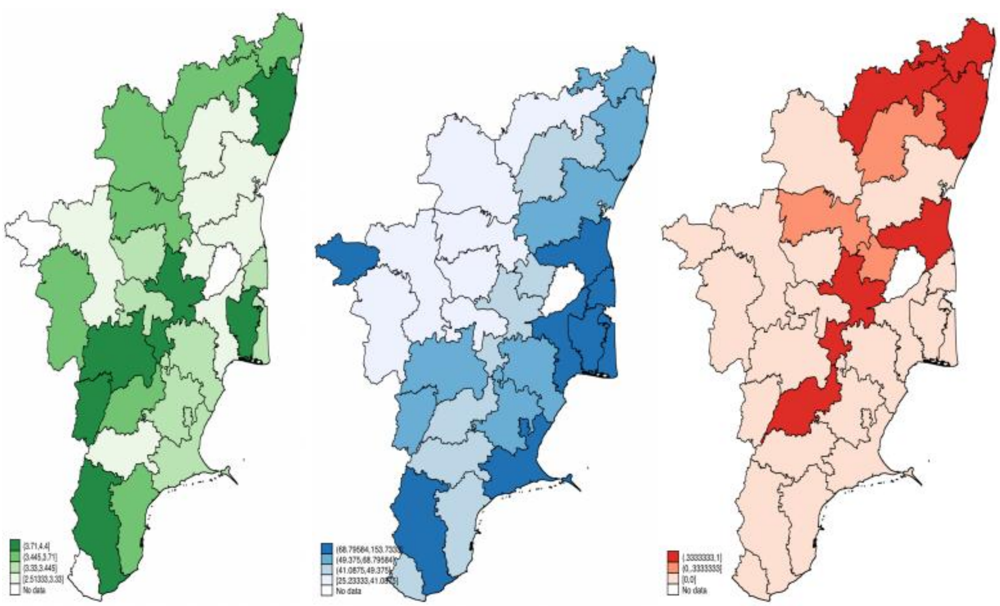
Average yield **Total rainfall** **District dummy for insurance cover (20%)**

Rabi



Average yield **Total rainfall** **District dummy for insurance cover (20%)**

Summer



Average yield **Total rainfall** **District dummy for insurance cover (20%)**

A3.7 Pooled OLS and panel regressions including irrigation dummy

Table A3.2a: Pooled OLS, FE and RE results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm and 1400 mm rainfall and an irrigation dummy

Particulars (1)	Pooled OLS			Fixed effects model			Random effects model		
	20% coverage (2)	25% coverage (3)	30% coverage (4)	20% coverage (5)	25% coverage (6)	30% coverage (7)	20% coverage (8)	25% coverage (9)	30% coverage (10)
Insurance district dummy	-0.4169***	-0.3565***	-0.4447***	-0.3261***	-0.2672***	-0.3064***	-0.3441***	-0.2871***	-0.3480***
	0.0778	0.0822	0.0851	0.0890	0.0808	0.0860	0.1053	0.0972	0.0992
Rain1 (<1200 mm)	-0.0009***	-0.0009***	-0.0009***	-0.0006***	-0.0007***	-0.0007***	-0.0007***	-0.0008***	-0.0008***
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Rain2 (1200-1400 mm)	-0.0017	-0.0015	-0.0014	-0.0033	-0.0034	-0.0034	-0.0015	-0.0014	-0.0013
	0.0016	0.0016	0.0016*	0.0048	0.0043	0.0047	0.0016	0.0016	0.0015
Rain3 (>1400 mm)	0.0018*	0.0019*	0.0019	0.0002	0.0002	0.0002	0.0013	0.0013	0.0013
	0.0010	0.0010	0.0010	0.0107	0.0085	0.0076	0.0009	0.0009	0.0009
Irrigation dummy	1.5807***	1.5682***	1.5566***	0.1809	0.1826	0.1801	1.5435***	1.5204***	1.5089***
	0.1988	0.2027	0.2019	6.1164	4.8091	3.8715	0.2538	0.2540	0.2533
NFSM district	-0.1637	-0.1837*	-0.1598				-0.0813	-0.1081	-0.0944
	0.1018	0.1028	0.1017				0.1712	0.1660	0.1626
Soil N quality_medium (B: Low)	-0.3641***	-0.3849***	-0.3818***				-0.3928**	-0.4043**	-0.4006**
	0.0956	0.0958	0.0942				0.1628	0.1614	0.1565
Soil P quality_medium (B: Low)	0.1600*	0.1680*	0.1671*				0.2070	0.2146	0.2148
	0.0884	0.0897	0.0879				0.1584	0.1600	0.1575
Soil K quality_medium (B: High)	0.2149***	0.2045***	0.2275***				0.2627*	0.2487	0.2647*
	0.0714	0.0721	0.0721				0.1504	0.1525	0.1511
Kharif season dummy	0.1337	0.1332	0.1541	0.3100***	0.3152***	0.3320***	0.2559**	0.2622**	0.2785**
	0.1087	0.1093	0.1108	0.1017	0.1145	0.0921	0.1161	0.1160	0.1147
Rabi season dummy	0.0379	0.0410	0.0618	0.0529	0.0659	0.0864	0.0498	0.0595	0.0786
	0.1032	0.1044	0.1048	0.1057	0.1139	0.0995	0.1429	0.1449	0.1428
Year 2007-08	0.0314	0.0441	0.0275	0.0188	0.0308	0.0231	0.0254	0.0366	0.0254
	0.0855	0.0858	0.0858	0.0660	0.0618	0.0621	0.0693	0.0685	0.0679

Table A3.2a continued: **Pooled OLS, FE and RE results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm and 1400 mm rainfall and an irrigation dummy**

Particulars (1)	**Pooled OLS**			**Fixed effects model**			**Random effects model**		
	20% coverage (2)	**25% coverage (3)**	**30% coverage (4)**	**20% coverage (5)**	**25% coverage (6)**	**30% coverage (7)**	**20% coverage (8)**	**25% coverage (9)**	**30% coverage (10)**
Year 2008-09	-0.0245	-0.0101	-0.0371	-0.0024	0.0110	-0.0050	-0.0115	0.0017	-0.0188
	0.0921	0.0926	0.0926	0.0627	0.0640	0.0653	0.0528	0.0517	0.0520
Constant	2.1161***	2.1025***	2.1029***	3.2811	3.2483	3.2483	1.8629***	1.8583***	1.8623***
	0.2377	0.2399	0.2397	5.7811	4.4819	3.6458	0.3113	0.3099	0.3076
Number of observations	409	409	409	412	412	412	409	409	409
R-squared	0.46	0.45	0.45	0.19	0.18	0.19			
F value/ Chi2 value	31.19	31.48	32.95	63.89	46.93	48.14	162.29	157.63	165.11

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. 20%, 25% and 30% coverage represent dummy measures for district level insurance penetration. Robust standard errors for pooled OLS and random effects and Bootstrapped standard errors for fixed effects model are provided below the coefficients. Rainfall spline1 represents rainfall below 1200 mm, Rainfall spline2 represents rainfall between 1200-1400 mm and Rainfall spline3 represents rainfall above 1400 mm. For soil quality N and P, the base category is low levels of fertility and base category for K is high fertility. The base category for season is ‘Summer’ and for year is ‘2009-10’.

Table A3.2b: Pooled OLS, FE and RE results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm rainfall and an irrigation dummy									
	Pooled OLS			**Fixed effects model**			**Random effects model**		
Particulars (1)	**20% coverage (2)**	**25% coverage (3)**	**30% coverage (4)**	**20% coverage (5)**	**25% coverage (6)**	**30% coverage (7)**	**20% coverage (8)**	**25% coverage (9)**	**30% coverage (10)**
Insurance district dummy	-0.4093***	-0.3520***	-0.4419***	-0.3410***	-0.2850***	-0.3228***	-0.3424***	-0.2887***	-0.3505***
	0.0777	0.0824	0.0855	0.0980	0.0801	0.0916	0.1084	0.1010	0.1036
Rain4 (<1200 mm)	-0.0010***	-0.0010***	-0.0010***	-0.0007***	-0.0007***	-0.0007***	-0.0008***	-0.0008***	-0.0008***
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Rain5 (>1200 mm)	0.0009**	0.0010**	0.0010**	-0.0001	-0.0001	-0.0001	0.0008	0.0008	0.0008
	0.0004	0.0005	0.0005	0.0023	0.0016	0.0046	0.0005	0.0005	0.0005
Irrigation dummy	1.5545***	1.5443***	1.5339***	0.0143	0.0144	0.0091	1.5425***	1.5213***	1.5097***
	0.1971	0.2007	0.2000	1.2488	0.8775	2.7400	0.2459	0.2452	0.2446
NFSM district	-0.1618	-0.1812*	-0.1571				-0.0570	-0.0831	-0.0698
	0.1012	0.1023	0.1011				0.1670	0.1616	0.1580
Soil N quality_medium (B: Low)	-0.3726***	-0.3922***	-0.3885***				-0.4210***	-0.4314***	-0.4271***
	0.0942	0.0945	0.0930				0.1584	0.1569	0.1522
Soil P quality_medium (B: Low)	0.1630*	0.1704*	0.1691*				0.2094	0.2164	0.2165
	0.0875	0.0889	0.0871				0.1579	0.1594	0.1570
Soil K quality_medium (B: High)	0.2268***	0.2160***	0.2389***				0.2828*	0.2688*	0.2846*
	0.0713	0.0720	0.0720				0.1497	0.1517	0.1501
Kharif season dummy	0.1478	0.1464	0.1667	0.3148***	0.3196***	0.3378***	0.2645**	0.2698**	0.2861**
	0.1086	0.1092	0.1108	0.1061	0.0982	0.0988	0.1158	0.1159	0.1146
Rabi season dummy	0.0472	0.0495	0.0698	0.0451	0.0575	0.0797	0.0527	0.0615	0.0807
	0.1036	0.1047	0.1051	0.1089	0.0977	0.0995	0.1442	0.1463	0.1439
Year 2007-08	0.0475	0.0588	0.0417	0.0231	0.0350	0.0274	0.0345	0.0446	0.0332
	0.0849	0.0850	0.0852	0.0651	0.0648	0.0689	0.0680	0.0675	0.0670
Year 2008-09	-0.0104	0.0025	-0.0248	-0.0024	0.0109	-0.0054	-0.0042	0.0080	-0.0126
	0.0917	0.0922	0.0922	0.0634	0.0632	0.0694	0.0521	0.0511	0.0516
Constant	2.1431***	2.1281***	2.1280***	3.4335***	3.4026***	3.4038	1.8557***	1.8503***	1.8548***
	0.2372	0.2391	0.2388	1.1818	0.8403	2.6042	0.3052	0.3034	0.3012

Table A3.2b continued**: Pooled OLS, FE and RE results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm rainfall and an irrigation dummy**									
	Pooled OLS			**Fixed effects model**			**Random effects model**		
Particulars (1)	**20% coverage (2)**	**25% coverage (3)**	**30% coverage (4)**	**20% coverage (5)**	**25% coverage (6)**	**30% coverage (7)**	**20% coverage (8)**	**25% coverage (9)**	**30% coverage (10)**
Number of observations	409	409	409	412	412	412	409	409	409
R-squared	0.46	0.45	0.45	0.19	0.18	0.18			
F value/ Chi2 value	32.90	33.56	35.21	60.41	51.26	50.24	181.49	181.05	189.45

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. 20%, 25% and 30% coverage represent dummy measures for district level insurance penetration. Robust standard errors for pooled OLS and random effects and Bootstrapped standard errors for fixed effects model are provided below the coefficients. Rainfall spline4 represents rainfall below 1200 mm and Rainfall spline5 represents rainfall above 1400 mm. For soil quality N and P, the base category is low levels of fertility and base category for K is high fertility. The base category for season is ‘Summer’ and for year is ‘2009-10’.

A3.8 Two-stage IV results including irrigation dummy

Table A3.3a: Two-stage IV results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm and 1400 mm rainfall and an irrigation dummy						
	20% coverage		**25% coverage**		**30% coverage**	
Particulars (1)	**First stage (2)**	**Second stage (3)**	**First stage (4)**	**Second stage (5)**	**First stage (6)**	**Second stage (7)**
Lagged insurance subsidies	0.0003***		0.0003***		0.0002***	
	0.0000		0.0000		0.0000	
Lagged insurance claims	-0.0007		-0.0005		0.0003	
	0.0005		0.0005		0.0005	
Insurance district dummy		-0.2093		-0.2087		-0.2513
		0.2125		0.2054		0.2240
Rain1 (<1200 mm)	-0.0001	-0.0009***	-0.0002	-0.0009***	-0.0002**	-0.0010***
	0.0001	0.0002	0.0001	0.0002	0.0001	0.0002
Rain2 (1200-1400 mm)	-0.0006	-0.0009	-0.0003	-0.0008	-0.0001	-0.0008
	0.0007	0.0020	0.0008	0.0020	0.0008	0.0020
Rain3 (>1400 mm)	-0.0001	0.0016*	-0.0001	0.0016*	-0.0001	0.0016*
	0.0002	0.0010	0.0002	0.0010	0.0002	0.0010
Irrigation dummy	0.1221	1.5986***	0.0454	1.5832***	-0.0033	1.5728***
	0.0834	0.2505	0.0827	0.2445	0.0827	0.2401
NFSM district	0.0688	-0.2657**	0.0433	-0.2697**	0.0618	-0.2605**
	0.0679	0.1272	0.0640	0.1271	0.0632	0.1282
Soil N quality_medium (B: Low)	0.2315***	-0.4278***	0.2343***	-0.4285***	0.1980***	-0.4305***
	0.0743	0.1262	0.0713	0.1254	0.0709	0.1219
Soil P quality_medium (B: Low)	-0.1566***	0.1788	-0.1529***	0.1801	-0.1430***	0.1777
	0.0578	0.1188	0.0543	0.1183	0.0529	0.1160
Soil K quality_medium (B: High)	0.0706	0.1410	0.0704	0.1405	0.1029**	0.1499
	0.0536	0.0983	0.0515	0.0982	0.0503	0.0991
Kharif season dummy	0.0278	0.0998	0.0062	0.0947	0.0369	0.1013
	0.0790	0.1446	0.0729	0.1449	0.0697	0.1458
Rabi season dummy	0.0096	0.1311	-0.0070	0.1280	0.0203	0.1361
	0.0811	0.1303	0.0787	0.1309	0.0766	0.1303

Table A3.3a continued: **Two-stage IV results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm and 1400 mm rainfall and an irrigation dummy**						
	20% coverage		**25% coverage**		**30% coverage**	
Particulars (1)	**First stage (2)**	**Second stage (3)**	**First stage (4)**	**Second stage (5)**	**First stage (6)**	**Second stage (7)**
Year 2009-10	0.1297***	-0.0107	0.1102**	-0.0141	0.1386***	-0.0001
	0.0486	0.0964	0.0459	0.0956	0.0447	0.0987
Constant	0.1188	2.0837***	0.1685	2.0923***	0.1534	2.0930***
	0.1134	0.2732	0.1114	0.2721	0.1091	0.2709
No. of observations	271	271	271	271	271	271
F value (overall significance of the regression)	18.4133	21.704	17.284	21.7655	15.1453	22.393
Prob >F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Centered R2	0.3691	0.4539	0.3792	0.4472	0.349	0.4563
Uncentered R2	0.5926	0.9511	0.5625	0.9505	0.51	0.9513
Instruments validation						
Cragg-Donald Wald F statistic		29.6380		36.4300		32.4120
Under identification test						
Anderson canon. corr. LM statistic						
Chi2 value/P-value	34.7080	0.0000	31.5810	0.0000	20.4800	0.0000
Over identification/validity of all instruments						
Hansen's J statistic						
Chi2 value/ P-value	0.1660	0.6839	0.1010	0.7505	0.0100	0.9203
Endogeneity tests						
Durbin-Wu-Hausman						
Chi2 value/P-value	2.9150*	0.0878	2.0580	0.1514	2.3970	0.1215

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. 20%, 25% and 30% coverage represent dummy measures for district level insurance penetration. Robust standard errors are provided below the coefficients. Rainfall spline1 represents rainfall below 1200 mm, Rainfall spline2 represents rainfall between 1200-1400 mm and Rainfall spline3 represents rainfall above 1400 mm. For soil quality N and P, the base category is low levels of fertility and base category for K is high fertility. The base category for season is 'Summer' and for year is '2008-09'. The null hypothesis of exogeneity of insurance purchase is rejected under all three insurance coverage categories.

Table A3.3b: Two-stage IV results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm rainfall and an irrigation dummy

Particulars	20% coverage		25% coverage		30% coverage	
	First stage (2)	Second stage (3)	First stage (4)	Second stage (5)	First stage (6)	Second stage (7)
(1)						
Lagged insurance subsidies	0.0003***		0.0003***		0.0002***	
	0.0000		0.0000		0.0000	
Lagged insurance claims	-0.0008*		-0.0005		0.0003	
	0.0005		0.0005		0.0005	
Insurance district dummy		-0.2057		-0.2096		-0.2628
		0.2156		0.2079		0.2258
Rain4 (<1200 mm)	-0.0002	-0.0010***	-0.0002	-0.0010***	-0.0002**	-0.0010***
	0.0001	0.0002	0.0001	0.0002	0.0001	0.0002
Rain5 (>1200 mm)	-0.0002	0.0011**	-0.0002	0.0011**	-0.0001	0.0011**
	0.0002	0.0005	0.0002	0.0005	0.0002	0.0005
Irrigation dummy	0.1189	1.5819***	0.0444	1.5685***	-0.0036	1.5605***
	0.0835	0.2495	0.0824	0.2436	0.0825	0.2394
NFSM district	0.0694	-0.2667**	0.0435	-0.2698**	0.0619	-0.2586**
	0.0676	0.1274	0.0638	0.1273	0.0629	0.1283
Soil N quality_medium (B: Low)	0.2297***	-0.4332***	0.2338***	-0.4327***	0.1978***	-0.4329***
	0.0740	0.1252	0.0707	0.1244	0.0701	0.1206
Soil P quality_medium (B: Low)	-0.1555***	0.1826	-0.1525***	0.1827	-0.1429***	0.1782
	0.0577	0.1181	0.0542	0.1176	0.0527	0.1152
Soil K quality_medium (B: High)	0.0722	0.1514	0.0709	0.1511	0.1031**	0.1616
	0.0534	0.0983	0.0513	0.0978	0.0502	0.0984
Kharif season dummy	0.0315	0.1204	0.0074	0.1144	0.0373	0.1202
	0.0784	0.1440	0.0723	0.1440	0.0689	0.1448
Rabi season dummy	0.0127	0.1446	-0.0060	0.1408	0.0206	0.1483
	0.0800	0.1306	0.0773	0.1311	0.0751	0.1304

Table A3.3b continued: **Two-stage IV results on the impact of district level crop insurance coverage on district level paddy productivity during 2007-08 to 2009-10 using linear rainfall splines knotted at 1200 mm rainfall and an irrigation dummy**

Particulars (1)	**20% coverage**		**25% coverage**		**30% coverage**	
	First stage (2)	**Second stage (3)**	**First stage (4)**	**Second stage (5)**	**First stage (6)**	**Second stage (7)**
Year 2009-10	0.1286***	-0.0199	0.1098**	-0.0223	0.1385***	-0.0063
	0.0484	0.0957	0.0456	0.0949	0.0443	0.0982
Constant	0.1226	2.1062***	0.1697	2.1135***	0.1538	2.1129***
	0.1131	0.2714	0.1108	0.2704	0.1086	0.2692
No. of observations	271	271	271	271	271	271
F value (overall significance of the regression)	19.8635	24.1216	18.6573	24.1946	16.1972	24.9373
Prob >F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Centered R2	0.3687	0.4512	0.3792	0.4451	0.349	0.4554
Uncentered R2	0.5923	0.9509	0.5625	0.9503	0.5099	0.9512
Instruments validation						
Cragg-Donald Wald F statistic		30.101		36.781		32.746
Under identification test						
Anderson canon. corr. LM statistic						
Chi2 value/P-value	34.7390	0.0000	31.5730	0.0000	20.3240	0.0000
Over identification/validity of all instruments						
Hansen's J statistic						
Chi2 value/ P-value	0.5420	0.4616	0.3800	0.5377	0.1290	0.7191
Endogeneity tests						
Durbin-Wu-Hausman						
Chi2 value/P-value	2.6170	0.1057	1.8300	0.1761	2.1960	0.1384

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. 20%, 25% and 30% coverage represent dummy measures for district level insurance penetration. Robust standard errors are provided below the coefficients. Rainfall spline4 represents rainfall below 1200 mm and Rainfall spline5 represents rainfall above 1400 mm. For soil quality N and P, the base category is low levels of fertility and base category for K is high fertility. The base category for season is ‘Summer’ and for year is ‘2008-09’. The null hypothesis of exogeneity of insurance purchase is rejected under all three insurance coverage categories.

A3.9 First stage Hurdle model results for Aman and Boro paddy

Table A3.4: First stage results from the Hurdle model analysis that incorporates missing yields						
Particulars (1)	**Aman paddy**			**Boro paddy**		
	Specification 1 (2)	**Specification 2 (3)**	**Specification 3 (4)**	**Specification 1 (5)**	**Specification 2 (6)**	**Specification 3 (7)**
Aman insurance	0.6901***	0.6939***	0.7014***			
	0.1517	0.1532	0.1555			
Boro insurance				0.2976	0.2976	0.2914
				0.2392	0.2390	0.2404
Risk aversion		-0.1251	-0.1465		0.0421	0.0178
		0.3902	0.3931		0.5991	0.6092
Age			-0.0010			0.0048
			0.0050			0.0063
Household size			0.0196			0.0306
			0.0308			0.0436
No. of crops produced	-0.3654***	-0.3647***	-0.3603***	0.6379	0.6379	0.6397
	0.1203	0.1202	0.1201	0.4006	0.4006	0.4033
Diversification	0.0975	0.1049	0.0901	-0.7299***	-0.7328***	-0.7499***
	0.1406	0.1431	0.1433	0.2427	0.2503	0.2545
Use machinery	0.1972	0.1932	0.1868	-0.6842***	-0.6830***	-0.7010***
	0.2062	0.2062	0.2062	0.2571	0.2548	0.2544
Land under crops	-0.0112	-0.0114	-0.0153	0.0657	0.0656	0.0626
	0.0264	0.0264	0.0268	0.0459	0.0457	0.0431
Cooperative member	0.2354	0.2401	0.2496	0.1600	0.1616	0.1511
	0.3392	0.3386	0.3435	0.4567	0.4575	0.4540
SHG member	0.5166***	0.5088***	0.5044***	-0.0688	-0.0666	-0.0575
	0.1677	0.1702	0.1708	0.2196	0.2143	0.2152
Year 2012 dummy	5.5571***	5.5150***	5.5127***	4.9114***	4.9158***	4.9154***
	0.1319	0.1778	0.1739	0.3586	0.3705	0.3721
Constant	0.7299***	0.8268**	0.80489*	0.2833	0.2502	-0.0643
	0.2297	0.3816	0.4470	0.8391	0.9761	1.0221

Table A3.4 continued: **First stage results from the Hurdle model analysis that incorporates missing yields**						
Particulars (1)	**Aman paddy**			**Boro paddy**		
	Specification 1 (2)	**Specification 2 (3)**	**Specification 3 (4)**	**Specification 1 (5)**	**Specification 2 (6)**	**Specification 3 (7)**
Number of observations	756	756	756	597	597	597
Chi2 value	5031.64	5073.88	5114.53	825.02	875.61	951.18
Pseudo log likelihood	-1913.11	-1913.02	-1912.48	-1852.90	-1851.61	-1850.18
Sigma	4.03	4.03	4.03	5.85	5.83	5.82

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust standard errors are provided below the coefficients. Specification 1 does not include risk aversion or household demographic variables. Specification 2 includes risk aversion, Specification 3 accounts for age, household size and risk aversion. Second stage results from the Hurdle model are presented Table 3.11a and Table 3.11b for Aman and Boro paddy respectively.

Appendix for Chapter IV

A4.1 Product note

The insurance product under study is described in this section. The product is provided on a voluntary basis to *non-loanee* farmers under the WBCIS scheme.

A4.1.1 Aman paddy

Aman paddy is insured against both deficit and excess rainfall. The details of the associated weather stations, insurance premium, pay-outs and trigger points are explained through the charts below.

Deficit rainfall cover

Block	Primary Weather Station[54]	Block	Primary Weather Station
Sankrail	Harishpur	Shyampur II	Garchumuk
Jagatballabhpur	Maju	Bagnan-I	Mahadevpur
Shyampur II	Sasati	Panchla	Kalagachia
Amta I	Ghoshpur	Shyampur I	Kultikari
Amta	Noapara	Udainarayanpur	Dihibhursut
Shyampur I	Pansilla		

Phases & Options	Sowing Phase (Phase 1)	Vegetative Growth Phase (Phase 2)	Flowering to grain Maturity Phase (Phase 3)	Harvesting Phase (Phase 4)
Option 1	01 Jul -25 Jul	26 Jul - 29 Aug	30 Aug - 13 Oct	14 Oct - 07 Nov
Option 2	NA	01 Aug -04 Sep	05 Sep - 19 Oct	20 Oct - 13 Nov

Cover Period	Phase 1		Phase 2		Phase 3		Phase 4	
Index	Cumulative Rainfall of the Phase in mm							
Option 1	Strike1	Notional (Rs.) 1	Strike1	Notional (Rs.) 1	Strike1	Notional (Rs.) 1	Strike1	Notional (Rs.) 1
	150	5	250	5	250	5	30	5
	Strike2	Notional (Rs.) 2	Strike2	Notional (Rs.) 2	Strike2	Notional (Rs.) 2	Strike2	Notional (Rs.) 2
	50	15	150	15	150	15		
Option 2	Strike1	Notional (Rs.) 1	Strike1	Notional (Rs.) 1	Strike1	Notional (Rs.) 1	Strike1	Notional (Rs.) 1
	NA	NA	250	5	250	5	30	5
	Strike2	Notional (Rs.) 2	Strike2	Notional (Rs.) 2	Strike2	Notional (Rs.) 2	Strike2	Notional (Rs.) 2
	NA	NA	150	15	150	15		
Payoff(Rs.)/ Phase	If Actual Rainfall < Strike 2 : [(Strike 2 – Actual Rainfall) X Notional2 + (Strike 1 – Strike 2) X Notional1]; If Actual Rainfall < Strike 1 & > Strike 2: [(Strike 1 – Actual Rainfall) X Notional1]; If Actual Rainfall >= Strike 1 : 0							

[54] Data is provided by INGEN and the back-up weather station is the nearest government weather station that supplies certified weather data.

Payoff for the Cover Period	Sum of phase wise Payoffs of all the phases	
Deductible Amount (Rs.)	Option 1	50
	Option 2	100
Max Sum Insured (Rs / Acre)	5000	
Total Payoff	Min [Max Sum Insured, Payoff for the Cover Period-Deductible]	
Premium (Incl. ST) / Acre	552	
Premium Payable by Farmer (Incl. ST / Acre)	138.00 (INR)	

I. **Water Deficit Index (WDI)** - Farmer transplants paddy normally when there is sufficient moisture available in the soil. Plants require water daily and this is supplied by means of rainfall or irrigation. Let us denote this as Strike. If there is no rainfall, plants use the moisture stored in the soil. This way, after transplanting, even if there is no rainfall, plants can survive for few days. However, subsequently if there is a deficiency of water, paddy yield will get affected. Let us denote this as WD (Water Deficit).

II. **Strike–**Strike is the level of rainfall below which paddy growth will be affected due to water stress and which will directly impact in production.

Excess rainfall cover

Block	Primary Weather Station[55]	Block	Primary Weather Station
Sankrail	Harishpur	Shyampur I	Kultikari
Jagatballabhpur	Maju	Udainarayanpur	Dihibhursut
Shyampur II	Sasati	Garhbeta II	Goaltore
Amta I	Ghoshpur	Garhbeta II	Kadra
Amta	Noapara	Ghatal	Danitra
Shyampur I	Pansilla	Nandkumar	Jalpai
Shyampur II	Garchumuk	Moyna	Moyna
Bagnan-I	Mahadevpur	Chandipur	Chandipur
Panchla	Kalagachia		

Phases & Options	Sowing Phase (Phase 1)	Vegetative Growth Phase (Phase 2)	Flowering to grain Maturity Phase (Phase 3)	Harvesting Phase (Phase 4)
Option 1	01 Jul -25 Jul	26 Jul - 29 Aug	30 Aug - 13 Oct	14 Oct - 07 Nov
Option 2	NA	01 Aug -04 Sep	05 Sep - 19 Oct	20 Oct - 13 Nov

[55] Data is provided by INGEN and the back-up weather station is the nearest government weather station that supplies certified weather data.

Cover Period	Phase 1	Phase 2	Phase 3	Phase 4
Index	Cumulative rainfall of consecutive 2 days along with continuous rainy days' rainfall			
Excess Rainfall Strike **(ERS 1)** in mm	150	175	175	75
Excess Rainfall Strike (**ERS 2**) in mm	15	15	10	10
Notional (Rs.)/ Phase	5	5	5	5
Cap on Single Day Rainfall	250	250	250	250
Excess Rainfall Count(ERC)/Phase	(Cumulative Rainfall of Consecutive 2 days – Strike 1) + Subsequent days' rainfall if it is > ERS 2			
Payoff / Phase	Sum of all ERCs for the phase X Notional			
Payoff for the Cover Period	Sum of Payoffs of all the phases			
Deductible Amount (Rs.)	250			
Total Payoff (Rs. / Acre)	Min [Max Sum Insured, Max {0, Payoff for the Cover Period - Deductible}]			
Max Sum Insured (Rs / Acre)	5000			
Premium (Incl. ST) / Acre	552			
Premium farmer share (Incl. ST / Acre)	138.00 (INR)			
Note: The counting for excess rainfall count will start from the first day of the phase. However, if there is a continuity of rainfall (for e.g. count starts at the end day of the phase and continuing to the next phase), it will be considered. Strike of phase in which continuity ends would be considered				

i. **Excess Rainfall Strike 1 (ERS 1) –** Excess Rainfall Strike is the level of rainfall up to which Paddy is expected to sustain without any significant impact on the yield. However, if the rainfall is more than this strike value, it can impact Paddy. Excess Rainfall Strike has been calculated by cumulating two consecutive days rainfall. The essence is to capture impact of intense rainfall causing water logging and plant wilting.

ii. **Excess Rainfall Strike 2 (ERS 2) –** Is the rainfall in subsequent days, which would magnify of unseasonal rainfall on the yield. It is generally observed that continuity of rainfall over a period of 4-5 days accelerates the crop loss and also creates conducive condition for disease attack. Continuity strike takes into account possible impact of continuous rainfall on the crop. In case the continuity of rainfall gets broken because of **one** day with rainfall less than the strike, it shall be ignored.

iii. **Excess Rainfall Count (ERC) –** If the cumulative two consecutive days' rainfall is more than the strike (ERS), it is expected that farmer would face a Paddy loss. The excess over strike would determine the extent of loss which farmer might have suffered due to excess rainfall. Excess Rainfall Count is thus, excess of rainfall over strike value suggested in the above table.

A4.1.2 Boro paddy (2010-11)

Boro paddy is insured against excess rainfall and high temperature. The details of the associated weather stations, insurance premium, payouts and trigger points are explained through the charts below.

Excess rainfall

Index	Cumulative rainfall of 2 consecutive days	
Max Sum Insured (Rs / Acre)	5,000	
Cover Period	Option 1	Feb 01 – May 01
	Option 2	Mar 01 – May 01
Strike (mm)	Strike 1	70
	Strike 2	5
Excess Rainfall Count1 (ERC 1)	Cumulative 2 consecutive days of rainfall – Strike 1	
Excess Rainfall Count 2 (ERC 2)	Subsequent days rainfall if it is >Strike 2 (gap of 1 day is allowed)	
Excess Rainfall Count (ERC)	ERC 1 + ERC 2	
Cumulative Excess Rainfall Count (CERC)	Sum total of all ERC's in the cover period	
Notional (Rs/CERC)	Option 1	24
	Option 2	24
SI (Rs. Per acre)	5000	
Premium (Rs) / Acre (Excluding S.T)	400	
Premium Rs. / Acre (Farmer's Share excluding service tax)	100	
Premium Rs/ Acre (Farmer's Share including service tax)	111	

Note: (1) Daily Rainfall is capped at 250 mm. (2) Break of 1 day in subsequent incidence is allowed and rainfall of the break day will be taken into count for calculation of ERC.

Extreme Temperature Cover

Extreme Temperature Index (ETI)		
Cove period	Option 1	Mar 01 – May 01
Index	Daily Average Temperature above the threshold	
Max Sum Insured / Acre	5,000	
Avg. Temp threshold	32.5^0 Celsius	
HDD (High Degree Days) count	Daily avg. temp over Threshold i.e. Max(0,day avg. temp – Avg. Temp Threshold)	
Cumulative HDD (T avg.)	Sum of all HDD count	
	Strike for HDD Count	Notional (Rs.) / HDD Count
Option 1	20	24
Payoff	(Cumulative HDD count – Strike for HDD count) * Notional	
SI (Rs. Per acre)	5000	
Premium (Rs) / Acre (excluding service tax)	400	
Premium Rs. / Acre (Farmer's Share excluding service tax)	100	
Premium Rs/ Acre (Farmer's Share including service tax)	111	

Note: Average Temperature would be average of max and min temperature of the day as per standard norms followed by Indian Meteorological Department

A4.2 Two-step IV on Aman paddy where input use is considered endogenous to insurance purchase decision

Table A4.1: Two-step IV to determine the impact of Aman input use on Aman insurance purchase decisions where input use is considered endogenous					
Variable (1)	**Stage 1 – Seed (2)**	**Stage 1 – Fertilizer (3)**	**Stage 1 – Pesticide (4)**	**Stage 1 – Labour (5)**	**Stage II – insurance (6)**
Aman seed type					-0.6452
					0.7166
Aman fertilizer					-1.7747**
					0.7778
Aman pesticide					-0.7050
					0.7411
Aman hired labour					0.0304*
					0.0181
Day of sowing	-0.1242***	0.0774***	0.0266	0.6812	
	0.0176	0.0151	0.0175	1.3941	
Input distance	0.0129	-0.0315***	-0.0421***	-1.4618**	
	0.0080	0.0060	0.0071	0.5727	
Lag costs: Fertilizers	-0.0001*	0.0002***	0.0004***	0.0214***	
	0.0001	0.0001	0.0001	0.0063	
Lag costs: Pesticides	0.0006	-0.0006	0.0029***	0.1067***	
	0.0005	0.0004	0.0005	0.0312	
MNREGA participation	-0.0775**	-0.0071	-0.0289	-5.3335**	
	0.0308	0.0255	0.0300	2.1670	
No. of crops grown	0.0253	0.0258	0.0441	4.4227	0.0557
	0.0269	0.0219	0.0277	2.9103	0.1077
Household size	0.0096	0.0163**	0.0089	-0.3597	0.0430
	0.0058	0.0052	0.0073	0.5451	0.0301
Livestock owned	-0.0168	-0.0354	0.0766**	-2.2396	0.0304
	0.0315	0.0261	0.0336	2.4635	0.1077
Risk aversion	-0.2394***	-0.1150**	-0.0807	1.0202	-0.3708
	0.0681	0.0572	0.0518	4.0205	0.3339
Diversification	0.1131***	-0.0318	-0.1251***	5.7599**	-0.2370
	0.0322	0.0269	0.0332	2.4938	0.1687
Land under crops	0.0003	0.0007	0.0111	7.2227***	-0.2069**
	0.0058	0.0043	0.0071	1.6797	0.0956
Year dummy (2012)	0.2831***	-0.5747***	-0.4972***	-11.6910***	-0.7594*
	0.0519	0.0420	0.0474	3.5636	0.4051
SHG membership	-0.0350	-0.0069	0.0558*	0.3842	0.1324
	0.0336	0.0285	0.0314	2.1832	0.1012
Cooperative affiliation	-0.0888	0.1306**	-0.0322	-2.5508	0.1803
	0.0762	0.0539	0.0577	4.4420	0.1636
Insurer trust	0.0274	0.0793***	0.0877***	2.0050	0.8530***
	0.0346	0.0304	0.0336	2.3136	0.1185
Boro insurance	-0.0181	0.0499	-0.0100	0.6027	-0.0598
	0.0410	0.0383	0.0410	3.1151	0.1280
Constant	0.4531***	0.7450***	0.0106	-21.8754**	1.8893*
	0.1250	0.1190	0.1183	10.4312	0.9744
Number of observations	756	756	756	756	756
F value	28.42	93.87	34.87	5.88	5.66
Prob >F	0.00	0.00	0.00	0.00	0.00
Centered R2	0.3131	0.5387	0.3299	0.3394	-4.1442

Table A4.1 continued**: Two-step IV to determine the impact of Aman input use on Aman insurance purchase decisions where input use is considered endogenous**					
Variable (1)	**Stage 1 – Seed (2)**	**Stage 1 – Fertilizer (3)**	**Stage 1 – Pesticide (4)**	**Stage 1 – Labour (5)**	**Stage II – insurance (6)**
Uncentered R2	0.5339	0.8261	0.5497	0.5529	-2.0008
Instruments validation					
Over identification test					
Hansen's J statistic					
Chi2 value					0.2140
P-value					0.6434

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust Standard errors appear below coefficients. Exogeneous determinants of inputs are as follows. Seeds are exogeneously determined using the day of sowing within the sowing month. Farmers that sow later are more likely to sow traditional seeds, as HYV seeds need to be sowed at the beginning of the season. Exogeneous determinants of fertilizers include distance to the nearest input source and lagged fertilizer costs aggregated at the block level. MNREGS participation is used to exogeneously account for hired labour, while lagged pesticides costs are used as instruments in the pesticide equation. Instrument validation tests confirm the relevance and orthogonality of the instruments.

A4.3 Boro paddy regressions

Table A4.2: Pooled OLS results for impact of insurance on input use for Boro paddy			
Variable (1)	**Seeds (2)**	**Irrigation (3)**	**Hired labour (4)**
Boro insurance	0.0487	0.2240*	9.5804*
	0.0402	0.1325	5.0857
Savings to finance seeds	0.1301***		
	0.0447		
Water pump		0.3757**	
		0.1547	
Labour availability			8.3122***
			3.0158
No. of crops grown	0.0767*	-0.3876***	-3.7408
	0.0414	0.1252	3.1455
Household size	-0.0003	0.0402	1.4783**
	0.0087	0.0274	0.7383
Livestock owned	-0.0379	-0.1035	-9.3590***
	0.0398	0.1063	2.8572
Risk aversion	0.2333***	-0.2724	18.3017***
	0.0772	0.1775	6.7303
Diversification	0.1192***	-0.0989	14.3837***
	0.0399	0.0879	2.5701
Land under crops	-0.0040	0.6382***	8.1938***
	0.0070	0.0648	1.8570
Year dummy (2012)	0.4926***	0.1618	-12.4603***
	0.0456	0.1026	2.4323
SHG membership	-0.0275	0.2082**	-4.5458*
	0.0386	0.0913	2.3532
Cooperative affiliation	0.0642	-0.0112	-7.5723
	0.0724	0.2144	5.1103
Constant	-0.1955	1.2789***	-8.9542
	0.1189	0.3085	9.2744
No. of observations	597	597	597
F value	27.76	37.71	10.72
R-squared	0.28	0.68	0.33

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust Standard errors appear below coefficients

Table A4.3: Two-step IV to determine the impact of Boro insurance on Boro input use where insurance is considered endogenous						
	Seed use		**Irrigation**		**Hired labour**	
Variable (1)	**Stage 1 – insurance (2)**	**Stage II (3)**	**Stage 1 – insurance (4)**	**Stage II (5)**	**Stage 1 – insurance (6)**	**Stage II (7)**
Boro insurance		0.2130**		0.4437*		14.2088
		0.0850		0.2624		10.0794
Insurer trust	0.4821***		0.4810***		0.4808***	
	0.0471		0.0474		0.0473	
Aman insurance	-0.1001**		-0.0986**		-0.1011**	
	0.0478		0.0481		0.0477	
No. of crops grown	-0.0978***	0.0917**	-0.0997***	-0.3667***	-0.0974***	-3.3208
	0.0319	0.0420	0.0322	0.1274	0.0318	3.2523
Household size	0.0139*	-0.0012	0.0138*	0.0391	0.0142	1.4494**
	0.0081	0.0088	0.0081	0.0267	0.0080	0.7204
Livestock owned	-0.0140	-0.0311	-0.0153	-0.0937	-0.0154	-9.1558***
	0.0354	0.0400	0.0353	0.1053	0.0354	2.7944
Risk aversion	-0.1104	0.2468***	-0.1042	-0.2568	-0.0989	18.5712***
	0.0749	0.0797	0.0696	0.1769	0.0701	6.8261
Diversification	-0.0037	0.1232***	-0.0035	-0.0939	-0.0040	14.4920***
	0.0352	0.0398	0.0352	0.0881	0.0352	2.6086
Land under crops	0.0236***	-0.0105	0.0231***	0.6298***	0.0233***	8.0152***
	0.0083	0.0076	0.0084	0.0650	0.0083	1.9023
Year dummy (2012)	0.0799*	0.4962***	0.0751*	0.1686*	0.0874**	-12.4705***
	0.0413	0.0461	0.0382	0.1013	0.0396	2.4296
SHG membership	0.0054	-0.0281	0.0057	0.2072**	0.0055	-4.5601*
	0.0362	0.0384	0.0363	0.0913	0.0364	2.3604
Cooperative affiliation	0.1468**	0.0244	0.1461*	-0.0633	0.1487**	-8.7027
	0.0742	0.0705	0.0751	0.2221	0.0744	5.6277
Savings to finance seeds	-0.0110	0.1329***				
	0.0422	0.0450				

Table A4.3 continued: **Two-step IV to determine the impact of Boro insurance on Boro input use where insurance is considered endogenous**						
	Seed use		**Irrigation**		**Hired labour**	
Variable (1)	**Stage 1 – insurance (2)**	**Stage II (3)**	**Stage 1 – insurance (4)**	**Stage II (5)**	**Stage 1 – insurance (6)**	**Stage II (7)**
Water pump			0.0140	0.3665**		
			0.0450	0.1504		
Labour availability					0.0227	8.0353***
					0.0349	2.8728
Constant	0.2394**	-0.2637**	0.2353**	1.1890***	0.2131**	-10.5758
	0.0988	0.1246	0.0970	0.3147	0.0984	10.1513
Number of observations	597	597	597	597	597	597
F value (overall significance of the regression)	21.16	28.64	21.19	34.42	21.80	10.56
Prob >F	0.00	0.00	0.00	0.00	0.00	0.00
Centered R2	0.2643	0.2640	0.2643	0.6847	0.2647	0.3296
Uncentered R2	0.4689	0.6104	0.4689	0.8807	0.4692	0.5342
Instruments validation						
Cragg-Donald Wald F statistic		68.8890		68.5420		67.1080
Underidentification test						
Anderson canon. corr. LM statistic						
Chi2 value/P-value	95.5620	0.0000	96.2120	0.0000	93.2120	0.0000
Over identification/validity of all instruments						
Hansen's J statistic						
Chi2 value/ P-value	0.0010	0.9716	0.1880	0.6644	2.1900	0.1389

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust Standard errors appear below coefficients. Exogeneous determinants of insurance include trust in the insurance provider and purchase of insurance for other crops (Aman). Instrument validation tests confirm the relevance and orthogonality of the instruments

Table A4.4: Two-step IV to determine the impact of Boro input use on Boro insurance purchase decisions where input use is considered endogenous				
Variable (1)	**Stage 1 - Seed type (2)**	**Stage 1 – Irrigation (3)**	**Stage 1 – Labour (4)**	**Stage II – insurance (5)**
Boro seed type				-0.0592
				0.5577
Boro irrigation				0.0275
				0.1730
Boro hired labour				0.0012
				0.0140
Savings to finance seeds	0.1494***	-0.0373	-2.8177	
	0.0430	0.1170	2.7425	
Water pump	-0.0562	0.3676**	-0.8011	
	0.0495	0.1587	4.7966	
Labour availability	-0.2090***	0.0006	9.0046***	
	0.0421	0.0927	3.3686	
No. of crops grown	0.0659	-0.3968***	-2.6380	-0.0799
	0.0417	0.1248	3.1381	0.0719
Household size	-0.0012	0.0448	1.5846**	0.0110
	0.0085	0.0283	0.7758	0.0294
Livestock owned	-0.0206	-0.1009	-9.5548***	-0.0031
	0.0389	0.1078	2.8349	0.1550
Risk aversion	0.1751**	-0.3177*	16.5255***	-0.1052
	0.0738	0.1855	6.1783	0.2696
Diversification	0.1108***	-0.0970	13.9758***	-0.0092
	0.0389	0.0886	2.3249	0.2473
Land under crops	0.0004	0.6397***	8.2935***	-0.0047
	0.0071	0.0646	2.0123	0.2111
Year dummy (2012)	0.4079***	0.2179*	-9.5073***	0.1204
	0.0524	0.1212	3.5868	0.1560
SHG membership	-0.0240	0.2128**	-3.9148*	0.0024
	0.0379	0.0910	2.2458	0.0594
Cooperative affiliation	0.0649	-0.0036	-6.9498	0.1569
	0.0697	0.2134	5.1080	0.0986
Insurer trust	0.1207***	0.2342*	10.0320	0.4683*
	0.0434	0.1400	6.6630	0.2474
Aman insurance	-0.0170	-0.0942	-9.3113	-0.0871
	0.0443	0.1217	6.2820	0.1633
Constant	-0.0345	1.3012***	-8.3204	0.1924
	0.1222	0.3184	9.7194	0.1768
No. of observations	597	597	597	597
F value	28.17	27.41	10.00	18.07
Prob >F	0.00	0.00	0.00	0.00
Centered R2	0.3256	0.6868	0.3321	0.2630
Uncentered R2	0.6430	0.8815	0.5360	0.4679

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust Standard errors appear below coefficients. Exogeneous determinants of inputs are as follows. Seeds are exogeneously determined using the source of financing. Exogeneous determinants of irrigation include usage of water pumps. Easy availability of human resources is used to exogeneously account for hired labour. Instrument validation tests are not provided since the model is exactly identified

Table A4.5: Durbin-Wu-Hausman test for exogeneity of insurance purchase and input allocation decisions for Boro paddy			
Case (i) Insurance is considered endogenous			
Particulars	**Insurance on Seed use**	**Insurance on irrigation**	**Insurance on Hired labour**
Durbin-Wu-Hausman			
Chi2 value	4.22**	1.28	0.00
P-value	0.04	0.25	0.97
Case (ii) Input is considered endogenous			
Particulars	**Seed use on insurance**	**Irrigation on insurance**	**Hired labour on insurance**
Durbin-Wu-Hausman			
Chi2 value	0.02	0.01	0.00
P-value	0.89	0.94	0.96

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10.

A4.4 Demand for labour under MNREGA scheme

Table A4.6: Household demand in Howrah for 2013													
S.No	**Block**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
1	Amta-I	265	2319	2827	462	0	1007	1068	917	1	0	0	0
2	Amta-II	2086	6101	4710	1306	107	742	1431	945	0	0	0	0
3	Bagnan-I	0	3372	2988	343	166	237	1339	1588	0	0	0	0
4	Bagnan-II	0	3104	1850	0	115	1038	958	1319	0	0	0	0
5	Bally-Jagacha	222	462	362	28	0	351	321	343	0	0	0	0
6	Domjur	12	451	189	25	0	509	546	463	0	0	0	0
7	Jagatballavpur	12	770	683	0	106	145	741	717	0	0	0	0
8	Panchla	23	212	8	135	0	52	100	82	0	0	0	0
9	Sankrail	161	263	0	0	0	70	274	380	0	0	0	0
10	Shyampur-I	235	3218	1915	234	164	777	530	396	0	0	0	0
11	Shyampur-II	40	5734	3218	367	6	0	1870	762	0	0	0	0
12	Udaynarayanpur	2327	8387	3282	1264	264	1031	1135	589	0	0	0	0
13	Uluberia-I	20	149	121	0	0	0	0	0	0	0	0	0
14	Uluberia-II	0	1394	1200	0	0	40	243	101	0	0	0	0
	Total	5403	35936	23353	4164	928	5999	10556	8602	1	0	0	0

Source: MNREGA website

Appendix for Chapter V

A5.1 Robustness check of the non-price effects of the first stage ordered probit model

Table A5.1: Robustness check of the non-price effects of the first stage ordered probit model			
Particulars (1)	Specification 1 (2)	Specification 2 (3)	Specification 3 (4)
Product literacy	0.3027*	0.3036*	0.3321**
	0.1614	0.1620	0.1643
Think poor	-0.2985*	-0.3014*	-0.3471**
	0.1649	0.1679	0.1648
Household size		-0.0966	-0.115
		0.1584	0.1587
Age		-0.0115	-0.0134*
		0.0075	0.0076
Risk aversion			-0.4928**
			0.2342
Start bid 1 (INR 1000)	0.5100**	0.4836**	0.5460***
	0.1999	0.2004	0.2019
Start bid 2 (INR 1500)	0.1703	0.1687	0.1863
	0.1947	0.1949	0.1957
Start bid 3 (INR 2000)	0.3790*	0.3827**	0.4273**
	0.1948	0.1941	0.1980
Start bid 4 (INR 2500)	-0.0456	-0.0417	-0.0407
	0.1953	0.1951	0.1954
Land 2	-0.1332	-0.1443	-0.173
	0.1624	0.1633	0.1628
Land 3	0.3599**	0.3663**	0.3363*
	0.1766	0.1793	0.1779
Land 4	0.7299**	0.7349**	0.6819**
	0.3029	0.3049	0.2985
Land 5	0.298	0.3386	0.315
	0.2759	0.2784	0.2826
Savings	-0.008	0.0135	-0.0381
	0.1316	0.1287	0.1306
Borrowings	-0.0756	-0.0648	-0.0994
	0.1211	0.1216	0.1220
Diversification (income)	-0.0344	-0.0141	0.037
	0.1634	0.1668	0.1646
Multiple crops	0.5486**	0.5280**	0.5571**
	0.2304	0.2343	0.2334
SHG/MFI member	-0.2998*	-0.2958*	-0.3017*
	0.1545	0.1556	0.1567
Mathematical literacy	0.3720**	0.3224**	0.3923**
	0.1571	0.1594	0.1612
Andhiyur	-0.7209***	-0.7594***	-0.7024***
	0.1700	0.1788	0.1840

Table A5.1 continued: **Robustness check of the non-price effects of the first stage ordered probit model**			
Particulars (1)	**Specification 1 (2)**	**Specification 2 (3)**	**Specification 3 (4)**
/cut1	-0.8516	-1.4802	-1.8887
/cut2	-0.3935	-1.0212	-1.4345
/cut3	0.8105	0.1896	-0.1902
No. of observations	398	398	397
Log pseudo likelihood	-402.2888	-400.8659	-393.6173
Pseudo R2	0.1666	0.1696	0.1806
Chi2	189.9471	189.8038	197.8095

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust standard errors are provided below coefficients. Specification 1 does not include risk aversion or household demographic variables. Specification 2 includes age and household size, Specification 3 also includes risk aversion. The base category for the land quintiles is 0-1.99 acres. Think poor and product literacy represent the exogenous determinants of WTJ. Variable 'start bid' is replaced by a set of dummies to completely control for the initial price at which the product is offered. The base category here is INR 3000. Results are similar to Table 5.3 presented in Chapter V.

A5.2 Non-parametric estimation (survival analysis) of the second stage Heckman model

Table A5.2: Second stage survival analysis estimates for willingness to pay of respondents who are *rather willing to join* the programme (WTJ==3)						
Particulars (1)	**Parametric**	**Non-parametric models**				
	Interval regression (2)	**Weibull (3)**	**Lognormal (4)**	**Loglogistic (5)**	**Gamma (6)**	**Exponential (7)**
Household size	-0.1702	-0.0293**	-0.0249	-0.0224	-0.0251	-0.2517
	0.1202	0.0150	0.0173	0.0153	0.0172	0.2191
Age	0.0029	0.0002	0.0004	0.0005	0.0004	0.0048
	0.0037	0.0005	0.0005	0.0005	0.0005	0.0079
Risk aversion	0.2314*	0.0273	0.0346*	0.0340	0.0343*	0.3286
	0.1364	0.0196	0.0198	0.0214	0.0197	0.2444
Start bid	0.0004***	0.0001***	0.0001***	0.0001***	0.0001***	-0.0003***
	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
Acres of planted area	0.0515***	0.0092***	0.0072***	0.0060**	0.0073***	0.1231***
	0.0185	0.0030	0.0027	0.0028	0.0027	0.0386
Savings	-0.2249***	-0.0289***	-0.0341***	-0.0357***	-0.0338***	-0.3790***
	0.0709	0.0106	0.0102	0.0111	0.0102	0.1292
Borrowings	-0.1705*	-0.0253**	-0.0247*	-0.0285*	-0.0245*	-0.2381
	0.0957	0.0120	0.0141	0.0148	0.0139	0.1494
Diversification (income)	-0.2378**	-0.0258*	-0.0348**	-0.0413***	-0.0341**	-0.2753
	0.1114	0.0138	0.0161	0.0160	0.0160	0.1977
SHG/MFI member	0.0020	-0.0010	0.0001	0.0022	-0.0001	-0.0321
	0.0967	0.0120	0.0140	0.0146	0.0139	0.1845
Multiple crops	-0.0217	-0.0324	-0.0055	0.0119	-0.0071	-0.2878
	0.2508	0.0306	0.0366	0.0347	0.0364	0.3955
Andhiyur	-0.6479***	-0.0914***	-0.0910***	-0.0982***	-0.0904***	-1.0497***
	0.1456	0.0212	0.0213	0.0200	0.0211	0.2887

Table A5.2 continued: **Second stage survival analysis estimates for willingness to pay of respondents who are *rather willing to join* the programme (WTJ==3)**						
Particulars (1)	**Parametric**	**Non-parametric models**				
	Interval regression (2)	**Weibull (3)**	**Lognormal (4)**	**Loglogistic (5)**	**Gamma (6)**	**Exponential (7)**
Mills ratio (WTJ=2)	0.0093	0.0172	-0.0008	-0.0038	-0.0002	0.1444
	0.1387	0.0191	0.0203	0.0201	0.0203	0.2356
Constant term	6.7116***	1.9545***	1.9077***	1.9051***	1.9090***	2.8918***
	0.2716	0.0486	0.0395	0.0385	0.0398	0.6286
sigma/p/gamma/alpha	-1.2082***	3.0647***	-3.1345***	-3.7692***	6.2557***	
	0.1349	0.1421	0.1339	0.1488	0.2701	
No. of observations	134	134	134	134	134	134
Log pseudo likelihood	-79.5584	-85.8494	-82.0318	-80.1173	-82.2502	-168.7099
Chi2	297.8688	177.9575	267.4989	277.6760	262.5806	105.2737
AIC	187.1168	199.6988	192.0636	188.2346	192.5003	363.4197
BIC	227.6865	240.2686	232.6334	228.8044	233.0701	401.0916

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust standard errors appear below coefficients. These results are based on Specification 3 of Table 5.5, which includes age, household size and risk aversion variables. Findings are similar to the parametric model estimated using interval regression. The AIC/BIC criterion indicate that the loglogistic distribution is the best fit among the survival regression models

Table A5.3: Second stage survival analysis estimates for willingness to pay of respondents who are *definitely willing to join* the programme (WTJ==4)

Particulars	Parametric	Non-parametric models				
(1)	Interval regression (2)	Weibull (3)	Lognormal (4)	Loglogistic (5)	Gamma (6)	Exponential (7)
Household size	-0.0101	-0.0014	-0.0015	-0.0022	-0.0014	-0.0372
	0.0405	0.0057	0.0054	0.0054	0.0054	0.1340
Age	-0.0001	0.0001	0.0000	-0.0001	0.0000	-0.0103
	0.0023	0.0003	0.0003	0.0003	0.0003	0.0087
Risk aversion	-0.1471**	-0.0289***	-0.0200**	-0.0134	-0.0203**	-0.5213**
	0.0710	0.0101	0.0096	0.0089	0.0096	0.2447
Start bid	0.0002***	0.0000***	0.0000***	0.0000***	0.0000***	-0.0008***
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
Acres of planted area	0.0205***	0.0024**	0.0026***	0.0028***	0.0026***	0.0951***
	0.0068	0.0011	0.0009	0.0009	0.0009	0.0309
Savings	-0.0516	-0.0127**	-0.0070	-0.0047	-0.0072	-0.1815
	0.0376	0.0052	0.0050	0.0048	0.0050	0.1310
Borrowings	-0.0871**	-0.0089	-0.0117**	-0.0105*	-0.0116**	-0.2193
	0.0414	0.0060	0.0056	0.0056	0.0056	0.1384
Diversification (income)	0.0484	0.0037	0.0064	0.0080	0.0064	0.1643
	0.0434	0.0062	0.0058	0.0060	0.0058	0.1715
SHG/MFI member	-0.0060	0.0049	-0.0007	-0.0039	-0.0006	0.0026
	0.0438	0.0071	0.0058	0.0054	0.0059	0.1540
Multiple crops	0.1991***	0.0284***	0.0270***	0.0181*	0.0271***	0.4082**
	0.0760	0.0100	0.0104	0.0106	0.0104	0.2001
Andhiyur	-0.6758***	-0.0820***	-0.0930***	-0.0969***	-0.0926***	-1.2510***
	0.0794	0.0116	0.0109	0.0107	0.0109	0.2247
Mills ratio (WTJ=3)	0.1539*	0.0220	0.0212*	0.0167	0.0213*	0.5140*
	0.0927	0.0137	0.0125	0.0131	0.0125	0.2980
Constant term	7.0429***	1.9544***	1.9544***	1.9662***	1.9544***	3.9893***
	0.1629	0.0220	0.0218	0.0233	0.0219	0.5991

Table A5.3 continued: **Second stage survival analysis estimates for willingness to pay of respondents who are *definitely willing to join* the programme (WTJ==4)**						
Particulars (1)	**Parametric**	**Non-parametric models**				
	Interval regression (2)	**Weibull (3)**	**Lognormal (4)**	**Loglogistic (5)**	**Gamma (6)**	**Exponential (7)**
sigma/p/gamma/alpha	-1.7362***	3.8643***	-3.7522***	-4.3738***	7.5064***	
	0.1070	0.0936	0.1118	0.1258	0.2228	
No. of observations	176	176	176	176	176	176
Log pseudo likelihood	-138.8770	-151.7083	-140.2570	-137.0403	-140.5134	-419.1045
Chi2	597.1557	372.6120	570.0993	752.2742	566.9501	104.1782
AIC	305.7539	331.4166	308.5141	302.0805	309.0268	864.2089
BIC	350.1407	375.8034	352.9009	346.4673	353.4135	905.4252

Note: ***Significant at P<0.01. **Significant at P<0.05. *Significant at P<0.10. Robust standard errors appear below coefficients. These results are based on Specification 3 of Table 5.5, which includes age, household size and risk aversion variables. Findings are similar to the parametric model estimated using interval regression. The AIC/BIC criterion indicate that the loglogistic distribution is the best fit among the survival regression models