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The Design, Pricing and Marketing of Weather Derivative Products

Jon Tindall

Outline:

1) Introduction
2) Market Update
3) Pricing
4) Developments
5) Marketing Opportunities
6) Where to from here?

Introduction

Introduction

- First formal recorded transaction in 1996 – Enron and Energy-Koch .
  - HDD swap – Milwaukee, winter 1997
  - De-regulation of energy industries – mainly in US and Europe.
  - Initially used as a hedge against variability in electricity supply.

- US Department of Commerce estimates that weather adversely affects:
  - 70% of all US companies;
  - 22% of total GDP.

  - 65% of CFO's surveyed believe they have inadequate weather risk management processes.

Contracts

- Wide variety of contract types and underlying variables
- Dominated by temperature futures and options

Contract Types:

- Futures - CME, OTC.
- Options – Majority of transactions to date.
- Swaps - increasing in popularity.

Underlying Variables:

- Temperature
- Rainfall
- Wind Speed
- Snow Fall
- Barometric Pressure
- Frost

Weather Markets

- Mature Over-the-Counter (OTC) market:
  - Existed since early 1990's.
  - Specifically 'tailored' products.
  - Large European banks and insurance brokers.
- Chicago Mercantile Exchange (CME):
  - operates electronic exchange for weather derivatives.
  - futures and option contracts over US and Canadian cities.
  - Approx 75% of total global turnover in 2007.
- L.I.F.F.E – Closed in 2004
  - series of contracts based on daily average temperatures in London, Paris and Berlin.

Temperature Derivatives

- Average daily temperature $$T_i = \frac{T_{\max} + T_{\min}}{2}$$

- The most popular derivative contracts are over Heating Degree Days (HDD) and Cooling Degree Days (CDD).

$$HDD = \sum_{month} \max\{0, (\overline{T} - T_i)\}$$

$$CDD = \sum_{month} \max\{0, (T_i - \overline{T})\}$$

  - Where the reference level, T, is usually 18º.
  - Heating is generally required below the reference temperature and cooling above it.
  - Cumulative number of degrees the average temperature was below the reference level

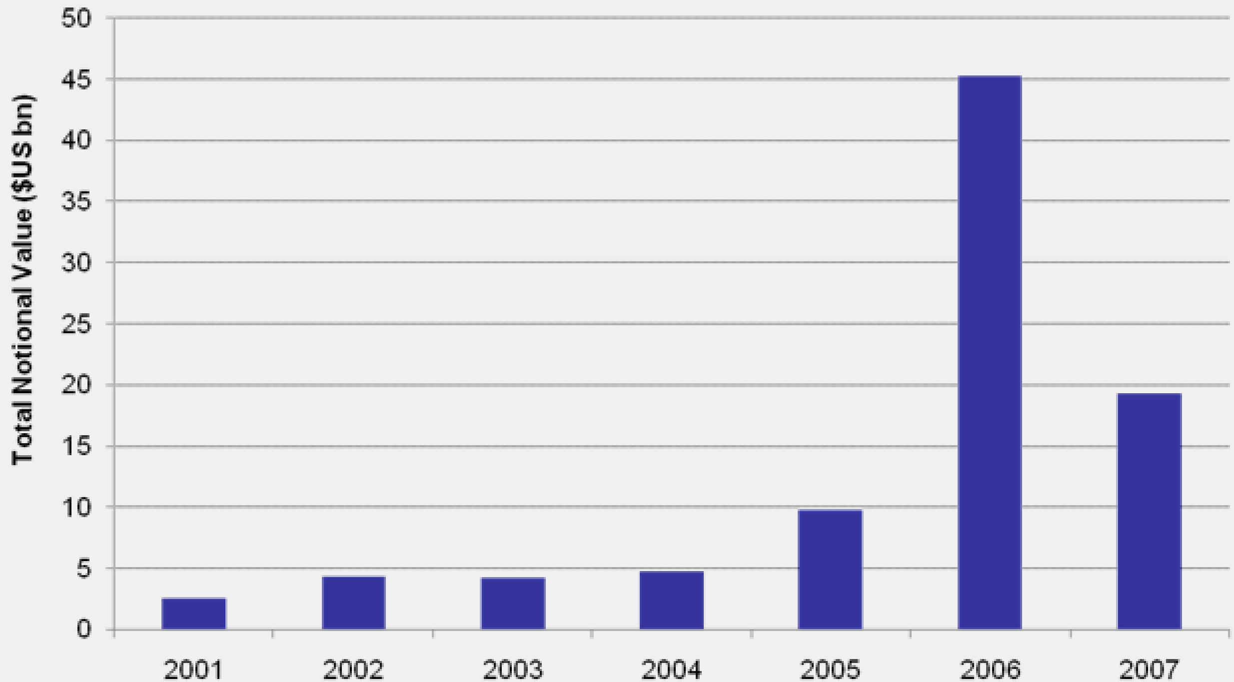
Rainfall Derivatives

Much less common than temperature-based derivatives.

- Market was born out of temperature exposure.
- ‘Discreetness’ of Rainfall
  - Basis risk - greatest barrier to expansion.
  - Modelling difficulties.
- Requirement for in situ weather stations.
- Lack of natural counter-parties.

Market Update

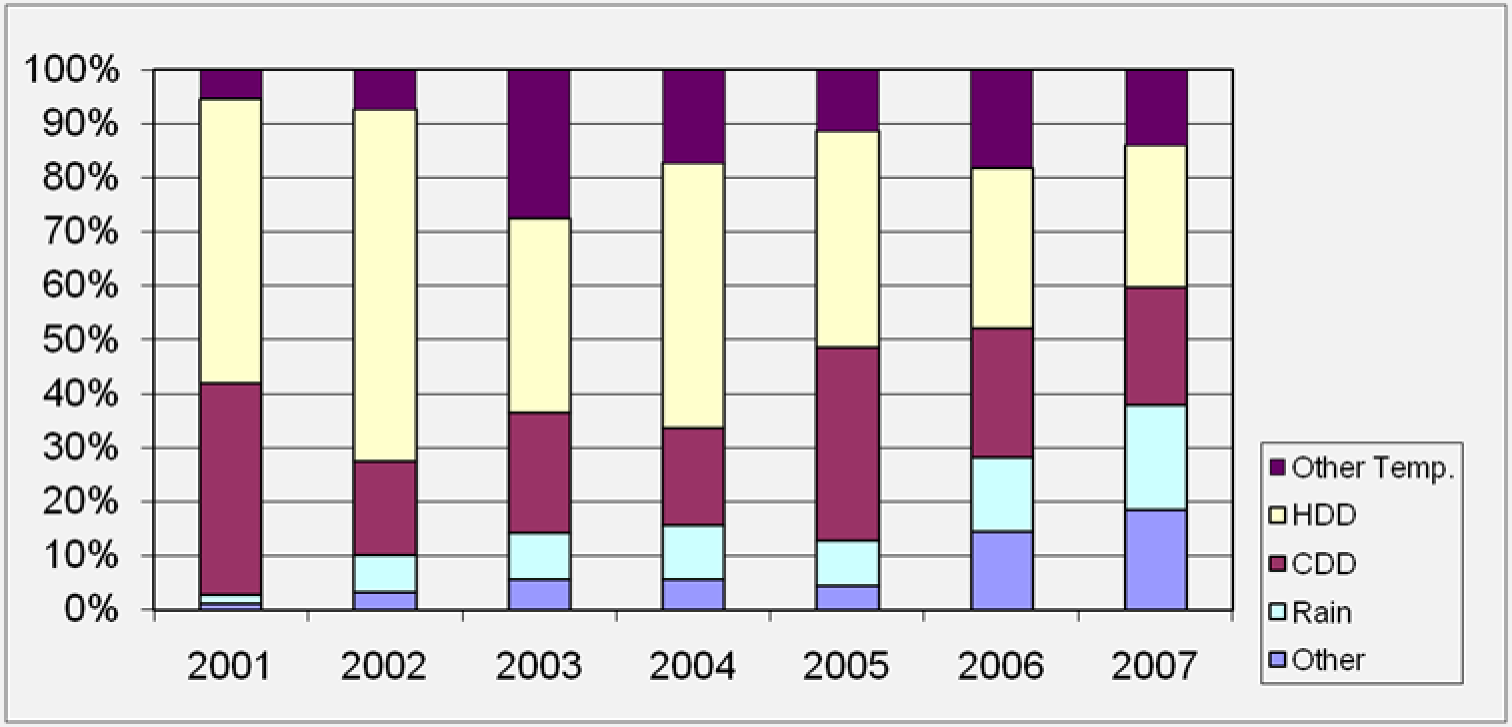
CME



PWC 2007 WRMA Survey

- Large increases in total notional value over past 5 years.
- Reduction in 2007 primarily due to a switch to monthly based contracts.

CME



PWC 2007 WRMA Survey

- Large increases in rainfall contracts.
- Temperature based contracts less dominant

Pricing

Pricing

Consistent basis to pricing still a major obstacle

Traditional Black-Scholes assumptions are not adequate:

- A traded underlying asset that can be used to create a hedge, i.e. sold short.
- Log-normal distribution.

Other methods must be found for the pricing of these contracts:

- Alternative BS framework.
  - Forward process
  - Black (76) model
- Martingale approach.
- Numerical simulation.
  - Data Intensive
  - Parameter estimation

Mean Reversion

- Weather variables do not rise or fall without bound.
- Mean reversion strength depends on several factors – most significantly, latitude.
- How do weather forecasts interact with the pricing of contracts.

- Mean-reversion component:

$$\frac{dX_t}{dt} = -\gamma.(X_t - \overline{X})$$

- Ornstein-Uhlenbeck (OU) process:

$$dX_t = \gamma(\overline{X} - X_t).dt + \sigma.dW_t$$

- Modified OU process:

$$dX_t = \left[\gamma(\overline{X} - X) + \frac{d\overline{X}_t}{dt}\right]dt + \sigma.dW_t$$

Alternative Black-Scholes

- Based on the Black(76) model
- Advantages:
  - Tractable
  - Closed-form solution
- Limitations:
  - Modelling weather variables as futures process.

- Futures Price:

$$Y_t = X_t . e^{r(T-t)}$$

- Process s.d.e:

$$dY_t = y[(\mu - r)dt + \sigma dW_t]$$

- Modified Black-Scholes p.d.e:

$$\frac{dV_t}{dt} = rV - \frac{1}{2}\sigma^2 y^2 \frac{d^2V}{dy^2}$$

- Solution:

$$V(y,t) = BS(ye^{-r\tau}, t, r, \sigma)$$
$$= e^{-r\tau}.BS(y, t, 0, \sigma)$$

Developments

Insurance Linked Securities (ILS)

- Huge global growth in ILS's
  - Approx. $US 8bn in turnover in 2008. Up 30% on 2006.
  - Effective in transferring much of the losses associated with Katrina.
  - Convergence of Insurance and Capital markets
- Properties of ILS's:
  - Low correlation to other markets.
  - Attractive returns.
  - i.e. high returns compared with the contribution to portfolio risk.
  - Attractive as an asset class – massive hedge fund interest.
  - Diversification tool

Brokering Services

WeatherBill

- Retail access to the weather derivatives market.
- Online quotes for customised contracts. Free burning cost analysis.
- Sits as the link between the client and the capital markets. Risks are on-sold to reinsurers.

Storm Exchange

- Diversified weather risk broker.
- Analyse ⇨ Benchmark ⇨ Structure ⇨ Transfer

Issues: Independence and Transparency

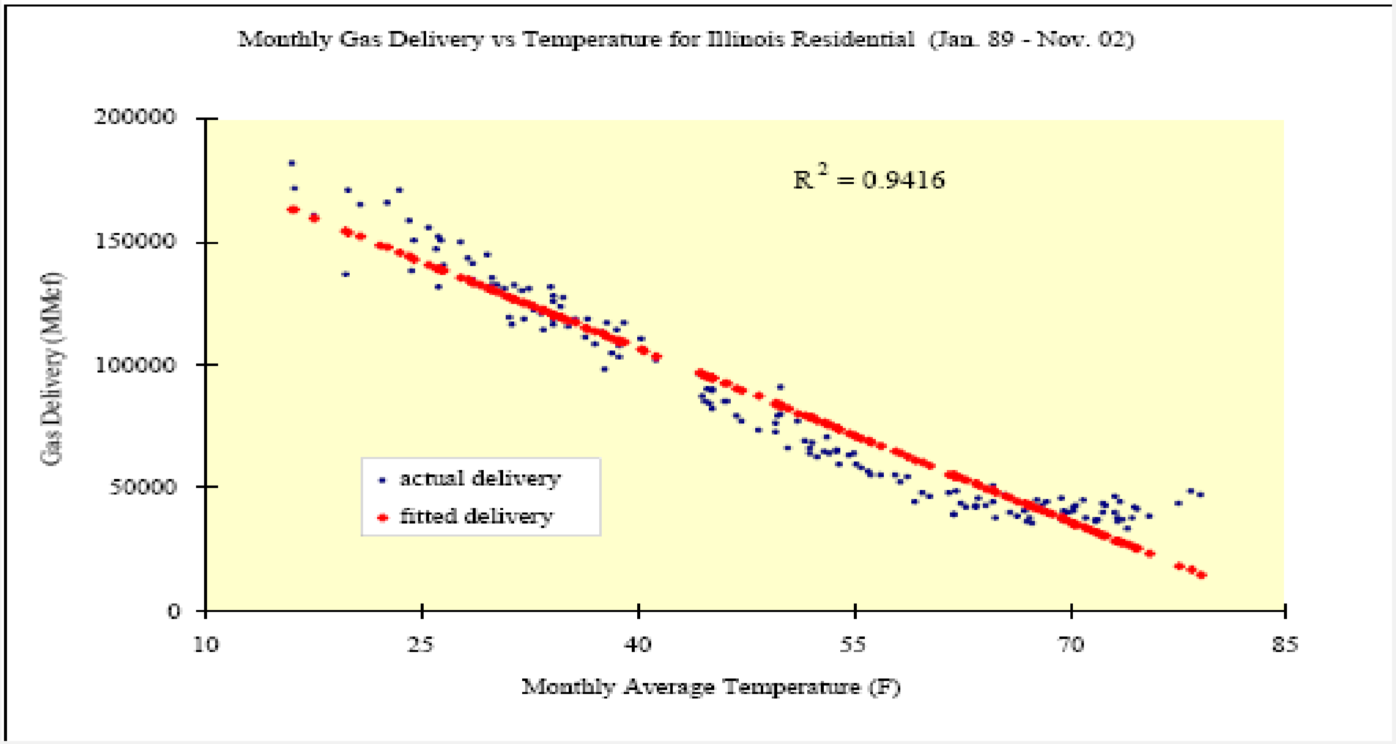
Brokering Services

TFS:

- Weather risk broker – pricing via Climetrix
- First ever Asian weather risk auction
  - Tokyo and Osaka – closed 27th March 2008.
  - $11.25m notional – capacity was oversubscribed.
  - Cumulative average temperature contracts for the May – September period.
  - Cleared on the CME.
  - Follows similar auctions for Rome > $64m

Marketing Opportunities

Natural Gas Demand



Weather Derivatives vs. Insurance

Some key differences:

- ✓ Identifiable Loss: There is no need to prove that a loss has occurred. Reduces costs – claims assessors, lawyers etc.
- ✓ Moral Risk: Nearly entirely removed – referenced to a transparent index
- ✓ Minimal Underwriting: Only counter-party credit risk requires investigation.
- ✓ Immediate Payout: – known magnitude.
- ✓ Basis risk

Opportunities

Some of the industries most sensitive to weather variables for which detailed transactions have been recorded in recent years include:

- Agriculture
- Energy
- Construction
- Mining
- Tourism
- Entertainment

Agriculture

- The industry most obviously susceptible to variations in the weather.
- Assist cooperative based crop protection mechanisms verification not required.
- Individual underwriting and claim verification not required.
- 3rd World Applications:
  - Earth Institute and Swiss Re – Kenya, Mali and Ethiopia. Sep 2007
  - Protection for 3 villages in distinct geographical locations.
  - Provides $2m of cover in the event of drought damage crops.
  - Indicates that capacity exists for these ART mechanisms.
- Retail based agricultural solutions are difficult to standardise.
- Need for regulated weather stations in more remote locations to remove basis risk

Construction

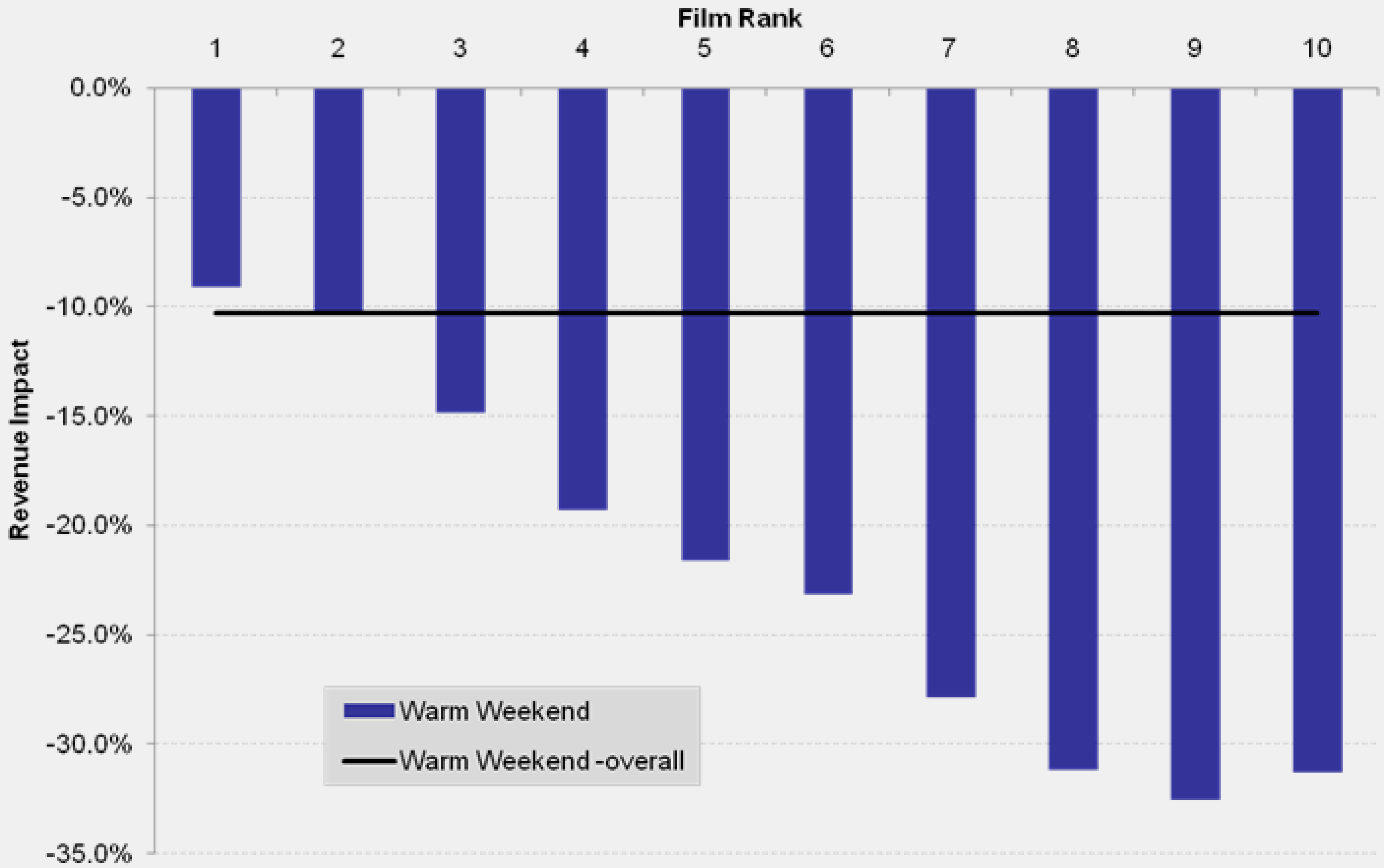
- Temperature:
  - Concrete curing (setting) is temperature dependent.
  - Productivity reduces at unusually high and low temperatures.
  - ‘Stop work’ laws.
- Rainfall:
  - Precipitation delays can often represent 10% of contract.
  - Subsidence.
- Other exposures:
  - Snow fall.
  - Wind speed – cranes and other heavy equipment.

Case Study: Box Office Returns

Study undertaken by WeatherBill

- 10 years of US box office data (Jan98 – Jul07)
- Tested the effect of weather on box office revenue on:
  - Weekend temperature
  - Weekend precipitation
  - Controlled for the individual films:
  - Popularity
  - Seasonality

Case Study: Box Office Returns



Case Study: US Flight Disruptions

- Bi-variate regression for both weather delays and cancellations.
- Regression over temperature and precipitation.

$$\phi = \alpha + \beta_T \Delta T + \beta_P \Delta P$$

where

- *Φ* represents the disruption measure
- β are the regression parameters
- ΔT and ΔP are the excess of the temperature and precipitation over the average.

Case Study: US Flight Disruptions

Results:

▪Precipitation has significant effect on flight disruptions and cancellations.

- More prominent in winter months.
- More significant in colder climates.

- Parameters significant at 1% for over 12 airports during winter months
- Conclusion: Precipitation based contracts could be used to hedge the economic exposure related to flight disruptions.

Where to from here?

Transparency

- Lack of consistent pricing is a major obstacle
  - Practitioners rely on data intensive numerical solutions.
  - Consistency of data – therefore consistency in price.

- Details of recent transactions are generally not publicised.
  - Contain significant proprietary value, i.e. data, models.
  - Protection of key personnel.
  - Hides the true market appetite for these products.

Data Issues

- Index development:
  - 3rd party – transparency
  - End user applications to analyse exposure.
- Free access to standardised data – EU
- Registered Weather Stations:
  - Particularly for primary industry applications where each location would require its own approved and monitored weather station.
  - Issue for the more discrete weather variables – i.e. precipitation

Thank You

Jon Tindall
email: jon.tindall@milliman.com