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A study of basis risk in the use of weather derivatives for hedging of agricultural yield

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ABSTRACT

Weather derivatives are a newer form of hedging the weather-related agricultural yield risk. The paper discusses the issue of geographic basis risk, which is likely to be an important factor when weather derivative trading is introduced in India. With the large number of villages and the large geographic spread, an understanding of the implications of basis risk would help, not only in the acceptability of weather derivatives as viable hedging instruments, but also in relevant policy matters. This would be so especially with respect to the number and kind of weather recording stations which would be required. The paper brings out a study of past data from two weather stations in New Delhi, located just a few kilometers apart, on rainfall correlations and uses these to indicate risks involved in using proxy weather stations.

Key words: Weather derivatives, agricultural risk.

Agriculture, especially in developing countries, is a sector which is vulnerable to risks of various types. Most importantly, weather-related risks play a major role in affecting agricultural income. These would include extreme rainfall events which result in floods/droughts, as well as extreme temperature events. Poor and small farmers are especially susceptible to income variability because of weather-related risks to their crops. In fact, even those rural poor who are not directly involved in agricultural production get affected because their incomes are often tied to the success of the agricultural production (Barnett and Mahul, 2007).

Controlling weather is not something we can do very much about – however, controlling the risks to agricultural produce due to the effect of weather is possible through the use of weather derivative products. A weather derivative can be defined as a “weather contingent contract whose payoff will be in an amount of cash determined by future weather events” (Dischel and Barreu, 2002). The settlement value of these weather events is determined from a weather index, expressed as values of a weather variable measured at a stated location.

Weather derivatives are likely to be introduced in the near future in India. One of the major challenges here is that climatic variability occurs on spatial and temporal scales. This is not too evident in the case of temperature in our country, but could have significant effects on derivatives based on rainfall. Geographical climatic differences lead to situations where there could be significant correlations between many locations, while there may be low correlations also between locations which are geographically not far apart. Basis risk can lead to imperfect hedging when the user wishes to cover a weather risk at one location, but is actually covered by the weather recorded at a location some kilometers away.

Most weather derivative contracts which have been traded world-wide have been based on temperature indices. However, in the case of farmers, especially in subtropical regions, their major interest is likely to be in rainfall-index related weather derivative products. An impediment to the growth of a market in these products could be the apprehension of the acceptability of rainfall linked derivative products in the face of an associated basis risk.

An understanding of the peculiarities of what basis risk entails, would be crucially important if weather derivatives are to be widely adopted (Woodard and Garcia, 2007). This would be more relevant in the case of farmers where a lack of knowledge or very little information about weather derivatives is further clouded by the issue of basis risk. A study of basis risk in weather derivatives where precipitation is the underlying, can be done by considering past rainfall records.

Geographic basis risk in the case of weather derivatives can be defined as the risk that the payout does not correspond with the deviation in the underlying weather parameter at the location at which hedging is desired. This, typically comes in when the weather station from which data-sets are used for deriving the index, is located at a distance away from the location at which hedging is desired. This would be a fairly common phenomenon, especially in a developing country, where the number of weather stations are limited. Ofcourse, whilst an increase in the number of weather stations would

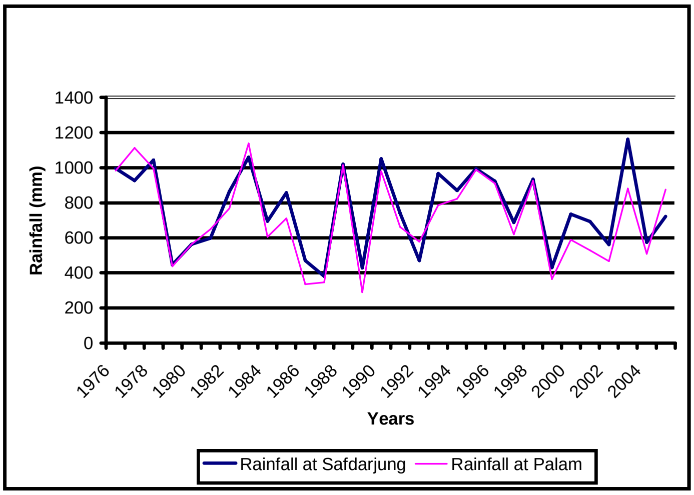

Fig. 1: Comparison of yearly rainfall

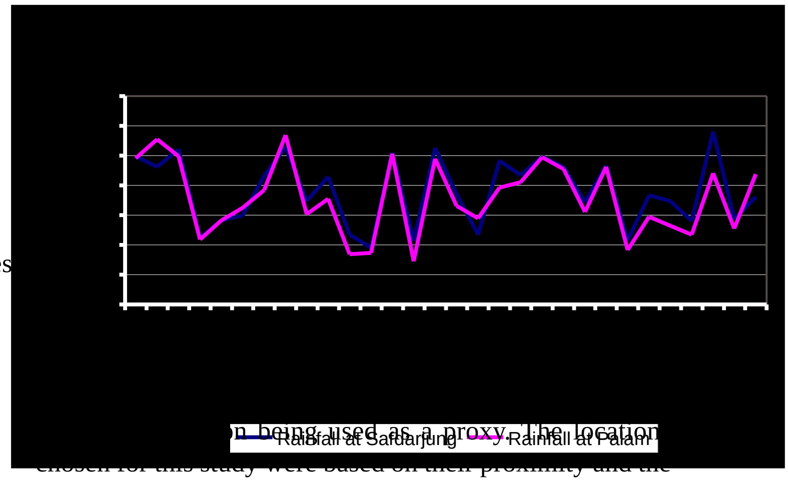

Fig. 2: Regression res

bring down the geographic basis risk, this may contribute to an increase in the administrative costs and hence an increase in the cost of the option. Brix and Jewson (2005) have brought out that there is, generally, a trade-off between basis risk and the price of the weather hedge.

Whilst geographic basis risk is the additional risk due to the use of a contract which is based on a non-local site, theoretically it is possible for location indices to be specified in terms of a set of locations which are weighted to capture the effect of offsetting the exposure risk using weather derivatives from multiple non-local markets (Woodard and Garcia, 2007).

MATERIALS AND METHODS

In order to establish the intensity of the issue, it was decided to use two weather stations located close to each

n being used as a proxy. The location chosen for this study were based on their proximity and the availability of reliable rainfall data for a period of 30 years. New Delhi has two airports – Palam and Safdarjung, both within the city and located less than 10 kilometers aerial distance apart. Both have weather stations of the India Meteorological Department (IMD) which have been in existence for many decades.

Daily rainfall data-sets were purchased from the IMD for the 30 year period from 1976 to 2005 and this was used for the study. A three stage comparison of the rainfall data was done. In the first instance, annual rainfall at the two locations was compared. Then the monthly rainfall in months

Fig. 3: Comparison of monthly rainfall in June

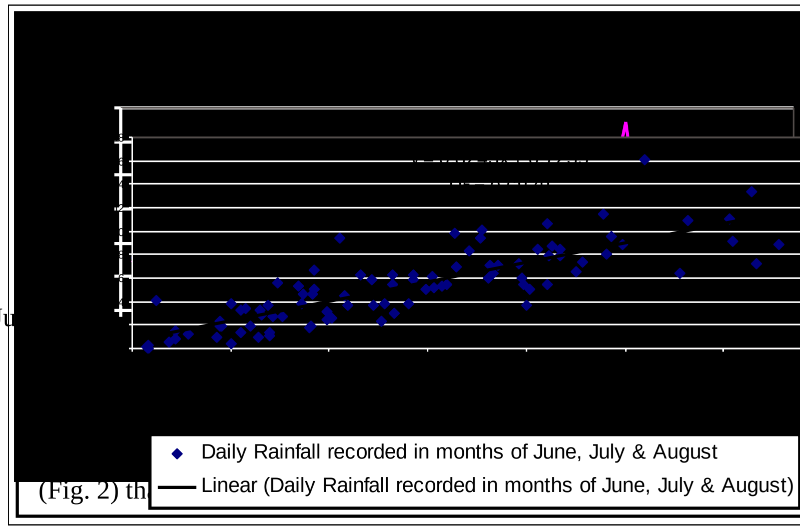

Fig. 4: Rainfall in Ju

of January, February, June, July and August were compared. In the other months the total rainfall was too little to give any significant results. Finally a comparison was made of the daily rainfall in the three- month period from 01 June to 31 August of each year for the 30 years.

RESULTS AND DISCUSSION

Yearly rainfall

A comparison of the yearly rainfall of the two locations from 1976 and 2005 is shown in Fig. 1. The annual average rainfall in the 30 years was 762.0 mm at Safdarjung and 714.5 mm at Palam. While this itself is not significant, it was noted that the greatest absolute difference was in the year 2003, when it rained 1161 mm at Safdarjung, which was 280 mm

(Fig. 2) th

Monthly rainfall

The farmer, however, is more interested in the rainfall that occurs during the monsoon months, especially in the months of June, July and August for the *Kharif* crop and in January and February for the *Rabi* crop. Rainfall in these five months at the two locations were compared. Correlations are indicated in the Table 1. The correlations in the month of June is low and so this gives us a noticeable result with respect to basis risk. (Fig. 3) The correlation is just 64.6 per cent. The largest absolute difference in rainfall occurred in the

Table 1: Correlations between monthly rainfall of the two locations.

Month	Season	Correlation (r)
January	*Rabi*	0.94
February	*Rabi*	0.86
June	*Kharif*	0.65
July	*Kharif*	0.88
August	*Kharif*	0.89

year 1998 when it was 279.1 mm at Palam, which was 147.9 mm more than the rainfall recorded at Safdarjung. The largest percentage difference, however, was in 2004 when the rainfall in the month of June was 331.6 per cent more at Safdarjung.

Of the 30 years rainfall data in the month of June, it is noticed that in 16 years the rainfall was more in Safdarjung, while in 14 years it was higher at Palam. So it is evident that the basis risk varies from month to month.While using Palam as a proxy weather station at Safdarjung or vice-versa might be acceptable in the month of August, in the month of June it could lead to a much higher basis risk.

Daily rainfall

An analysis was also done of the rainfall on a daily basis for the months of June, July and August ie. for 92 days across the same 30 year period. (Fig. 4.) This is probably the most relevant to weather derivatives, because in rainfall-index based derivatives, small period of contracts are likely to be used. On regression, a R-squared value of 0.688 is obtained, which implies significant variations in the rainfall amounts at the two stations which are located so close to each other. The largest difference occurred on 30th June, when the average rainfall over 30 years was 16.14 mm at Palam, which was 5.17 mm greater than that at Safdarjung. The largest percentage difference was on 4th June when the rainfall at Safdarjung was 933 per cent higher than the rainfall at Palam. On 53 of the 92 days studied in the 30 years period, rainfall was higher at Safdarjung, while on 39 days, it was higher at Palam. Infact, on 7 days, the difference in rainfall at the two locations was more than 100 per cent. A similar study was done on data from two locations in London by Moreno (2005), with fairly similar results.

CONCLUSION

It is concluded that the shorter the period in which the rainfall is looked at, the greater is the difference between the rainfall between the two locations.

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