Weather Risk Management

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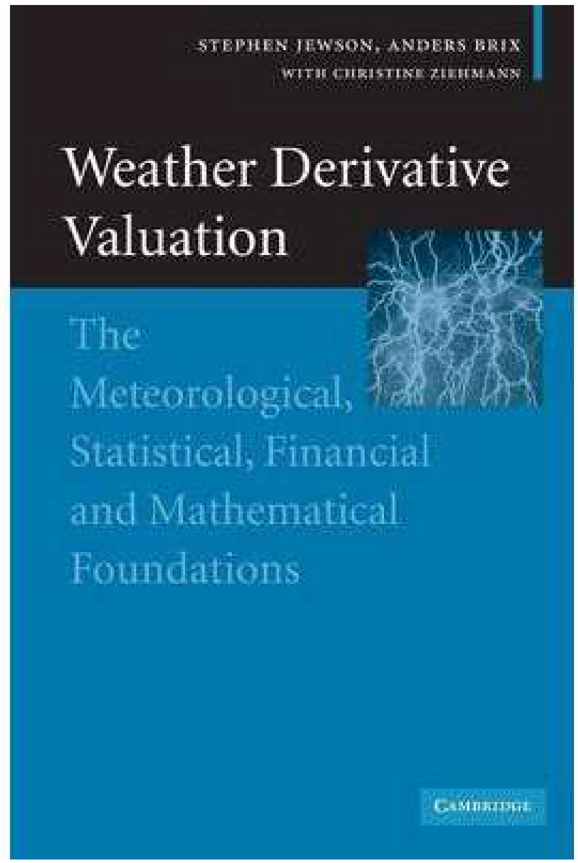
The Material



Types

- Catastrophic weather event – insurance / cat bond
- Non-catastrophic weather event – weather derivatives

Introduction to Weather Derivative

Hedgers vs Speculators

- Players
  - Hedgers
  - Speculators

- ข้อดี
  - return จากตราสารเหล่านี้ไม่เกี่ยวข้องกับ market / other financial returns
  - สามารถกระจายความเสี่ยงจากพื้นที่ที่มี low weather risk ไปยังพื้นที่ที่มี high weather risk ได้ง่าย

Contract

- The contract period
- A measurement station
- A weather variable
- An index
- A pay-off function
- Premiums

Index-based and Indemnity-based Weather Insurance

- Index-based -> ง่าย แต่มี basis risk… basis risk จะหมดไปถ้า loss highly correlated กับ weather
- Indemnity-based -> คำนวณยาก

Index

- Temperature-based
- Wind-based
- Rain-based and Precipitation-based
- Snow-based
- Number of sunshine hours

Temperature-based Indices

- Degree day indices
  - Heating degree days (HDDs)
  - Cooling degree days (CDDs)
- Average of average temperature indices
- Cumulative average temperature indices
- Event indices
- A general classification of indices

Derivative Payoffs

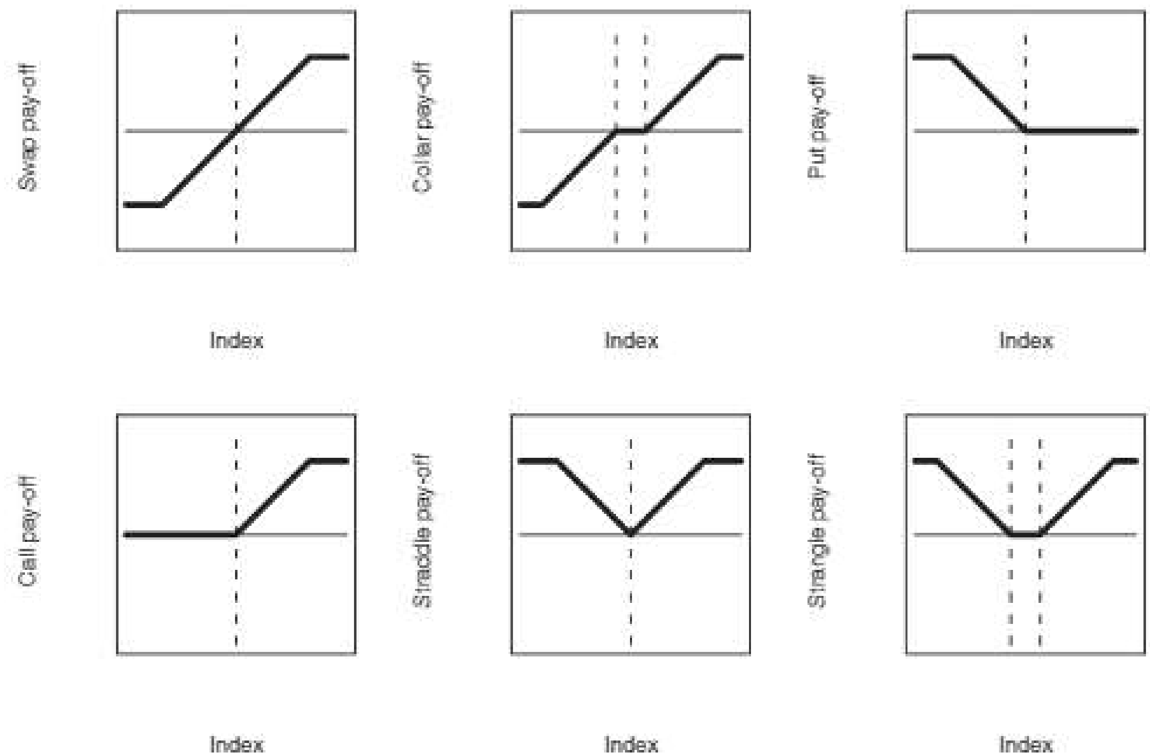


Figure 1.3. The pay-off functions for the various contracts described in the text.

Data Cleaning and Trends

How to Price Weather Derivatives using Meteorological Data

- Data Cleaning: filling/intra-extrapolating missing values + outliers
- Identify jumps in the data due to station change
- Remove trends

- Check out Boissonnade et al, 2002 for detail

Data

- Data source: National Meteorological Services (NMSs)
    - US data… good and cleaned
    - Others… expensive and often available in hard copies
- Types
    - Synoptic
    - Climate
- Challenges
    - Gaps/missing data
    - Jumps… caused by station changes
        - 0.5 degree Celcius change is considered large already!
    - Trends / mean shifts

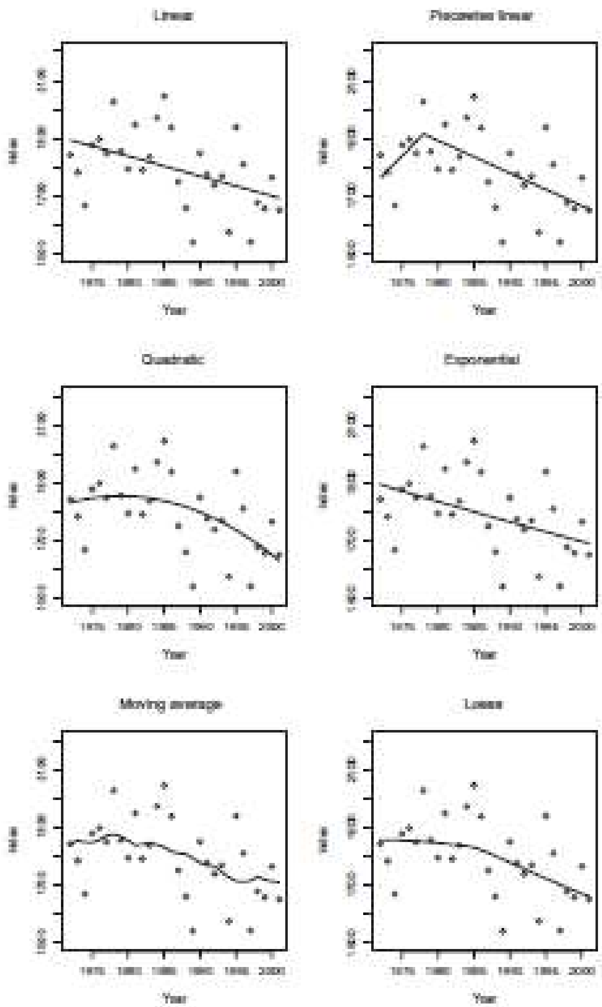


Figure 2.5. Examples of the six trend shapes discussed in the text, all fitted to London Heathrow November to March HDDs, 1972 to 2001.

Pricing

Burn Analysis

- Idea: how a contract would have performed in previous years
- No distributional structure or Monte Carlo simulation required

- Linear Swaps
  - Strike K = E[X]; X = weather index used
  - Add a risk loading… e.g. 20% of a standard deviation of the underlying index

- Option
  - Average historical option payoffs = option price
  - Add a risk loading

Index Modeling: Statistical Modeling Method

- Steps:
  - Step 1: Model the distribution of the underlying index using statistical method
  - Step 2: Use the payoff function and the distribution of the underlying index to compute the expected payoff… that's the price.

- Caveat: Wrong distribution choice -> Worse result than burn method!

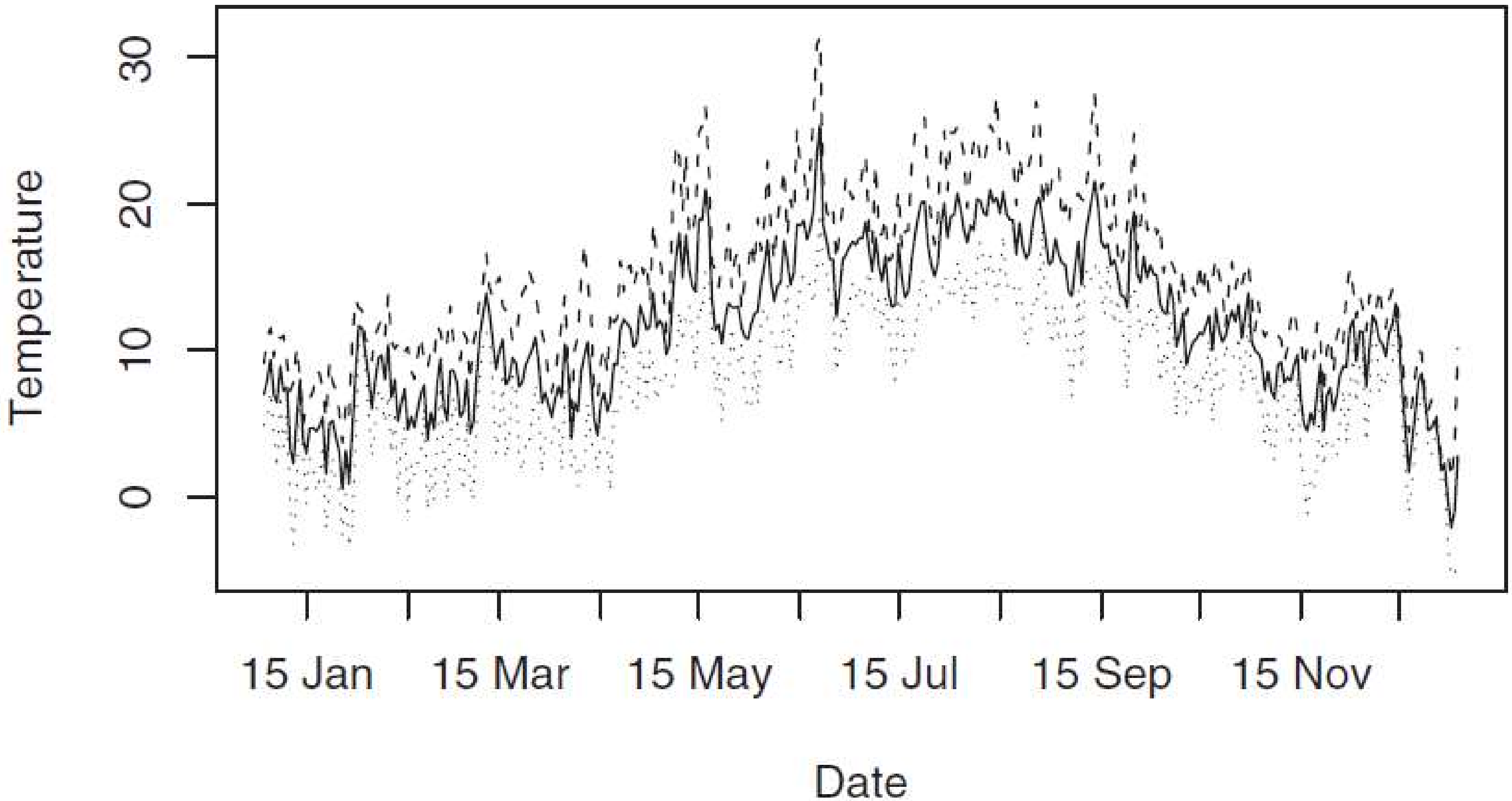


Figure 1.1. Daily minimum (dotted line), maximum (dashed line) and average (solid line) temperatures for London Heathrow, 2000.

How to fit the index?

- Discrete vs Continuous?
- Parametric vs Non-parametric (kernel density approach)?
- Fitting the distribution
  - MM or MLE
- Testing the goodness of fit
  - Histogram, qq-plot, CDF plot
  - Chi-squared test, Kolmogorov-Smirnov test, Anderson-Darling test, Shapiro-Wilk test

A side note on Kernel Density approach...

Calculation of Expected Payoffs

- Analytical/closed-form solution
- Numerical integration
- Simulation

Paper

Papers

Innovation in risk transfer for natural hazards impacting agriculture ☆

Hector Ibarra[a,*], Jerry Skees[b,c]

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Abstract

Agricultural income from growing crops is susceptible to a variety of risks—the price of output and the actual amount of output are generally the largest risk variables. This article focuses on yield risk rather than price risk by reviewing innovation in risk transfer for natural hazard risk in agriculture. While many higher-income countries have long-standing crop insurance programs, these programs are not appropriate for lower-income countries. Lower-income countries can ill-afford the subsidies that are used in most multiple peril crop insurance programs throughout the world. Still, lower-income countries have large numbers of small farms increasing the need for agricultural insurance to protect against common problems that create disastrous losses for many individual farm households.

Keywords: Agriculture risk management

Quantifying spatial basis risk for weather index insurance

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Abstract

Purpose – The purpose of this paper to develop an empirical methodology for managing spatial basis risk in weather index insurance by studying the fundamental causes for differences in weather risk between distributed locations.

Design/methodology/approach – The paper systematically compares insurance payouts at nearby locations based on differences in geographical characteristics. The geographic characteristics include distance between stations and differences in altitude, latitude, and longitude.

Findings – Geographic differences are poor predictors of payouts. The strongest predictor of payout at a given location is payout at nearby location. However, altitude has a persistent effect on heat risk and distance between stations increases payout discrepancies for precipitation risk.

Practical implications – Given that payouts in a given area are highly correlated, it may be possible to insure multiple weather stations in a single contract as a "risk portfolio" for any one location.

Originality/value – Spatial basis risk is a fundamental problem of index insurance and yet is still largely unexplored in the literature.

Keywords Insurance, Precipitation, Rainfall, Index insurance, Weather derivatives, Spatial basis risk, Basis risk

Paper type Research paper

Innovations in Index Insurance for the Poor in Lower Income Countries

Jerry R. Skees

This article focuses on innovation in weather insurance designed to fit the special circumstances of the poor in lower income countries where rural and agricultural financial markets are largely underdeveloped. Index insurance is an innovation that circumvents many of the fundamental problems that hamper the development of insurance for weather risks in lower income countries. With index insurance, payments are made based upon an objective and independent *index* that serves as a *proxy* for significant losses to crops, livestock, or other property. For example, the index can be based upon extreme rainfall measures that create either drought or flooding. Weather stations or even satellite imagery coupled with computer models can be used to create reliable "indexes" as the basis of payments. This article reviews this innovation by providing the background for its development and the motivation for using the innovation for the poor.

Key Words: index insurance, financial innovation for the poor, weather insurance, correlated risk, poverty trap, ex ante risk management

ABSTRACT

Rural finance is about managing risk. Lenders can effectively pool and aggregate risk held by a large number of borrowers if the risk they face is largely independent. A major advantage of microfinance entities and other forms of collective action has been the ability to pool risk. However, correlated risk can not be pooled. Small rural finance entities (RFEs) are simply not capable of pooling and managing correlated risk on their own.

Agriculture remains a dominant activity in many rural economies of the poorest nations in the world. A large majority of the poorest households in the world are directly linked to agriculture in some fashion. Risks in agriculture are correlated. When one household suffers bad fortune it is likely that many are suffering. When agricultural commodity prices decline everyone faces a lower price. When there is a natural disaster that destroys either crops or livestock, many suffer. Insurance markets are sorely lacking in most developing and emerging economies, and rarely do local insurance markets emerge to address correlated risk problems. There a numerous challenges in developing financial markets to manage risk in developing countries. Many of these are reviewed in this paper.

Nonetheless, there is hope. This paper builds upon that hope by reviewing innovations in global financial markets that provide unique opportunities for RFEs to manage correlated risk and expand their ability to help rural households. Two innovations offering the most hope are: 1) the use of global futures markets by intermediaries who can offer a form of price insurance; and 2) the use of index insurance contracts to shift natural disaster risk into the global markets. Recommendations are offered for blending these forms of index insurance and rural finance.

Conclusion