Insuring disaster: A study of weather index-based insurance in developing world agriculture

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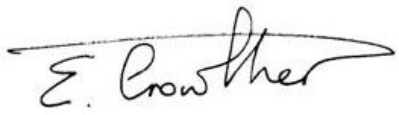

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Abstract

Agriculture in the developing world is inherently risky. The methods traditionally used by poor farmers to manage this risk help to lock them into poverty. Drought is a particular type of shock which cannot be countered using 'traditional' risk management strategies. The problem of covariate risk in drought-stricken regions poses unique challenges to attempts to solve the problem. The failure of 'conventional' crop insurance, and the problems associated with post disaster aid are examined. Drought insurance is presented as a response to these problems, and as an interesting product of recent financial liberalisation and innovation. The structure of drought insurance schemes is examined, with reference to two recent projects in Malawi and Ethiopia. Finally, the study synthesises the recent experimentation with drought insurance with experiences of disaster insurance from the developed world. The result is sobering, suggesting that even in regions with relatively high levels of wealth, and no financial market failures, the take up of even basic types of insurance can be much lower than the optimal predicted by rational economic behaviour. Secondly, the issue of inequalities that might arise, or be exacerbated by, the introduction of drought insurance, is looked at.

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Introduction

This study focuses on drought insurance and its suitability to and application in developing country agriculture. It aims to outline the basic principles of drought insurance, and examine the ways by which it can be used to improve the lives of poor farmers in developing countries. This study is also interested by the ways by which a financial innovation born in the deregulating financial and energy markets of the West in the 1980s and 1990s 'filtered into' development thinking and has been applied to agricultural situations in the developing world.

The study begins with an examination of the basic problem – that of widespread risks inherent in agriculture – and summarises the approaches that can be used to counter these risks. Traditional coping strategies are outlined, and noted as costly and problematic. The perceived failure of 'conventional' crop insurance is then examined – an exercise which is particularly illuminating as its 'fatal flaws' are those which drought insurance has been used to 'fix'. Thirdly food aid is looked at, as a commonly used tool to manage the effects of drought.

These three types of drought risk management are found wanting in some respect, and the study moves into a discussion of the design of drought insurance schemes, with reference to two schemes in Ethiopia and Malawi, run by the WFP and World Bank respectively. The 'technical' problems of drought insurance schemes – weather data and basis risk – are discussed.

Finally, focus is turned onto the potential problems that may hinder broader application of drought insurance in the developing world. These are primarily the 'psychology' of the insurance decision and the potential negative outcomes of providing drought insurance for increasing existing inequalities.

Limitations

It quickly became apparent when compiling this study that a deep, objective analysis of drought insurance would be difficult, owing to both the novelty of drought insurance as a risk control mechanism, and the almost complete monopoly over the literature exercised by those individuals and organisations advocating it.

The relative novelty of drought insurance means that to date, there has been insufficient time for the long term results of drought insurance to be fully assessed, nor for those results to filter through into the literature. With regard to the 'monopoly' held over the literature by the advocating organisations, this study highlights only the fact that it is therefore difficult to form any kind of objective, third party view on the impact of drought insurance. For example, the only 'voices' from the Malawian example are 'heard' via the World Bank's literature. The monopoly over the literature is particularly

important given the 'selective learning' that development organisations are often accused of[1].

With these factors in mind, the study chose instead to synthesise the available material with work done on insurance (especially disaster insurance) in the developed world.

[1] See for example '*Organizational learning in NGOs: What have we learned?*' by Michael Edwards, 1997. Though a detailed discussion of 'selective learning' is beyond the scope of this study, the theory suggests that NGOs (and other types of development organisation) have strong incentives to 'cherry pick' lessons from positive examples, while tending to ignore the negative.

The problem

The uncertainty/risk distinction

It is necessary first to make a distinction between *risk* and *uncertainty*, which some authors in this field use interchangeably. *Risk* is defined as 'a form of uncertainty where, while the actual outcome of an action is not known, it is expected that it will be determined as the result of a random drawing from a set of possible outcomes whose distribution is known' (Oxford Dictionary of Economics, 1997, 406). The dictionary notes wryly that 'where this information [about the distribution of outcomes] is supposed to come from is usually not discussed' (ibid). *Uncertainty* is defined as 'a consciousness of lack of knowledge about present facts or future possibilities. This is the normal condition of the human race, not only in economics… Uncertainty covers cases where the frequency distribution of events is unknown' (Oxford Dictionary of Economics).

Insurance is one of the chief *informational* and *financial* methods use to control risk. The distinction is important here as it must be recognised that insurance, in the absence of known probability distributions, can do nothing about uncertainty.

At the broadest level, then, this is a study of how uncertainty in agriculture can, through the use of information gathering, be transformed into risk, and how this risk is subsequently managed.

Agriculture and its risks

Agriculture everywhere is pervaded with risk – more so in the developing world. This is because two of the primary inputs – sunlight and water – are still largely beyond the control of mankind. In addition, its locations of production are generally exposed to the elements and therefore subject to extremes of climatic variation (wind, frost etc) which may damage or destroy output. To summarise, 'the majority of agriculture in developing countries remains highly susceptible to extreme, uncontrollable weather events that can severely impact both quality and yield of a crop' (Bryla and Syroka, 2007, pg. 1)

These variations in inputs and climate can be controlled to a certain extent: irrigation and other forms of water storage and management are the most obvious example. 'Cloud seeding' to try and induce rainfall is another. Forms of protection for exposed crops, such as tubular plastic tents, are widely used in developed world agriculture. There have been experiments with orbiting solar mirrors to provide increased or even 24 hour sunlight to chosen regions. All these methods are direct, *technical* means of reducing the uncertainty of agricultural production, and are beyond the scope of this study. Instead, this study focuses on the *informational* and *financial* means of quantifying, controlling and transferring risk.

The deleterious effects of risk on developing country agriculture

What is the rationale for reducing the risk inherent in agriculture in developing countries? On a macro-level, it is obvious that agriculture forms a major part of the income of many low-income developing countries. Secondly, a majority of the population of many developing countries is employed in agricultural activities. Consider for example these statistics from the USDA: 'Of the 148 countries that are currently members of the WTO, two-thirds of them are developing countries. A large number of these countries, especially the least developed, relied on agriculture for as much as 30 percent of their gross domestic product (GDP) in 2001. From 2003 to 2004, agriculture employed more than 50 percent of the workforce in developing countries' (USDA, 2005) Therefore mechanisms which could be utilised to reduce uncertainty and control risk in agricultural production will have a large positive impact on global welfare.

On a micro-level, the reaction of the poor to the uncertainties of agricultural production has been well-documented by numerous agricultural economists. Nieto sums it thus: 'The poor have little access to the risk-minimisation methods used by others. They therefore seek to avoid risk by minimising their exposure to it. In the case of small-holder farmers, this means minimising investment in the main risk they confront, growing a crop, such as not applying fertiliser to it. Although risk is lessened, the potential to generate profit is also lessened. Risk avoidance is thus inefficient and using it locks small-holders into poverty' (Nieto, 2003, pg. vii). This poverty is reflected most broadly (i.e. taking into account subsistence farmers who do not market the bulk of their crop) by a lack of *food security*. Another major factor is the link between risk and access to credit, as 'confronted

with risky borrowers, lenders must seek to reduce the possibility of poor loan recovery rates in unfavourable years, even if this means only modest levels of lending to agriculture' (Skees, 1999, pg. 4)

Drought

If the risks inherent in developing country agriculture under 'normal' circumstances were not enough, many regions of the developing world also face extreme forms of risk in the shape of natural disasters. The effects of natural disasters on development cannot be understated. A recent UNDP report focused on the staggering economic losses associated with natural disasters in the developing world, and stated that they pose a serious obstacle to achieving the Millennium Development Goal of halving extreme poverty by 2015. Furthermore, the UNDP pointed out that '85 percent of the people exposed to earthquakes, tropical cyclones, floods and droughts live in countries having either medium or low human development' (UNDP, 2004, pg 5)

Tackling *the effects* of drought is the key focus of this study. Drought is a type of natural disaster which reduces or completely removes available water, one of the key agricultural primary inputs. This often has devastating effects on farmers in the developing world, who already face difficulties in agricultural production under 'normal' circumstances. For example, a study by the World Bank in India showed that natural disasters (drought chief among them) were by far the most important shocks facing farmers in the study area (Gine, 2005, pg. 6)

The ‘shock’ of a drought on the poor is of especial importance to this study. By definition, the poor have few financial reserves with which to meet shocks, and in extreme cases ‘shocks can be so frequent that, even if the costs of each is low, poor people often fall into a never-ending cycle of responding to crisis after crisis, such that they never manage to stay above poverty’ (ADA, 2007, pg. 1)

Owing to the limited scope of this study, droughts are treated here as ‘acts of god’ – i.e. outside anyone’s control. However, it is worth recognising that there are arguments suggesting that droughts are affecting more people globally, as population pressures force people onto what was previously deemed sub-optimal agricultural land, and that the frequency and severity of droughts may be exacerbated by climate change. A neat summary of these arguments is provided by Pandya and Mitchell: ‘Loss in [*sic*] lives and livelihood as a result of disasters have been increasing. Various dynamics associated with globalisation are responsible for this increase in the frequency and magnitude of disaster occurrence. On one hand, climate change is increasing the frequency of disasters; poverty resulting from local and international policy factors on the other hand are increasing poor peoples’ vulnerability to disasters…’ (Pandya and Mitchell, 2006, pg. 1) An upward trend in economic and insured losses owing to natural catastrophes over the past 50 years ‘is likely [to] continue into the future due to the higher concentration of population and built environment in areas susceptible to natural hazards worldwide’ (Freeman, 1997, pg. 160)

Though a critical examination of these arguments is outside this study's remit, they suggest that effective means of tackling the effects of drought (and other natural disasters) will become even more important in the future. The UNDP summarises: 'the global community is facing a critical challenge: How to better anticipate — and then manage and reduce — disaster risk by integrating the potential threat into its planning and policies' (UNDP, 2004, pg 5)

The inadequacy of traditional coping strategies in the face of drought

In this section, the various 'traditional' coping strategies employed by the poor will be examined. It will quickly become apparent that these strategies have severe drawbacks when employed in the face of a drought situation.

Gautam et al (1994) focus on the phenomenon of drought, and the variety of coping strategies employed by the poor: 'Some of these are primarily risk-reducing in nature (e.g. income diversification, intercropping, farm fragmentation and seasonal migration), while others are coping devices designed to protect consumption once income losses have occurred (e.g. borrowing from local money lenders, drawing down food stocks, selling assets and participating in government relief programs)' (Gautam, 1994, pg. 1)

The risk-reducing nature of some of these coping strategies has already been mentioned above, and it was noted that these risk-reducing strategies also helps to 'lock' smallholder

farmers into poverty, as it reduces the opportunities for greater income via increasing specialisation or more intensive use of inputs. The study will now turn to the 'consumption protection' devices that Gautam alludes to, including borrowing, drawing down food stocks, selling assets and so on.

The first problems are the obvious costs associated with these consumption protection devices – borrowed money must be repaid with interest, sold assets may have to be repurchased at a higher price and so on. But the second, and probably more important, set of problems are those associated with covariate risk. 'This feature of drought damage' says Gautam (1994), 'the simultaneous effect on most households within a region – is an important limitation on many traditional risk management strategies'.

Gautam notes how for example simultaneous demand for credit in times of drought raises local interest rates, or how widespread sale of assets depresses prices. Furthermore, other strategies, such as diversification, are similarly rendered ineffectual by the presence of covariate risk. For example, the practice of income diversification will be useless if (in a primarily agricultural region) other sources of income dry up as the region's economy is affected by the drought, 'since many of the sources of the diversified portfolio of income remain tied to the well-being of farming in the community, any shocks that hurt the local agricultural output can place the diversified income of the rural poor in jeopardy' (Skees, 2002, pg. 3)

To overcome the covariate risk problem, then, 'requires risk-sharing mechanisms that cut across regions that do not experience drought simultaneously' (Gautam, 1994, pg 1). Given the huge geographic regions that drought often strikes, this may mean, in practice, risk-sharing mechanisms that cross international boundaries.

Given the inadequacies of traditional coping mechanisms, it is therefore desirable to provide some form of risk management strategy to the rural poor that not only a) has fewer associated costs than 'traditional' strategies, but also b) reduces or eliminates the covariate risk problem by transferring risk outside the region to be insured.

Crop insurance

For some time in the 1980s, the focus was on crop insurance as a means of controlling agricultural risk in developing countries. Crop insurance is a fairly 'conventional' form of insurance in which the premium is based on the estimated probability of the loss occurring, and the total expected loss. However, it quickly became apparent that crop insurance had a number of fatal shortcomings in the context of developing country agriculture. Articles with titles like '*Area-yield crop insurance reconsidered*'[2] from the early nineties chart the way in which the optimism placed in crop insurance faded. A short discussion of the failings of crop insurance is necessary to highlight the perceived benefits of drought insurance, and the way in which drought insurance was developed as an alternative.

[2] Miranda, 1991

Various contemporary authors on the topic (e.g. Gautam, 1994) note that there have been very few, if any, successful examples of crop insurance – with success defined as a lack of reliance on government subsidies to a high degree. In this definition, 'success' is essentially synonymous with commercial viability, or what Miranda calls an 'actuarially sound basis' (Miranda, 1991, pg. 233) – i.e. a subjective usage which focuses only on the scheme's performance as a risk-reducing mechanism. Clearly, a crop insurance scheme operating under heavy subsidy may be highly 'successful' in disbursing funds to drought-stricken farmers, with corresponding social welfare gains that are without question laudable. But by combining insurance with a large degree of government subsidy, it cannot be deemed a 'successful' insurance scheme in terms of commercial viability (or actuarial soundness), and such a scheme would raise questions about financial sustainability in the long term and '…further, [the use of] public funds to support crop insurance is also questionable since these funds likely have a higher return when used for other purposes[3]' (Skees, 2002, pg. 8)

Gautam (1994, Appendix A) lays down four conditions that must be met for crop insurance to be 'successful' (i.e. commercially viable) as a risk-management strategy for agriculture in developing countries.

1) The likelihood of the event must be quantifiable, with good actuarial data.

2) The damage caused must be easy to attribute and value.

3) Absence of moral hazard (i.e. damage or likelihood cannot be affected by insured person's behaviour)

[3] Among the theorists on the topic, Skees was perhaps the harshest critic of crop insurance, writing elsewhere that 'the financial experience with publicly provided […] crop insurance has been disastrous' (Skees, 1999, pg. 7)

4) The event should not occur so frequently that farmers cannot afford the premium.

With respect to these four conditions, it is easy to see why, by and large, crop insurance programmes have not succeeded in the developing world.

1) Weather data is often poor and/or incomplete in many developing countries – especially with regard to the highly accurate data which is needed to build actuarial models. It must be noted in fairness to crop insurance that this is a problem shared with its successor, drought insurance, and a further discussion of these data-related problems will be given below.

2) Inspecting and attributing damage can be so expensive in the case of small-scale developing world farmers as to render administration costs (and therefore premiums) impossibly high. There is a need with crop insurance for 'significant monitoring and some form of farm level inspection to verify crop losses… [which is] cost prohibitive for a private firm' (Skees, 2002, pg. 8)

3) Moral hazard is another major problem – there are many ways in which farmers could affect either the probability of damage or the total loss, for example by failing to take adequate precautions, and like all such insurance schemes it would be open to simple fraud.

In addition, crop insurance suffers from the added problem of 'adverse selection', in which high-risk farmers would be more likely to insure themselves. 'The failure of... crop insurance programs to operate on an actuarially sound basis can be attributed to the problems inherent in trying to tailor coverage to individual yield-loss experience. The

most serious of these problems, adverse selection, arises because producers are better informed about the distribution of their own yields and thus better able to assess the actuarial fairness of their premiums than the insurer...' (Miranda, 1991, pg. 233)

Disaster aid

The third potential solution which must be examined with respect to drought is *post hoc* disaster aid, which is a common response to natural catastrophes from both national governments and the international community. The form which this aid can take varies widely, from food aid distributed across disaster hit regions, to cash handouts or even forms of debt forgiveness.

An in-depth analysis of the forms and effectiveness of various types of direct, *post hoc* disaster aid is beyond the scope of this study. Rather, this study will suggest that post hoc disaster aid suffers from a number of key drawbacks in the context of droughts in the developing world.

Firstly, it could be described as a 'binary' solution – either it is forthcoming, or it is not. In this way, it does not easily allow a graded response to natural disasters of varying severity. This is linked to the problem with defining exactly what constitutes a natural disaster. Skees outlines this dilemma, and suggests that 'governments should define disaster and catastrophe within the context of frequency as well as severity. For example, it would be a mistake and very expensive to have government intervention too frequently. The infrequent events that create serious problems may require some level of intervention, such as free disaster aid. Those events that are more frequent but still cause serious losses

may be more appropriately left to the private sector insurance markets' (Skees, 2002, pg. 2) He also notes that international disaster aid is more forthcoming for certain types of natural disaster – specifically the more obviously catastrophic disasters like hurricanes and earthquakes – and is often 'not as forthcoming when the natural disaster is a slowly developing drought' (Skees, 2002, pg. 2)

A second avenue of critique, especially in light of this study's focus on insurance, centres on the incentives that disaster aid (or the expectation thereof) creates. 'Economists are rightly concerned with the incentives embedded in free disaster aid… When households grow to expect government compensation for natural disaster losses, they will take on additional risks. If they do not bear the consequences of risky decisions, they will engage in activities that expose them to still more risks' (Skees, 2002, pg. 9)

Though these incentive effects cannot be dismissed out of hand, it is worth noting that the evidence to support these risk-increasing incentives effects comes almost exclusively from agriculture in the US. There is little evidence that poor farmers in the developing world increase their exposure to risk in the expectation of receiving disaster aid in the event of a natural catastrophe. Furthermore, other authors on disaster aid and incentives call these incentives into question, stating that (of US homeowners in earthquake zones) 'few are aware of federal aid, among [both] the insured and uninsured' (Kunreuther, 1978, pg. 235)

These informational problems are of great interest to this study, and will be examined in greater detail later.

Drought insurance

Drought insurance is a form of insurance that can be used to manage the risk of deficient rainfall. It is often also termed 'rainfall insurance'[4]. It has even been referred to as 'hunger insurance' (Linnerooth-Bayer, 2005, pg. 1045)

Origins

Drought insurance began to be touted in the mid 1990s as a 'response to the unsatisfactory experiences with crop insurance [from the 1950s to the 1980s]' (Mishra, 1996, pg. 273). The impetus for the innovation was 'born in the creative crucible that was the rapidly deregulating US energy sector of the 1990s. The break-up of regulated, often state-run, monopolies in electricity and gas supply was bringing a whole new approach to risk – and radical new thinking as to how that risk could be managed' (Nicholls, 2004) It was made possible by 'advances in computerized modelling… progress in the mathematics of extreme value theory and in the convergence of the theories of finance and insurance, rendering possible the pricing of exotic risk-transfer instruments such as weather derivatives and catastrophe bonds' (Linnerooth-Bayer, 2005, pg. 1045). Initially, weather risk trading was confined to the US energy market, but it was quickly recognised that it could be put to broader use. It was not long before weather risk trading began to influence US and European agriculture, and at some point it filtered into development thinking.

[4] Some authors claim there is a difference between the two. Mishra, for example, defines drought insurance as only insuring against deficient rain, whereas rainfall insurance insures against both deficient and excessive rainfall (Mishra, 1996, pg. 272). This study will utilise the term 'drought insurance', as its examples are in areas prone to deficient rainfall only.

More broadly, drought insurance can be situated firmly within the recent development of what Robert Shiller calls a 'New Financial Order', in which financial markets will be used to control a far greater amount of risk than is currently the case. Envisaging a world of 'democratized' finance, Shiller outlines his ideas of financial markets controlling huge amounts of risk, 'Our fundamental risks will thus be insured against, hedged, diversified, making for a safer world.' (Shiller, 2003, Ch. 1) In this 'New Financial Order', drought insurance is but one means by which natural disaster risk might be controlled in the developing world. Skees also lists catastrophe ('cat') bonds, insurance, exotic options and other derivative financial instruments as means of managing and sharing natural disaster risk (Skees, 2002, pg. 10)

The nature of drought insurance

Hazell provides a succinct description of the basic principle behind drought insurance: 'the producer… hedge[s] against excessive or inadequate rainfall by placing a 'bet' on the adverse situation against which he is seeking to hedge' (Hazell, 1986, pg. 164) The contract is based on a local weather index (in the case of drought insurance, rainfall), and is therefore a 'parametric' form of insurance, i.e. triggered by the occurrence (or non-occurrence) of an event[5]. 'The outcome of purchasing the risk transfer instrument is to limit the adverse impact of weather on the buyer's economics and to finance the

[5] The strict definition of a parametric financial instrument: Payment is tied to a statistic whose probability distribution can be estimated and the event can be measured (e.g. rainfall – or lack thereof – earthquakes, winds etc)

consequences of adverse weather conditions when and if they take place' (WRMA website, 2007)

Unlike crop insurance, there is no direct link to agricultural output. Instead, 'indemnifications are triggered by pre-specified patterns of the index, not by actual yields. This reliance on factors beyond the control of farmers reduces the occurrence of moral hazard and adverse selection' (Bryla and Syroka, 2007, pg. 3)

This reduction of moral hazard and adverse selection is one of the key benefits over 'traditional' crop insurance. Moral hazard is all but eliminated as the insured have no control over the index event in question, and there is no financial 'loss evaluation' (against which as traditional crop insurance settlement would be judged) that can be affected by individual behaviour. Similarly, the problem of adverse selection is avoided as it is irrelevant (from the point of the insurance scheme) whether it is 'high' or 'low' risk farmers that purchase the drought insurance.

Furthermore, as advocates of the scheme point out: 'it also eliminates the need for field visits, which speeds up claim settlement and significantly reduces costs' (Bryla and Syroka, 2007, pg. 3) It will be remembered from the discussion of 'traditional' crop insurance that expensive farm visits and damage verification was one of the key factors behind the failure of those schemes. Eliminating the need for such inspections keeps costs low and helps make the insurance more affordable to the poor.

Involving international capital and reinsurance markets

A final important point about drought insurance is that it can be reinsured on the global weather risk markets far more easily than crop insurance, 'effectively transferring the risk from [the developing country] to the international reinsurance and capital markets' (Hess and Syroka, 2005, pg. ix) This is an important factor in reducing (though not entirely eliminating) the problem of covariate risk that bedevils many insurance schemes.

It is worth briefly examining why the international capital markets should have any interest in reinsuring developing country drought risk at all. From an insurance perspective, 'the new risks and locations, introduced by the new countries, allow for more diversification and hence enhance the risk/return characteristics of portfolios' (Hess and Syroka, 2005, pg. ix). For example, 'a risk taker who has… accumulated weather exposures around Chicago, may be able to sell a portion of these exposures to a counterparty who is looking for Chicago exposures or to exchange a portion of these exposures for weather exposures in South Africa, Belgium or Japan in order to diversify its business' (WRMA website, 2007). This is very much in line with Shiller's theory of the development of 'macro risk pooling', as was discussed earlier.

Having examined the benefits of drought insurance over its predecessors, the study will now examine the design of a typical drought insurance scheme in a developing country context. This is important because it is from examining the design of a drought insurance scheme that some of its potential problems become apparent.

The design of a drought insurance scheme

The study will examine the design of typical drought insurance schemes in developing countries, with particular reference to the WFP pilot in Ethiopia.

Project objectives

The WFP pilot used a weather derivative to 'demonstrate the feasibility of establishing contingency funding for an effective aid response [in the event of a drought]' (Syroka, 2006). The objectives of the project were: to develop a rainfall index for Ethiopia; to put in place a small derivative contract, thereby demonstrating the feasibility of transferring LDC weather risk to the international market; to enable price discovery for Ethiopian weather risk on the international markets and to explore the processes necessary for ex-ante risk management in LDCs.

In order to do this, it was necessary to 'index drought risk to an objective, independent variable that proxies the risk farmers face' (Syroka, 2006). In the case of the Ethiopian pilot project, the independent variable is rainfall, though more generally 'a weather index can be constructed using any combination of measurable weather variables, over any period of time and any number of weather stations that best represent the risk to the agricultural end user' (Bryla and Syroka, 2007, pg. 3).

The importance of weather data

The next step after identifying a variable is assessment of weather data. Almost all authors on the subject identify the need for at least 30 years of 'clean and internally consistent' weather data to 'allow for a proper actuarial analysis of the weather risks

involved' (Bryla and Syroka, 2007, pg. 6). Such data is an 'absolute necessity' for the valuation of a weather index (Clemmons, 2000, pg. 35).

Equally important to the historical record is of course 'reliable and trustworthy on-going daily collection and reporting procedures (of weather data)' (Hess and Syroka, 2005, pg. 53). Ideally, these should be 'automated stations that report daily to the GTS – the World Meteorological Organization's Global Telecommunication System' (ibid).

A third and rather interesting requirement is the need for independent verification of the data. This is necessary to avoid the 'obvious potential for moral hazard when writing insurance contracts settled on data collected from ground-based observatories' (Hess and Syroka, 2005, pg. 53). This problem was identified early on by authors such as Hazell: 'there could be difficulties in measuring the cumulative rainfall over the specified period if large numbers of local people have an interest in a low reading' (Hazell, 1994, pg. 40). It is hard to decide whether to read either an element of the farcical or of paranoia into the following thought: 'guarding the weather stations… [would be] expensive, nor would it necessarioly [sic] be successful since the guards might acquire a financial interest themselves…' (ibid) In the case of the WFP pilot project, rainfall data collected on the ground was verified by the US company MDA Federal, suppliers of satellite data, who 'ensure[d] the accuracy of the rainfall numbers' (Lacey, 2006)

It is important to note that without such data, weather index insurance may not be possible – an obvious barrier to implementation in a number of LDCs, especially those

that have suffered recent conflict or civil unrest. A DFID report on meteorology in Africa, for example, noted that 'the density of weather watch stations in Africa is eight times lower than the minimum level recommended by the World Meteorological Organisation, and reporting rates are the lowest in the world… Data deterioration is a further pressing problem, with many irreplaceable records currently at risk' (DFID, 2005, pg. 18). With reference to Zambia (as an example country in Southern Africa), 'severe under-funding of the Zambian Meteorological Office… has resulted in large data gaps and poor reporting quality from its weather stations network. Furthermore, the spatial coverage of the rain-gauge network (across Southern Africa)… may not be sufficient to fully represent each country's risk profile' (Hess and Syroka, 2005, pg. 53)

Creating the index – and the importance of 'basis risk'

After identifying a variable and confirming that there is sufficient weather data, the next step is to construct an index by 'showing a causal link between the… weather event and crop loss' (Nieto, 2003, pg. viii). This involves careful analysis of such factors as crop sensitivities to rainfall, growing periods, soil textures and so on. In the case of the WFP Ethiopia project, this was done by identifying 'Secure Crop Baskets' (SCBs) in each region, and tying this to the FAO's Water Requirement Satisfaction Index (WRSI), which 'captures the impact of timing of rains, seasonal total and distribution of rainfall on yields' (Syroka, 2006). According to Bryla and Syroka, this is 'the most critical process in designing a weather risk management strategy' (Bryla and Syroka, 2007, pg. 3). By severing the link with actual agricultural output, drought insurance only *proxies* the loss that farmers face owing to deficient rainfall. If the index is constructed poorly, then the index will be of little use to the farmers in the region in which the insurance is sold.

The importance of this risk, so-called ‘basis risk’ is the very hinge on which the overall effectiveness of drought insurance pivots. Basis risk relates to the situation where a loss is experienced without a payout occurring (or a payout not equalling the loss), and equally where a payout is received by the insured, exceeding the loss incurred. This is particularly relevant to drought insurance which, it will be remembered, does away with ‘on the ground’ inspections and individual verification of losses.

As weather readings are only taken at certain locations – i.e. the weather stations – an extreme way of imagining this problem is the situation of a single grey cloud raining only onto the weather station, while drought ravages the farms round it. No payout will be made as weather in that particular region will be reported as wet. The farmers affected by the drought would obviously take exception to this outcome! Various authors on the subject have referred to this problem as one of the potential for unanticipated ‘micro-climates’ which will increase this ‘basis risk’.

As Skees notes: ‘the effectiveness of index insurance as a risk management tool depends on how positively correlated farm-yield losses are with… the weather index’ (Skees, 2003, pg. 19) It will noted that earlier World Bank projects to develop weather-index based insurance in Central America foundered following lack of interest. The main outcome cited was that the indices were poorly correlated with individual losses – i.e. the presence of unacceptable levels of basis risk (Auffret, 2003, pg. 11)

The proponents of drought insurance believe that this issue of basis risk can be overcome, as long as the correlation between yields and the chosen index is high, and the index is well constructed.

Linking the index to anticipated financial losses

With an index identified, it is then necessary to convert it into a 'financial equivalent that mirrors the [farmer's] exposure' (Bryla and Syroka, pg. 4). This can be done by looking at expected production and input costs, or by examining anticipated revenues from sale following harvesting. Models can be used, or forms of regression analysis against historical data. These methods serve to 'establish the relationship between different values of a weather index and the financial loss or gain a farmer can expect' (Bryla and Syroka, 2007, pg. 4) In the Ethiopian WFP project, this was done by examining the average agricultural income of 'at risk' households (primarily small farmers), and assuming that fluctuations in crop yields were directly proportional to fluctuations in agricultural income.

Drawing up a risk transfer contract

With this relationship identified, an index-based contract can be drawn up. The World Bank's Commodity Risk Management Group (CRMG) has developed a standardised contract which can be widely applied. The following features are included (taken from Bryla and Syroka, 2007, pg. 3; and Syroka, 2007, pg. 6):

1) A dynamic start date that 'mimics the decision a farmer would take as to when to sow his crop' (Bryla and Syroka, 2007, pg. 3).

2) Three phases (sowing and establishment, growth and flowering, yield formation to harvest), during which cumulative rainfall is measured, with 'trigger' and 'exit' levels in each phase. The 'trigger' level determines the level below which cumulative rainfall must fall for a farmer to begin receiving a fixed payout per mm of deficient rainfall. It will be noted that these trigger levels correspond to the levels determined by the WRSI, i.e. the link between rainfall and crop yields, identified in the design phase. The 'exit' level is the level below which measured rainfall must drop for a farmer to receive the maximum payout, his crop assumed to have been completely destroyed.
3) A payout rate per phase as identified above – i.e. the payout rate per mm of deficient rainfall, in between the trigger and exit levels.

Finally, losses in the scheme are aggregated. In the Ethiopian pilot, the sum of drought-related agricultural income losses for 'at risk' farmers in all 26 'micro-climate' areas was aggregated, providing the definition of the Ethiopia Drought Index. In the final contract, signed with the French reinsurer AXA Re, $7.1 million was secured as contingency funding in the case of an extreme drought during the 2006 agricultural season. The 'trigger' level of the Ethiopia Drought Index was US$ 55 million, with the WFP receiving a payout from the WFP of US$ 0.35 for every US$ 1 the index rose above the trigger level, to a maximum of US$ 7.1 million.

In the case of a maximum payout, this would have provided cash payouts of approximately 900 birr (US $103) to 67,000 beneficiary households, which would 'be targeted by the communities themselves, according to Ethiopia's Productive Safety-Net

Programme (PSNP) community-based targeting principles. The targeting process… [would involve] communities and Kebele (groups of villages) bodies in all steps of beneficiary screening' (WFP, 2006, pg. 5)

Weather data from 26 Ethiopian weather stations was monitored daily, allowing the WFP to assess 'how the 2006 [agricultural] season was performing in respect to the average' (WFP, 2006, pg. 6) This allowed for ongoing update on the likelihood of a payment *during* the season, rather than simply at the end of it.

It will be noted (in light of the early discussion of the patchy nature of weather collection across the African continent), that the need to 'ensure that radios and full-time dedicated and trained staff were available at each of the 26 stations and that procedures were in place for the daily reporting of data to the NMA headquarters in Addis Ababa' (WFP, 2006, pg. 5) also 'allowed the NMA to report regularly to the United Nations World Meteorological Organization Telecommunication System for the first time in four years' (ibid).

Drought insurance in Malawi – a World Bank pilot

Having discussed some of the features of the WFP drought insurance pilot project, the study will now briefly examine the World Bank's Malawi Project, the pilot of which ran from 2005-2006. Owing to space limitations (and a natural desire to move swiftly towards the conclusion!) this study will not attempt an in-depth analysis of the design of the Malawi project, noting important differences to the WFP's Ethiopia scheme.

The World Bank (specifically the Bank's Commodity Risk Management Group) partnered with NASFAM (a Malawian agricultural marketing firm) and the Insurance Association of Malawi. NASFAM became interested in managing the risk of agricultural loan default to groundnut farmers in Malawi by using an index-based weather insurance policy: drought insurance.

Unlike the WFP Ethiopia project then, which was directed at providing the WFP with credit to distribute in a drought situation, the Malawi pilot's objective was securing access to credit for Malawian groundnut farmers. As noted by the World Bank: 'Before the pilot, farmers had little cash and no access to finance… Banks were unwilling to lend to these farmers for a variety of reasons, but primarily because of the risk that farmers would not be able to repay their loans if there was drought' (World Bank, 2005) Drought insurance was therefore packaged with agricultural loans.

Groundnut was chosen as the crop with which to pilot drought insurance. The scheme was designed so that farmers would not receive any money in advance, but rather transfer

part of the loan to NASFAM, for seed purchase, and part to the Insurance Association of Malawi, to pay for the drought insurance component (IRI, 2007, pg. 82) The farmers agreed to sell their crop to NASFAM at an agreed price, though there was concern that 'side selling' might occur, 'thereby jeopardizing loan repayment' (IRI, 2007, pg. 80)

Without further describing the scheme, the study will summarise experiences from the 2005-2006 agricultural season (as described in the 2007 IRI report and by personal communication with Joanna Syroka at the World Bank). The IRI report notes that: 'In three of the four pilot locations adequate rainfall was received to avoid payouts, but farmers in the Kasungu area received a small payout of US$ 0.68 each' (IRI, 2007, pg. 83)

Of particular interest is the following: 'One concern expressed by the farmers was that the rainfall data used to determine payouts were from a single rainfall station that could be up to 20km away. As a result some farmers were winners and others losers, as rainfall on their farms differed from that at the station' (IRI, 2007, pg. 83) This is a precise example of 'basis risk' which was discussed above, as the most fundamental problem facing any weather-index based insurance scheme.

However, despite the problems of side-selling and exposure to basis risk, 'practically all the farmers involved are keen to participate again in the second year, and demand from new farmers greatly outstrips the capacity of the project to enrol [sic], educate and manage them... The main attraction [is] that the scheme facilitate[s] access to production loans' (IRI, 2007, pg. 84)

Other factors identified by the project were the extremely important enabling environments provided by functioning markets for grain and agricultural inputs – a recognition that drought insurance can never be a panacea, but rather one tool to be employed in tackling the effects of a drought.

Potential problems

The study has examined both the theoretical and historical background of drought insurance, and also briefly looked at how a couple of key drought insurance schemes have fared 'in the field'. In this final section, the study will move to examine potential obstacles to the continued success of existing drought insurance schemes, and potential problems that drought insurance might create.

The problems identified by the advocates of drought insurance have already been identified – namely the issue of 'basis risk' and the paucity of weather data in many developing countries. Rather than go over these problems again, this study will instead focus on two issues.

Firstly, the 'psychology' of the insurance decision will be examined. The study will aim to summarise research done in this field and suggest possible implications for the application of drought insurance.

Secondly, the issue of inequality, which may have differing effects to those predicted by the advocates of drought insurance. Certain authors believe that there is more to the issue than simply the need to provide subsidised insurance.

The study concludes that these problems have already been countered to an extent by existing drought insurance schemes, but will need to be borne in mind in the future.

The insurance decision

The ‘promotional’ literature on drought insurance tends to suggest that, other than for ‘technical’ problems posed by basis risk and poor weather data, there is nothing to prevent drought insurance (or other types of weather index-based disaster insurance) being rolled out on a large scale across the areas of the developing world subject to natural disaster risk. This study does not contend the point that drought insurance is clearly an innovation that has many advantages over what went before. Rather, it suggests that there may be problems beyond the ‘technical’, relating to the psychology of the insurance decision that may hinder the decision to insure on the part of individuals.

It is necessary to briefly examine some of the literature on how insurance decisions are made. Kunreuther (1978) compares two approaches which can be used to ‘model’ the insurance decision. The first is the ‘Expected utility Model’ (hereafter abbreviated to EUM). This is an economic model, in which the individual is aware of, or able to collect data on, the probabilities of and costs associated with varying courses of action. The second is the ‘Bounded Rationality Model’ (hereafter abbreviated to BRM), which suggests that there are limits to an individual’s perceptive, cognitive and data-gathering abilities, and that individuals make decisions in a way that widely differs from that suggested by the EUM.

Furthermore, Kunreuther (1978) suggests that these two models have differing implications for policy. An examination of the two decision models and their differing implications is provided below.

The Expected Utility Model

In a disaster insurance context, the EUM suggests that individuals will purchase insurance voluntarily if it is attractively priced (i.e. premiums are set as close as possible to the actuarially fair level) and there is no expectation of free post-disaster assistance (precisely the 'negative incentives' problem that this study touched upon earlier).

In the EUM, an individual behaves 'as if he assigned probabilities to different states of nature… assigned numerical utilities to the possible results of each course of action… and then chose a course of action that would give him the highest possible utility' (Kunreuther, 1978, pg. 45). In the case of drought insurance, such an EUM would incorporate the probability of drought occurring, the protection offered by drought insurance and the probability of receiving and amount of food aid post-drought[6]. In the EUM, changing any of these variables (e.g. the probability assigned to post-drought food aid) would have an immediate impact on an individual's decision to insure.

The fundamental objection to the EUM is related to the definitional difference between 'risk' and 'uncertainty' noted at the very beginning of this study – that individuals often face difficulty in calculating the probability of events, particularly ones occurring with low frequency, and therefore are facing 'uncertainty' rather than (definitionally pure) 'risk'. As a result, individuals are unable to supply the EUM with the information necessary to calculate a utility-maximising course of action. Even if this information were available, 'even if a person… collected [this] data, his computational limitations

[6] I am grateful to Dr Ben Groom (SOAS) for providing me with an example of such a model.

may lead him to behave in a manner that is inconsistent with the assumptions of [Expected] [U]tility [T]heory' (Kunreuther, 1978, pg. 54)

Such criticisms of the EUM are prevalent in the literature on the psychology of the insurance decision. With particular reference to disaster insurance: 'One commonly reported misperception is an inability to react logically [to] low-probability events… In part, this misperception arises from [the] limited capacity people have for processing risk information' (Shanteau and Ngui, 1989, pg. 3)

The Bounded Rationality Model

The second model of decision making is the Bounded Rationality Model (BRM), derived from the work of Herbert Simon. In this model, 'the decision maker's cognitive limitations force him to construct a simplified model of the world' (Kunreuther, 1978, pg. 55)

In this model, rather than using a cost/benefit analysis of perceived outcomes, the individual relies on a number of factors in making his decision as to whether or not to purchase insurance, and as to the level of coverage selected. Personal experience of the disaster in question, and the ease with which it can be remembered, are shown to be particularly important. The processing of information is likely to follow much simpler lines than the matrix of payoffs to alternative courses of action suggested by the EUM.

Rather than the 'actuarial fairness' of premiums and the elimination of basis risk (though these of course remain important from a scheme design point of view), the BRM suggests

that the advocates of drought insurance need to focus on making farmers aware of potential losses, and the diffusion of information about the 'product' through the media (Kunreuther, 1978, pg. 57)

The BRM suggests that the consumer himself is a source of 'market failure'. In addition to the 'failure' to treat insurance purchasing as an economically rational activity, a second major failing on the part of the consumer is that 'people tend to treat insurance as an investment, rather than as protection' (Shanteau, 1989, pg. 8) Because of this, insurance is often seen as a poor investment by consumers as they believe they are unlikely to receive anything back for their premiums. With this in mind, the role of the institution selling the insurance is to educate the consumer that the 'biggest return… is not to have any return at all' (Kunreuther, 1978, pg. 251)

EUM, BRM and insurance decisions in the real world

The difference between the EUM and BRM are especially evident when compared to evidence on levels of insurance in the developed world. If insurance is lacking in the developing world, argue the advocates of drought insurance, this is largely because of various market failures which can be corrected. To a certain extent this is probably true – noting for example the 250,000 Indian farmers currently buying 'standalone' drought insurance – but only up to a point. The study would like to emphasise that it is likely that even if the 'technical' problems of drought insurance are ironed out, take up is likely to be less than expected, simply because the evidence suggests that people do not make 'rational economic decisions' when faced with risk. The policy prescriptions of the BRM are therefore likely to be more useful than those of the EUM.

This study believes that presenting evidence on levels of insurance from the developed world is relevant here because the developed world is (relatively speaking) rich, well educated and has been 'saturated' with many forms of financial products (including insurance of different types) for a long period of time – therefore inserting an 'understanding' of financial products into society and culture[7].

If anywhere could be expected to exhibit optimal levels of insurance against various types of risk, then, it should be in the developed world. The evidence is therefore sobering. For example, in the UK, 1 in 4 households is without home contents insurance, and the lack of this type of basic insurance is strongly correlated to socio-economic status: 60% of council and housing association tenants are without cover (Whyley, 1998, pg. 3) Whyley's study examines the relative expense of insurance for a low income household compared to a wealthier one, and also highlights the lack of information problem: 'many [poor] households are likely to have difficulty in understanding what their policy does and does not cover…' (Whyley, 1998, pg. 6) Other examples can be found elsewhere in the developed world: in 1992, only 50% of Californian homeowners had earthquake insurance (Palm & Hodgson, 1992, pg. 207) Here, *perception* of risk was found to be the motivating factor in the decision to purchase insurance, rather than the actual risk of earthquakes *per se*. While some households situated right on top of fault lines were found

[7] This study does not make too much of this last point, recognising it as mildly controversial and highly contentious. Joanna Syroka (in personal communication with the author) noted how the Malawian farmers involved in the World Bank pilot project had no local word for 'insurance', and therefore adopted the English word to describe it. This suggests that describing and understanding the concept of insurance will be much harder in such cases. Then again, the French do not have their own word for 'le weekend', but this study does not doubt that the concept is well understood in la Belle France…

to be uninsured, others – located in areas that would barely be shaken by even a major earthquake – were found to be over-insured.

To a certain extent, the drought insurance schemes discussed above have either taken these considerations into account, or avoid them by dint of their design. In the WFP project, insurance is bought for the recipient individuals by the WFP, thereby avoiding any 'choice' on the part of the Ethiopians who will receive payouts. In the case of Malawi, insurance was packaged with agricultural loans as a precondition for receiving one.

Inequality

The issue of inequality is one that is not covered much by the literature on drought insurance. Clearly poverty is an important factor in deciding whether to purchase insurance, both for financial and informational reasons.

In terms of information problems: 'In some cases, poor people view insurance negatively, seeing it as something that is only for the rich and generally irrelevant, unaffordable or even unfair to the poor. Based on their experiences or what they have heard [poor] people often mistrust insurers or believe they charge a lot for nothing in return' (ADA, 2007, pg. 2)

With the poor naturally disinclined towards insurance, and often unable to afford it – Morduch presents a scenario where 'the situation for those who do not have access to…

[drought] insurance is worse than if it would not be available at all as it creates inequalities' (ADA, 2006, pg. 3) One of the benefits of drought insurance during a drought is that it 'smooths' the income of those who have it, maintaining their purchasing power and preventing the widespread sale of assets and corresponding fall in prices for goods and services. Morduch considers the case of landless labourers (or indeed other such groups) who might not have access to drought insurance. During a drought, drought insurance is now available to farmers who can maintain their purchasing power. Without access to this insurance (and of course with no work as a drought is occurring), the high prices – beneficial to farmers and providers of goods and services, make things even worse for the insurance-less and landless labourers (Morduch, 2001, pg. 4)

Conclusion

This study concludes that drought insurance is an interesting and promising financial innovation with the potential to effect widespread and significant welfare gains for farmers (and other purchasers of it) across the developed world. ‘Technical’ issues obstructing its progress, as recognised by the project designers, include the paucity of weather data in certain regions of the developing world, and ‘basis risk’. Furthermore, as is widely recognised, drought insurance is not a panacea, and is merely one tool which needs to be employed in tackling drought risks – the presence of functioning markets for crops and agricultural inputs are equally important. Other potential issues identified by this study include the psychology of the insurance decision, which suggests that (unless addressed) take-up of insurance could be less enthusiastic than expected, and the ever-present issue of inequality.