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POTENTIAL FOR INDEX INSURANCE IN *BARANI* AREAS OF PAKISTAN

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Abstract

This paper explores the possibility of utilizing rainfall data and Normalized the Difference Vegetation Index (NDVI) data for developing an insurance product that protects farmers from weather related yield losses of wheat production in Pakistan's *barani* areas. This study finds that while rainfall data serves as an effective index, NDVI data (only) partially captures the yield variability in wheat production.

Key Words: Pakistan, NDVI, Index Insurance, *Barani* Areas.
JEL Classification: Q140, Q180013.

I. Introduction

Pakistan has the fortune of owning one of the most extensive irrigation network in the world; the Indus Basin irrigation system [Rehman (1993)]. However, while this forms the core of agricultural production system in Pakistan, there are agricultural regions which are not part of the network and still depend on rainfall as the first source for water. The extent and timing of rainfall is an important factor impacting crop yields in all districts of Pakistan. It is most critical in those areas where it serves as the primary or only source of water for crops.

This paper focuses on four districts in the north of Pakistani Punjab which are not served directly by irrigation water and are classified as '*barani*' districts (Figure 1). Additionally most of the discussion will surround the wheat crop which is the most critical grain for most areas of Pakistan.

It is expected that in regions which depend on rainfall for irrigation water, wheat yield is not only the lower but also more variable (Figure 2). It is important to note that yield tends to be lower in '*barani*' areas not only because of the lack of irrigation water but also because farmers tend to spend less on other inputs such as fertilizer because of the uncertainty associated with the crop yields. The analysis offered in this paper is motivated by considering that reducing uncertainty which surrounds farmers' income from crops will encourage improved production practices which in turn will

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Note: The figure shows the map of Pakistan with *barani* districts being considered in this paper highlighted in red. *Barani* areas are defined according to Agroecological Zones (AEZs). They include the districts of Jhelum, Chakwal, Attock and Rawalpindi, while there is some variation in districts that are categorized as *barani* (for some districts like Gujranwala only parts are considered as *barani*), we utilize district categories that are utilized in HIES. (Household Income Expenditure Survey).

FIGURE 1

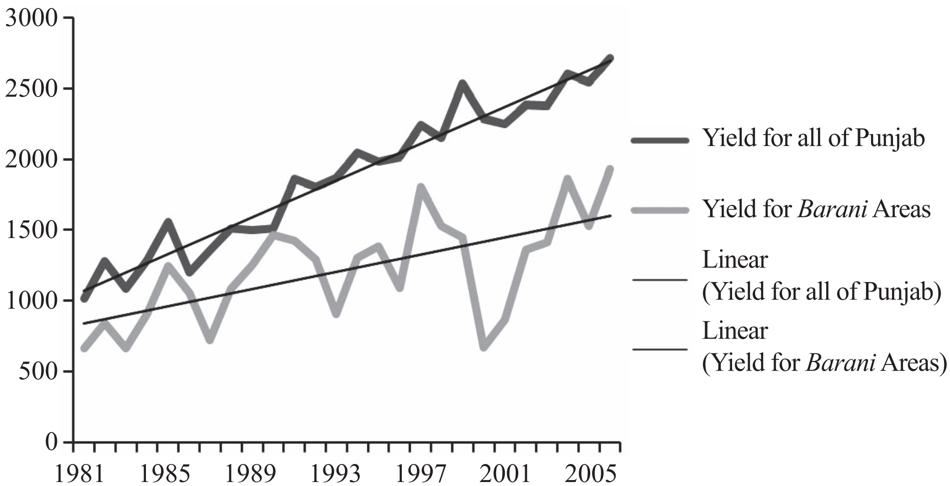
Barani Districts of Pakistan

improve the overall yield levels [Dercon (2005), Just (1974). Therefore, offering solution that can help farmers to stabilize income can be an important part of the strategy that can improve crop production in Pakistan.

Farmers utilize many methods to reduce income uncertainty such as loans from family, friends and semi-formal setups like Rotating and Saving Credit Associations (ROSCA). Larger land-holders are also likely to utilize formal financial services in the form of financial products like different types of insurance for better management risk. Standard insurance works on the principle that large number of uncorrelated observations reduces variance, thereby reducing the risk. It implies that while these methods are suitable to deal with idiosyncratic risk, they are not designed to provide protection from some risks that are engaged in crop production.

In agriculture, weather events such as drought or floods are highly spatially correlated. As an example this correlation implies that when there is a drought season the yield of farmers fall, and therefore the money lenders increase their interest rates or might even refuse credit because of its high demand as they can be selective [Barnett, et al. (2008)]. Self-insurance techniques such as selling semi-liquid assets might also be insufficient because surplus might bring down the prices [Hatfield and Davies (2006)].

The high level of systemic risk in agricultural is one of the key reasons why even in countries with high developed financial systems, agricultural insurance is



Note: Produced by author utilizing data provided by the Ministry of Food Security and Research, (Statistics Division 2010). Yield for all of Punjab is inclusive of *Barani* areas.

FIGURE 2

Comparing Yield for all of Punjab
versus Yield of *Barani* Districts

usually heavily subsidized by the government. In a well-known study which highlighted the role of systemic risk in agricultural insurance in the USA, the authors estimated that absence of stochastic independence in yields across farms translates into insurance portfolios which are 50 times riskier. This would imply extremely the high premiums when translated into a financially viable product for insurers, and would eventually make it unaffordable and unattractive for most farmers [Miranda and Glauber (1997)].

This paper examines the viability of a relatively new financial product called the Index Insurance (IT) within the context of the barani areas of northern Pakistani Punjab. The key difference between the Index based insurance and other insurance products is that index based insurance products payouts are based on movement of certain index which should be correlated with overall loss in a specified region but independent of actual loss that an individual might experience (or at least not able to be influenced by individual action). As discussed (later) in this paper this can be a useful and viable (lower premiums) financial product when there is a high level of systemic (spatially aggregated) risk. The next part of the paper will provide a more detailed explanation and research on Index Insurance. The paper will then move onto the empirical application concerning the barani areas. We will first look at the data being used and then move onto the methodology used to ascertain the viability of such a product. Finally the paper will also present calculations that look at the pricing of such a product.

II. Literature Review

Before diving into the literature related to index insurance products, we will briefly explain the basic concept behind the product using example of a farmer primarily engaged in wheat production. If for example, an index insurance product utilizes a district level of rainfall as an index and farmer 'x' has decided to purchase this insurance product for 2014-15 for Rabi season; and if the accumulated rainfall (October 2014 to March 2015) in the month of March is below the trigger value (100 mm pre-determined before season) of insurance product then farmer 'x' receives a payout from the insurance company. The payout is independent of farmer X's own crop production performance. If in the next year the farmer faces yield losses, for example due to an aphid infestation but the accumulated rainfall is above the trigger value of 100 mm, he will not receive a payout.

Index based products are initially developed in sectors which are outside the agriculture. An example of this is in electricity markets where weather based indices are used in the agricultural markets. There is now an emerging opinion that index based products can be an effective risk management tool for agriculturists in developing countries, as well [Skees and Barnett (2006)]. Within agriculture (while it has been the most frequently applied to crops) it has occasionally been used within the context of insuring livestock as with a World Bank Project in Mongolia, and in a more recent project in the ASALs of Kenya [Mahul, et al. (2009)].

The largest index insurance product in terms of number of farmers is the index insurance provided by the Agriculture Insurance Company in India. The original version of this crop insurance scheme was initiated in 1999 and it covered nearly 22 million farmers in 2010. It was primarily a government run program focused on crops, which placed a cap on the premiums that farmers paid with the central and state government subsidizing the rest at the time of claim payment. This program faced many challenges, the least of which was that farmers received 3.5 times more in claims then the amount they paid in premiums. Perhaps, even more problematically the yield estimation calculations used have proven to be inaccurate, resulting in what has been termed as 'arbitrary allocation of government subsidies' [Mahul and Verma (2012)].

There is now a modified version of this insurance product, the 'Modified National Agriculture Insurance Scheme' which was launched in 2010 and combined weather and yield data for development of the index. This product was also opened to the private sector with the government stepping in by providing premium subsidies instead of covering the balance at the time of claim settlement. One of the key challenges associated with index based products is the element of basis risk, which does not typically exist in traditional insurance products [Woodard and Garcia (2008b)]. This kind of risk implies that those farmers suffering losses (in terms of yield loss or livestock mortality) might not receive indemnity payments, while those who have not experienced any loss, might end up to receiving payments. The risk of this error depends a great deal on index being used and its correlation with the loss experienced by farmers.

One of the key determining factors behind the successful implementation of index based insurance products is the design of an index which is highly correlated with the covariate risk that insurance product is covering [Smith and Watts (2009)]. The lack of an effective index basically indicates that the product has failed to capture the risk for which it was designed to manage. This failure is likely to lead to dissatisfaction amongst clients and act as a deterrent towards repurchase. This means that if we are designing an index product based on rainfall, then the crop yields should be correlated with rainfall of that area.

Index option includes precipitation and temperature, and the area yields. Others, relatively newer indices include vegetation indices of which the Normalized Difference Vegetation Index (NDVI) is the most popular. Closer examination of the rainfall index, which has been a frequently used index in insurance products reveals a great deal of variability in correlation between the index (rainfall) and the yields that are being insured [Woodard and Garcia (2008a)]. Depending also on specific crops, this correlation can vary from a low of 0.2 to a high of 0.82. An important conclusion that can be drawn from the research of Turvey and Mclaurin (2012) is that when developing indices for insurance products, it is critical to examine the localized relationships between variables' and to examine closely as to what level of spatial aggregation appear to be the most reasonable [Makaudze and Miranda (2010)].

Regarding index insurance in context to Pakistan there is just been one small pilot which tried to examine factors that affect farmers willingness to pay for the product. The pilot was held in Soon Valley and Talang (rain-fed agricultural areas in Pakistani Punjab). It found that willingness to pay is positively correlated with larger landholdings, fewer sources of off-farm income, and ownership of livestock. However some studies found that though the farmers cultivated more land-post, the purchase of such an insurance product was needed to be heavily subsidized before farmers would purchase it [Ali (2013)]. Similarly, research on rainfall-based (Index Based Insurance Product in India initiated by BASIX), indicated that take-up of the product is extremely sensitive to pricing. Evidence from Malawi also indicates that take-up of the product was highly correlated with household wealth [Giné, et al. (2007)].

The issue of low willingness to pay can be dealt within a number of ways, the simplest of which is direct government subsidies. Some of the largest projects in index based agriculture insurance in USA and India are heavily subsidized by the government. Other methods used include: requiring farmers to work on community projects in exchange for insurance or collaborating with others in the supply chain, for example, fertilizer and seed suppliers, reduce the eventual cost of premium for farmers.

III. Objectives of the Study

The main objective of this paper is to examine the viability of an index insurance in the context of *Barani* regions in Pakistan. This paper utilize two types of data which are rainfall data and the NDVI data (satellite vegetation index data) and evaluate the role of both types of data as an index product. The next objective is to see as to how much such products would cost, to study its commercial viability.

IV. Overview of the Data

As discussed earlier the paper looks to examine the viability of designing an index insurance product for the *Barani* regions in Pakistan. This section provides an overview of the data that we used and the key data requirement for developing an index insurance product; which is the data for the index itself and the crop yield data to examine if index data is correlated with the yield data.

Two data sources used to develop an index are: one of which is rainfall data and the other is NDVI (Normalized Difference Vegetation Index). The rainfall data is acquired from Aphrodite[1] (Asian Precipitation - Highly-Resolved Observational Data Integration Towards Evaluation of Water Resources) which is accessible free academic purposes. This data is available at a daily level at pixel density of 0.25, 0.25 degrees and 0.5, 0.5 degrees, and is collected from weather stations all across Asia. For the purposes of this research, the data available at the pixel density of 0.25 by 0.25 degrees[2] is utilize. It means that we have one observation of rainfall data for a grid cell with a size of 25 km by 25 km.

The other source that we examine for developing an index is the Normalized Difference Vegetation Index (NDVI) data. This paper utilizes a dataset that was developed by using imagery from Advanced Very High Resolution Radiometer (AVHRR). The dataset is available for a 25 year period from 1981-2006 and is calibrated to account for numerous other factors that could influence readings other than vegetation.[3] NDVI data has been utilized for crop yield modeling in different parts of the world. In some cases it has been combined with other weather variables like rainfall to create predictive models for crop yield. For example, research in Canada indicates that NDVI data can be used to predict yields nearly 4 weeks earlier than the other models that use other physical data [Tucker (2004)].

This paper, specifically focus on the wheat[4] yields; the data of which is at the district level[5] for Pakistan. The yield data for relevant areas was obtained from the Ministry of Food Security and Research.

[1] Detailed information on the nature of data and calibrations used for processing can be accessed at http://www.chikyu.ac.jp/precip/scope/index.html.

[2] It is based on weather station recorded data which is then processed to ensure consistency across all regions.

[3] Detailed information on the processing and calibration for this data is available at http://iridl.ldeo.columbia.edu/SOURCES/.UMD/.GLCF/.GIMMS/.NDVIg/.global/.dataset_documentation.html.

[4] The paper focuses specifically on wheat because of its importance for households. However, the same model can be explored for other crops as well.

[5] Unfortunately, the data is not available at a more disaggregated level (tehsil, union council) which does not allow us to explore the design or nature of the contract at a more disaggregated level.

V. Analysis of the Rainfall Insurance

This paper develops a rainfall index following a process similar to the one identified by the World Bank experts for the design of a rainfall index insurance product in Morocco [Stoppa and Hess (2003)]. Since this study is on district level yield data, the rainfall data also needs to be aggregated at the district level. Following the formula, the rainfall data is added across the smaller area, so that a single data value per district is obtained. At this point we have a daily rainfall value for each day of the year. However, it has been established that since cropping patterns for most crops can be broken into 10 day cycles, therefore the next step involves the summing up values for daily rainfall data into dekad length (10 day intervals). A key step is to develop an index which maximize correlation between the rainfall and yield data series from 1981 to 2006.[6] Rainfall data is utilized from the beginning of October when sowing has already started which ends till March (next year) when harvesting has either started or is scheduled to begin soon. This totals to about 180 days but as discussed earlier the rainfall data has been aggregated to be used for each district at 10 day intervals. To review this, it means that we have 18 points of rainfall data for each district, for each year.

The eventual goal of index is that it serves as an effective predictor of wheat yield. The current data is utilized to determine the predictor way; the goal of which is to utilize the available rainfall data in the best possible way. It is clear that different stages of rainfall (18 in our case) will affect the crop in different ways. Rainfall at different times will vary as to how critical it is for the crop yields. The next stage of aggregation is to add these 18 values in such a way that it maximizes the correlation of rainfall data with the yield data. To accomplish this, weights are assigned to each of the 18 dekads in order to maximize this correlation for each of the 4 districts. The value is assigned to each of the 18 dekads which is 0-1 and sums to 1. Therefore, by the end of this process a weighted sum of rainfall data is obtained and there will be one data point of rainfall for each district for each year.

TABLE 1

District Level Yield and Rainfall Data

District Name	Mean of Rainfall Index	Yield Mean (kg/acre)	Correlation
Attock	11.65	1253.85	0.89
Rawalpindi	16.97	1336.83	0.88
Jhelum	08.53	1348.42	0.91
Chakwal	06.58	1062.53	0.91

[6] Yield data is detrended.

$$\max_w \operatorname{corr}\left((\textstyle\sum_{d=1}^{18} w_{dekad,year,district} * R_{dekad,year,district}), Y_{year,district} \right) \tag{1}$$

Equation (1) summarizes the discussion that selecting weights would maximize correlation between the wheat yield and rainfall data, using the entire (available) data. These determined weights will now be utilized to add rainfall data in order to create the referred rainfall index.

The basic premise of an index insurance product (as discussed) is that a specified threshold value of index value will trigger a payment to all purchasers of the product. There are many methods by which the threshold value is determined. For the purpose of this paper the threshold value of index is taken to be a certain percentage below the mean of rainfall index, over the last 25 years. This percentage is referred to as the strike rate which can be modified being based on how sensitive the contract is to be made. For example, if average of the rainfall index is 250 mm for District Attock, the strike rate will then be set in 2007 season and farmers would receive a payout if rainfall is below 225 mm. If however, the strike rate is set to 20 per cent, farmers would only get a payout if the rainfall is below 200mm, in 2007.

Equation (2) summarizes the discussion where T_{di} is the threshold value.

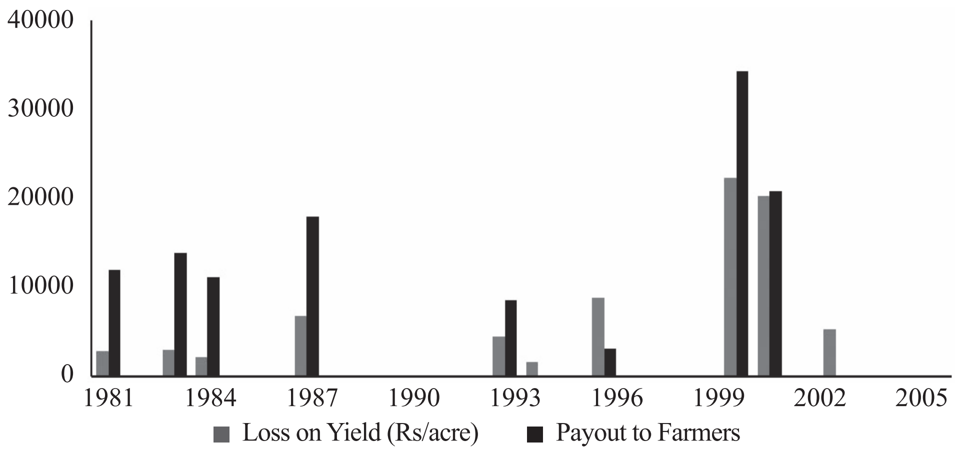
$$T_{di} = \frac{\sum_{t=1}^{t} R_{di,t}}{N} - \text{Strike} * \left(\frac{\sum_{t=1}^{t} R_{di,t}}{N} \right) \tag{2}$$

The next step is to determine as to how much the payout should be referred to as indemnity. The payout is also, eventually dependent on the nature of rainfall. This is to create a mechanism so that farmers get more in a really dry year. The indemnity (payout) of the contract calculation is assumed that maximum liability (of the insurance company) is an average of yield times and the price of wheat. Equation (3) shows as to how the payout is calculated. T_{di} is the threshold value described in Equation (2) and $R_{di,t}$ is the calculated rainfall index for that year.

$$\text{Indemnity}_{di,t} = \max\left(\frac{T_{di} - R_{di,t}}{T_{di}}, 0 \right) * \text{liability} \tag{3}$$

To examine performance of this contract, Figure 3 provides a picture of how it would have performed over the last 26 years (1981-2006). We look at district Attock and look at how the index will do if strike rate of 25 per cent is set. Losses of yield are calculated in terms of deviation from the mean for that district.[7] The payout fails to occur in two years (1993 and 2004) when farmers sustain a loss. However, during two years (2000 and 2001) when there was a most significant loss, the contract gave a payout which was equivalent to or exceeded the loss. (Figure 3). This suggested that the contract was ef-

[7] Similar graphs for other three districts have been provided in the Appendix.



Note: The payout variable is calculated based on how the index would have performed for that year. The loss on yield variable is calculated by the deviation of that year's yield below the mean. The graph above is calculated at a strike rate of 25%.

FIGURE 3

Loss Estimates with Rainfall Index for District Attock

fective in protecting farmers when there was a serious drop in the yield. However, a key challenge that arose is the development of an effective index insurance products that utilized rainfall data and lacked availability of spatially dense and accurately recorded rainfall data [Barnett and Mahul]. Unfortunately, aphrodite rainfall is not available for future years, limiting its use for development of a viable rainfall index. Alternate sources of rainfall data might include utilization of rainfall data, collected at weather stations at the district level in Pakistan.[8]

Index using Normalized Difference Vegetation Index (NDVI) has been utilized for yield prediction models with mixed results. For example, research looking at the role of NDVI in yield prediction models in Morocco found variation of its predictive power across provinces [Balaghi, et al. (2008)]. A closer examination of data allows to see its performance within the context of barani regions in Pakistan. For this study AVHRR data which is available for every 14 day intervals is utilized.[9] NDVI has many advantages as an index, the most important of which is the spatial density at which it is available. While AVHRR (1981-2005) data utilized in this study is available for free at a density of 8 by 8 km (pixel size for which a data point is available); more recent datasets collected from MODIS are available at a much finer spatial density (1 by 1 km). Additionally, the nature of NDVI ensures the development of an index that is less susceptible to manipulation.

8 The data is collected by government officials through instruments present at the DCO office. Unfortunately, at the present time this data might be of poor quality and inconsistent across multiple stations. Another source of rainfall data might be through SUPARCO.

9 The data is processed through maximum value compositing.

The present study use the aggregated district level values for NDVI two steps and employ it in order to control the impact of natural vegetation on the NDVI data. Initially the NDVI data is filtered and restricted it only to areas where some form of agricultural activity is occurring [M. (1998)]. The data is also transformed into a Vegetation Condition Index for the purpose to control the impact of weather induced vegetation growth as opposed to growth which can be attributed to other (more favorable) conditions like better soil quality [Unganai and Kogan (1998)].

$$VCI^{10}_{p,t} = 100 * (NDVI_{p,t} - NDVImin_p)/(NDVImax_p - NDVImin_p) \quad (4)$$

After this step all VCI values are aggregated for each district in a similar manner, to the rainfall data. This leaves us with a corresponding VCI value for each district and each year (1981 to 2005). The next step is to assess the predictive power of NDVI values on wheat yields. Ordinary Least Square and the VCI values on wheat yields are regressed for each district (Table 2).

$$Yield_{di} = \alpha + VCI_{di} + \varepsilon \quad (5)$$

The results presented in the regression (Table 2) suggest that aggregated VCI values fail to capture enough the yield variability in all the four districts under consideration. In the districts of Attock and Jhelum the VCI is also statistically insignificant along with extremely low R-squared values of 0.051 and 0.025, respectively. In order to examine the performance of a modified contract further (using NDVI values), similar exercise (to the one) already conducted with the rainfall index is performed. The loss on yield is defined as deviation from the mean yield with the payout that farmers would receive, is based on the output of this model (Figure 4).

TABLE 2

Regression Output

Independent Variables	De-trended Yield			
	Attock	Chakwal	Rawalpindi	Jhelum
VCI	1.194	1.210*	0.550	1.559*
	(1.078)	(0.670)	(0.723)	(0.862)
Constant	453.6	370.5	1,018**	431.2
	(708.9)	(380.1)	(416.3)	(498.1)
Observations	25	22	25	25
R-squared	0.051	0.140	0.025	0.124

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Note: Results were obtained by regressing VCI values for each of the four districts against de-trended yield data.

[10] VCI values for each pixel and each time period. The maximum and minimum are across time for each pixel.

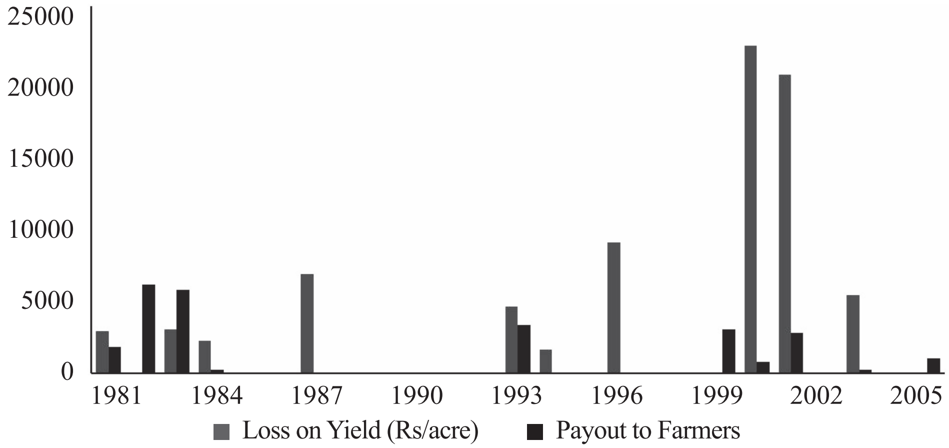


FIGURE 4

Loss Estimates with NDVI Data for District Attock

There is a need to put a value on maximum liability for the purpose of this paper and take average yield's time and price of wheat for that district.[11] One of the key issue with this contract is that in years 2000 and 2001 the contract failed to compensate for a large part of the yield drop. This is despite the fact that for this version of the contract a much lower strike rate of 5 per cent was used. In combing the regression results it suggests that NDVI data might not be very effective as a predictor for wheat yield in the four districts on which this study is worked on.

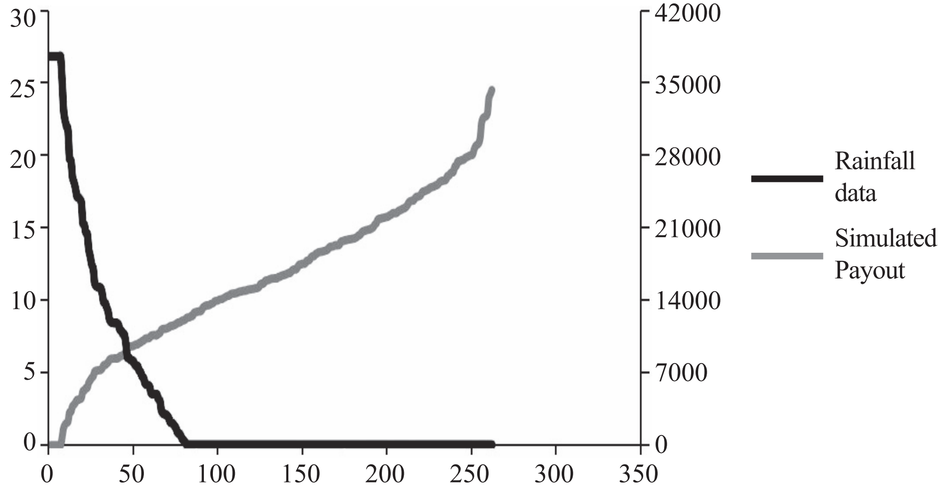
VI. The Contract Design

This section of the study help the framed discussion in a more practical light by examining as to what an actual insurance product would look like and how it would perform. For utilizing the rainfall data from October to March (next year) the contract needs to be purchased before the start of October. In order to calculate the premium for insurance, the product like this should simulate the value of indemnity for randomly generated values of the rainfall index. It is assumed that rainfall has a normal distribution which is truncated at zero.[12]

Figure 5 provides a picture of what happens to the payouts with movement of the rainfall index. The simulation conducted allows to estimate a value of premium based on the estimated payouts. The payouts and the premium can be modulated by changing the strike rate. Basically, the higher is the strike rate the lower will be the frequency

[11] For the purposes of this iteration we take this to be PKR 30/kg.

[12] http://ilri.org/infoserv/Webpub/fulldocs/X5524E/X5524E03.HTM.
Excels randon number generator is utilized to simulate 300 different probabilities.



Note: The figure was created by running 300 simulations. Initially the excel random number generator produced a probability number. This value was then utilized to generate the associated value of rainfall index assuming that it was normally distributed but truncated at the value of zero. The horizontal axis represents the number of simulations.

FIGURE 5

Simulated Distribution of Rainfall and Indemnity

and value of payouts which in turn results in a lower premium (Table 3). The premium obtained from the simulated values is around 3500 PKR. On an average the yield of (approximately) 2700 kg/acre with a wheat price of 30 kg/acre; the farmers' total revenue would be PKR. 81000. The premium would be approximately 4 per cent of the revenue which is a sizeable amount considering numerous other expenses which the farmers have to face. It means that for the product to be viable, a subsidy targeted specifically towards small farm holders would be in order. Additionally, it is important to note that this premium does not include the loading factors (which are included as operational and other costs borne by the insurance company who is responsible for the product); which should be included to capture what the farmer would be paying.

TABLE 3

Estimated Premiums

District Name	Loss(%)	Premium[13] (PKR)
Attock	10.38	3906
Rawalpindi	10.84	3458
Jhelum	14.47	5853
Chakwal	9.92	3981

[13] Since these premiums are based on simulated values they will vary slightly.

VII. Policy Implication

As discussed in this paper index insurance can serve as a financial instrument that can stabilize income of farmers in areas which are primarily rain-fed and where yields and income can fluctuate, depending on the weather. There are evidences from many parts of the world that stabilizing farmer's income in turn means greater investment in crop production on their part which in turn could help agricultural policy makers to meet food production goals.

However, the nature of index insurance product means that farmers are still exposed to spatial basis risk which can be extensive and in case of this paper an entire district is considered as one spatial unit. In order to minimize the spatial basis risk, associated index products can be marketed to farmer associations as opposed to individual farmers. Each farmer in the association would pay the premium to be determined by the insurer (post addition of loading factor). but payouts to each farmer would be based on their actual loss of wheat production. It is quite possible that payout to association is not sufficient to cover the actual losses and in such a case the payouts would be distributed in proportion to the actual losses incurred by the farmers.

The burden of monitoring members of the association and minimizing moral hazards fall on the association itself. The main benefit of this is that there are no administrative costs beyond those associated with the index products in general. A key challenge needed to be determined by association is to determine the actual losses incurred by each farmer. If expected yield minus actual production is determined as actual loss, then it is important that expected yield is within 10-15 per cent of farmers previous years' wheat yield.

While such a structure will raise to its own set of challenges a key advantage of this is that smaller communities will have a protection mechanism against risk that affects the entire area. One way to formulate such a product could be through a 'takaful product'. In a takaful product participants contribute to a fund where payouts (in case of a financial loss) can include a death , crop loss or accidents [Archer, et al. (2011)]. The concept of 'takaful insurance' can be combined with an 'index insurance' to develop a product which is more effective at protecting farmers from systemic and individual risk that is associated with agricultural production. Islamic insurance products are somewhat similar to mutual insurance, in which the policy holders are owners of the insurance fund. In a takaful product the insurer play the role of underwriter known as the wakeel. The wakeel manages the insurance fund and can be made responsible for investing the money in a Shariah compliant way.

VIII. Conclusions

This paper focuses specifically on the mechanics of designing such an index product which would confirm the impact of rainfall on yields in *barani* areas in Pakistani

Northern Punjab. The results of this study indicate that NDVI data does not perform well as a predictor for yields. This is an important contribution because in Pakistan there is little work based on this topic. However, there is a need for more work to examine the specific product designs and their viability in terms of farmer adoption.

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APPENDIX

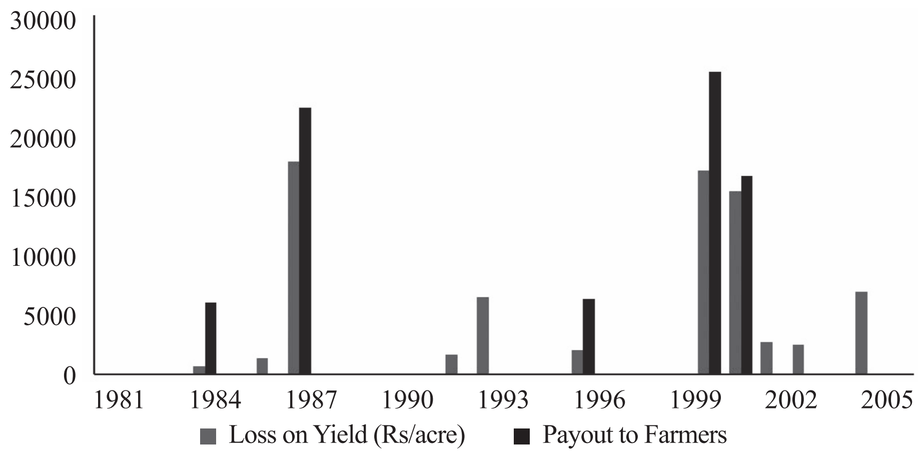

FIGURE A-1

Loss Estimates with Rainfall Index for District Chakwal

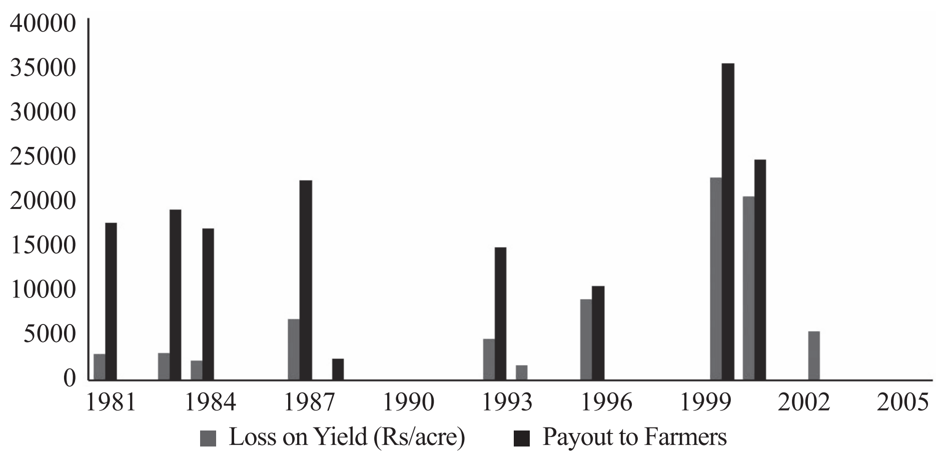

FIGURE A-2

Loss Estimates with Rainfall Index for District Jhelum

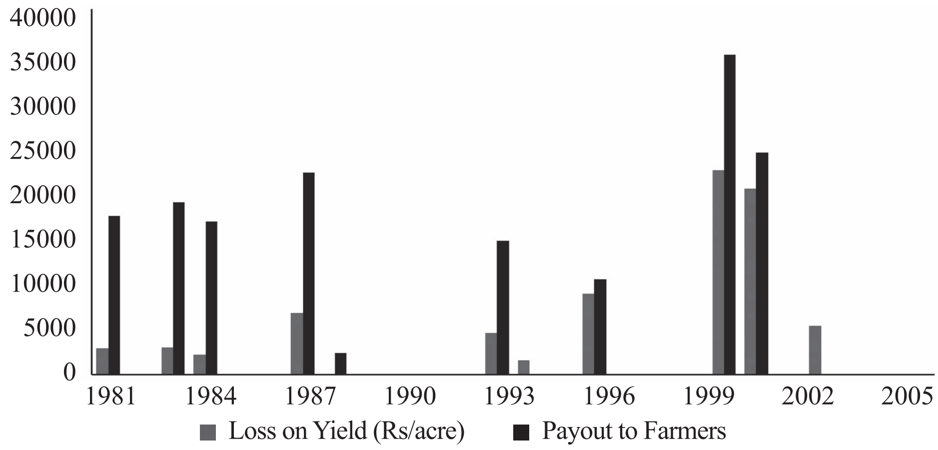

FIGURE A-3

Loss Estimates with Rainfall Index for District Rawalpindi