

The Nature and Use of Weather Derivatives

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Outline

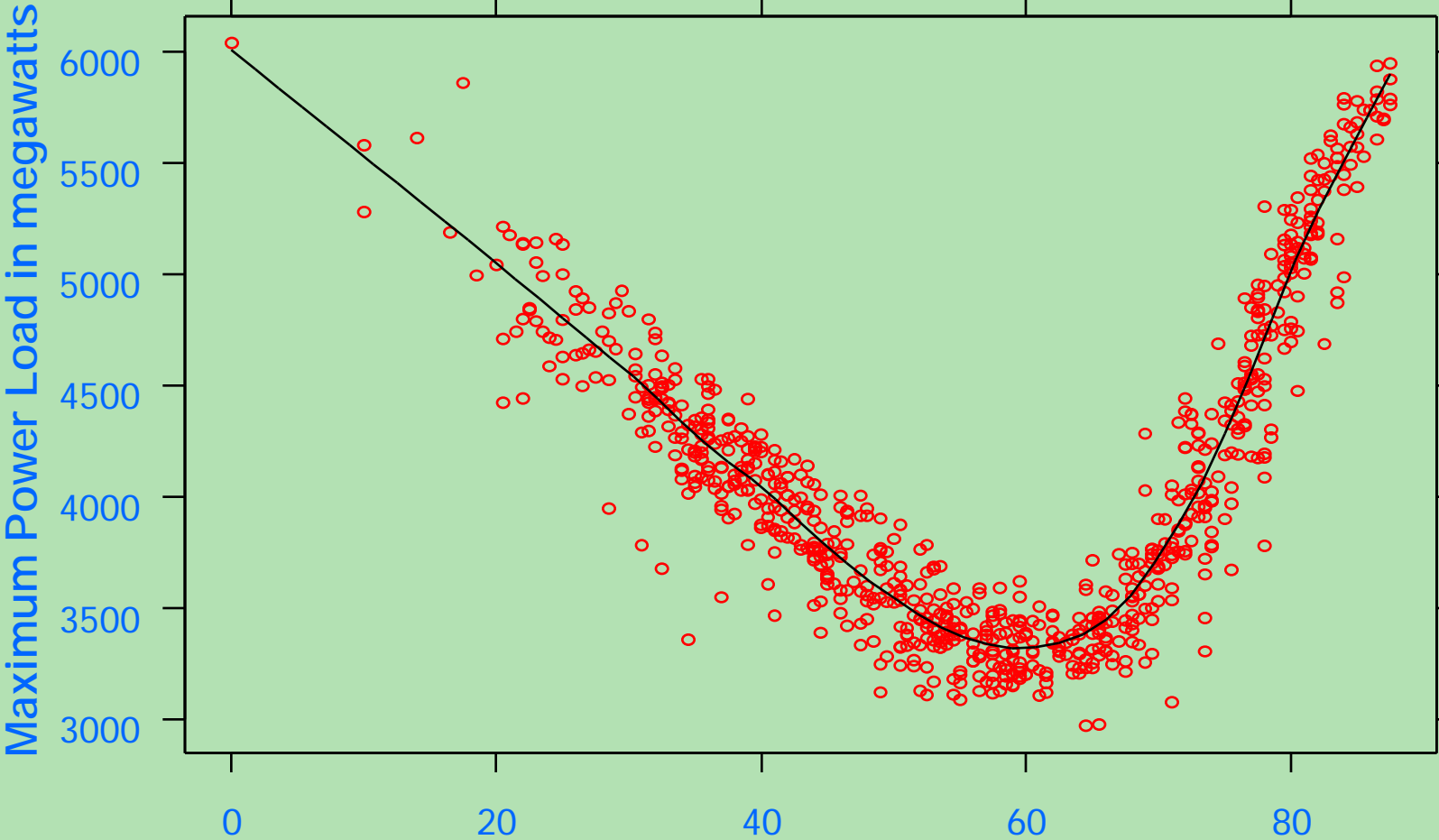
1. Describing the weather derivatives market
2. Introducing the weather derivatives contracts
3. Broader application in investments
4. Conclusions

The Markets

- * \$1 trillion of \$7 trillion U.S. GDP is affected by weather risks
- * Power and utility industry: quantity of electricity and natural gas sold largely depends on weather conditions
- * Agricultural products
- * Retail sectors
- * Recreational, travel, etc.

Maximum Power Load Vs Average Daily Temperature in Baltimore

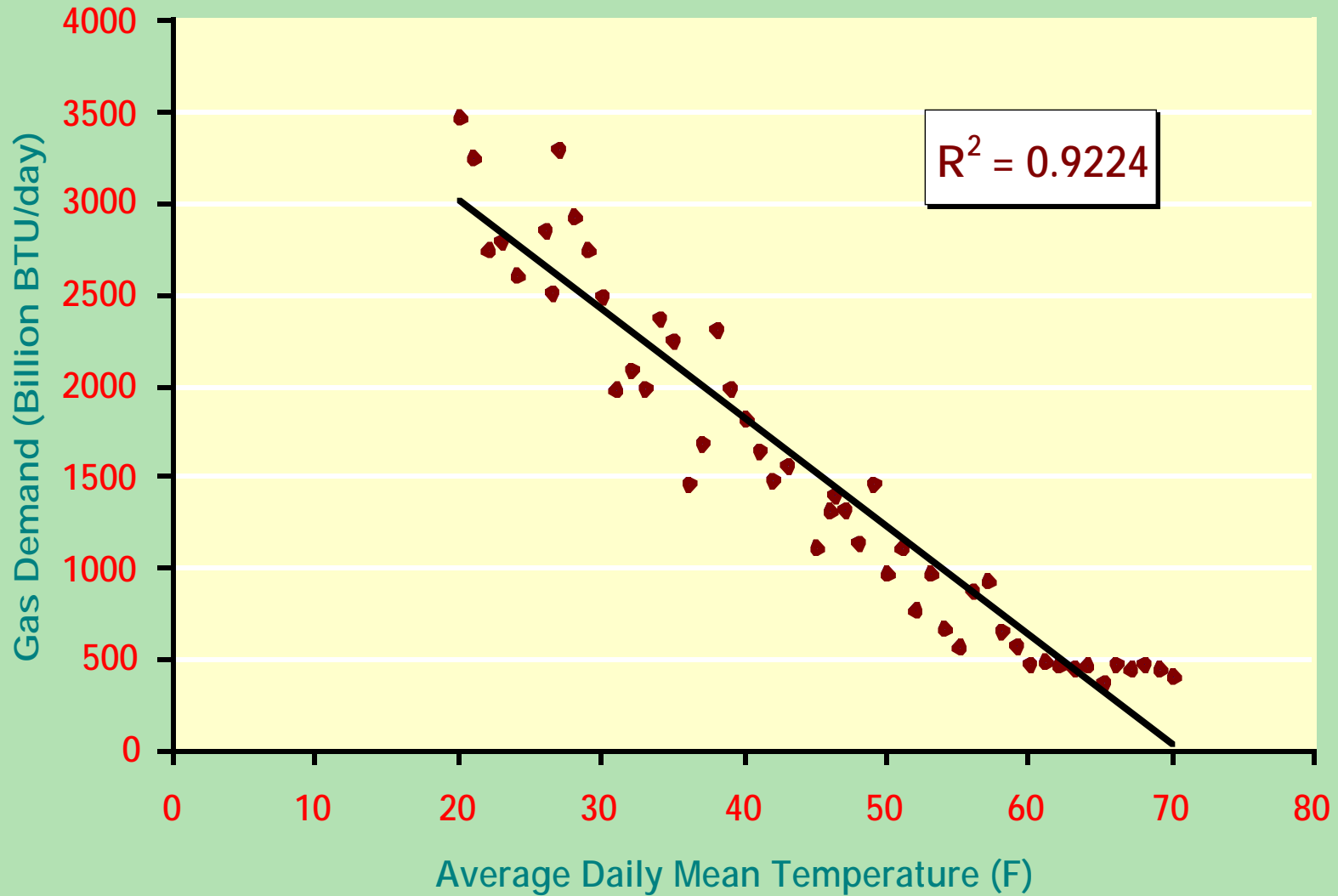
January 1993 - December 1995



Average Daily Temperature

Monthly Gas Demand Vs Temperature

Illinois Residential Customers 1/94 - 2/98



The Markets

- * Increasing competition
higher volatility in price and volume
more need for power companies
to stabilize revenues

- * For Example:

$$\text{Revenue} = \frac{\text{Electricity}}{\text{Price}} \times \frac{\text{Kilowatt Hours}}{\text{Sold}}$$

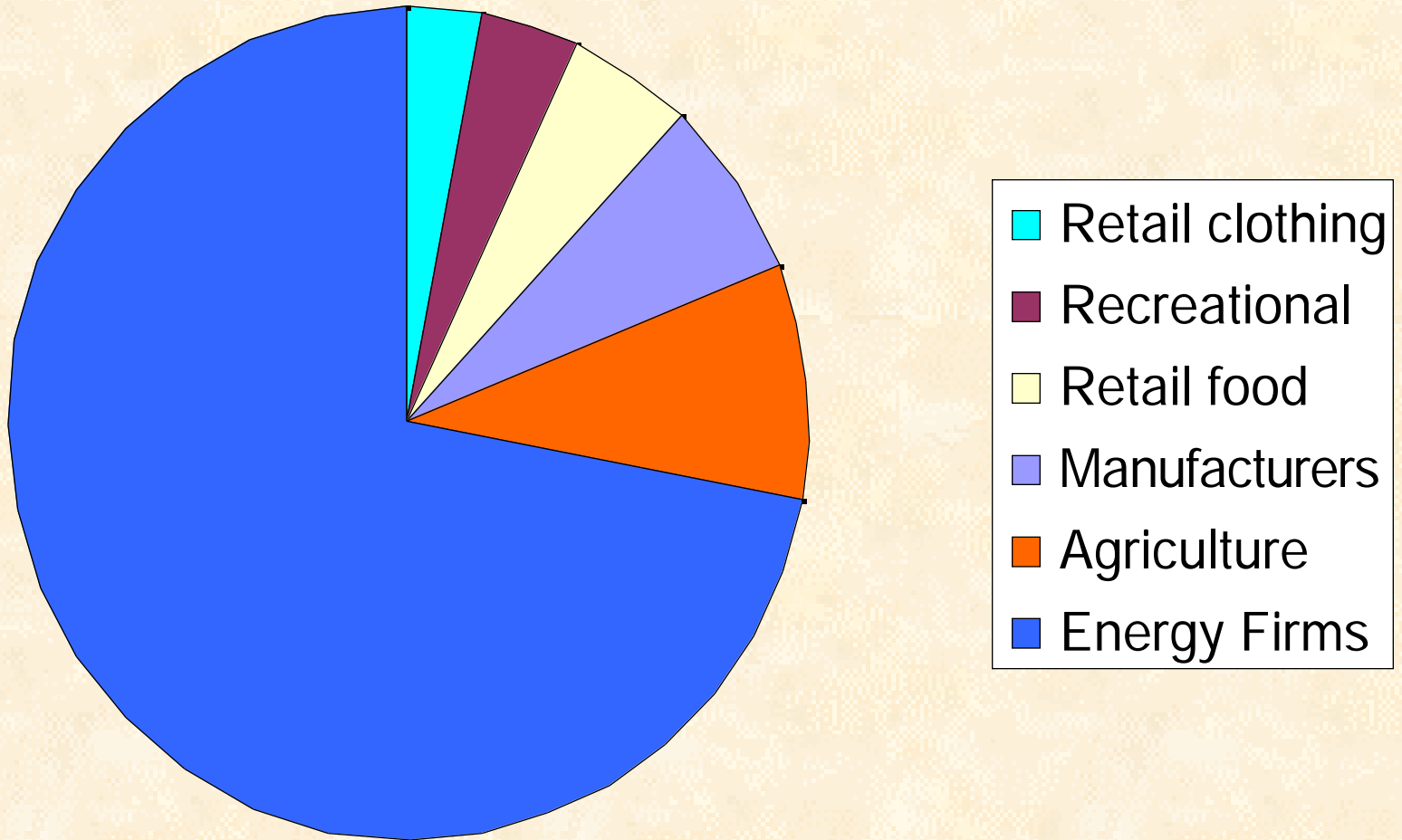
- Electricity contract: hedge price risk
- Weather derivatives: hedge volumetric risk

The Markets

Who use weather derivatives?

- * Utility firms (especially under deregulation)
- * Energy distributors
- * Agricultural firms
- * Insurance and reinsurance companies
- * Airlines, retailers, certain manufacturers
(e.g. inventory control for retailers, snow removal
for manufacturers)
- * Investment funds(?)

End Users



The Markets

Brief History:

Sept 1997: first degree-day deal between Enron and Koch

Winter 1997: El Nino, strong impact on U.S. economy

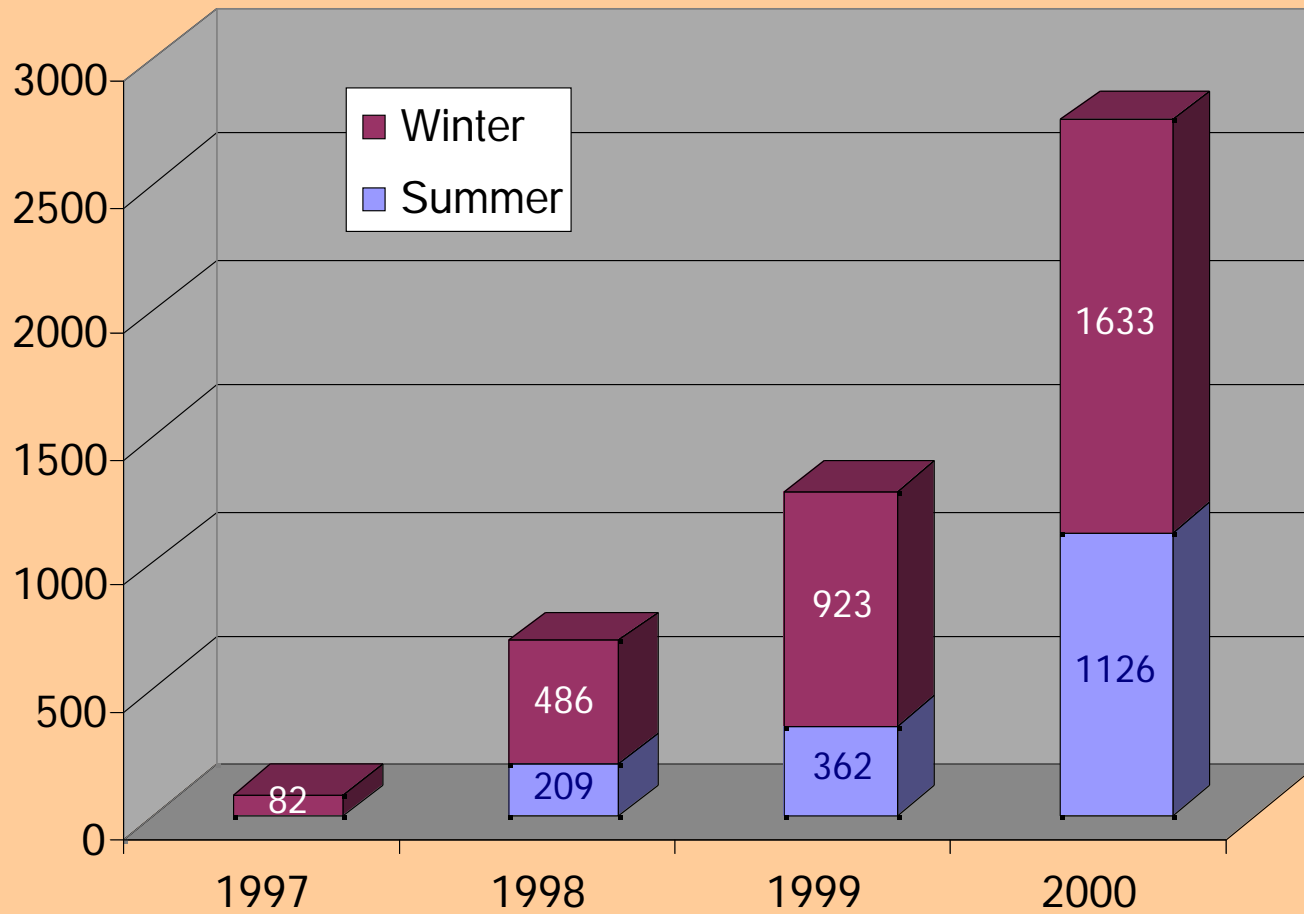
June 1999: Weather Risk Mgmt. Association (Wash. D.C.)

Sept 1999: first futures for degree-days on CME

Dec 1999: first online weather exchange, I-WeX (with LIFFE)

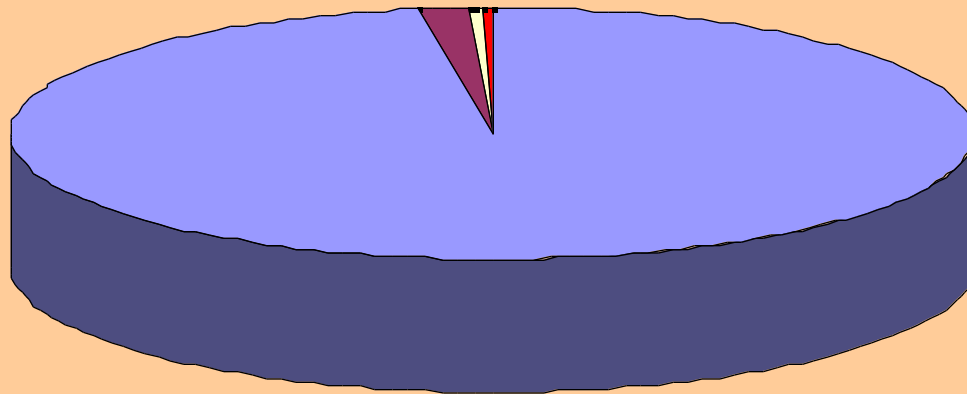
July 2001: LIFFE launched 3 temperature-based European weather indices (Berlin, Paris, London)

Weather Derivatives -- Market Growth (# of Trades)



Source: PricewaterhouseCoopers, June 2001

Cumulative Notional Value of Weather Contracts, 1998 - 2000 (millions)



■ US:	\$7,121
■ Europe:	\$120
■ Asia:	\$51
■ Australia:	\$2.5
■ Other:	\$12.2

The Markets

Why have the markets grown at different rates?

Big growth in US:

- + sophistication in financial mgmt
- + availability of high quality weather data (e.g. National Climate Data Center)
- + large seasonal variations in climate

Slow growth in Europe:

- + small variation in climate: "no summer in UK"
- + less use of air-conditioning
- + lack of high quality weather data

Asia, Australia: catching up

Canada: winter hibernation?

The Weather Variables

- * Temperature
- * Precipitation (rainfall and snowfall)
- * Wind speed
- * Humidity

The Weather Variables

Temperature-based variables

Heating Degree Days (HDD)

= max (0, 65 F - daily average temperature)

Cooling Degree Days (CDD)

= max (0, daily average temperature - 65 F)

Note: "daily average temperature" = (max + min) / 2

Monthly Accumulation of Heating Degree Day (HDD)

Date	Min Temperature	Max Temperature	Average Temperature	HDD
March 1	59F	63F	61F	4
March 2	60F	66F	63F	2
:	:	:	:	:
March 30	68F	72F	70F	0
March 31	70F	74F	72F	0
Total Monthly HDD				102

Monthly Accumulation of Cooling Degree Day (CDD)

Date	Min Temperature	Max Temperature	Average Temperature	CDD
July 1	80F	86F	83F	18
July 2	80F	88F	84F	19
:	:	:	:	:
July 30	84F	90F	87F	22
July 31	82F	88F	85F	20
Total Monthly CDD				346

The Weather Variables

Temperature-based variables: critical day events

Example: May 2000, Corney & Barrow (wine bar chain in London)

- * contract event: Thursdays and Fridays in the summer (June - September) where temp is below 24C
- * payoff: $\text{£}1500(24C - T)$ per day for up to $\text{£}15,000$ / day and $\text{£}100,000$ per summer
- * Pay a one-time premium for the contract

Other examples: restaurants on weekends

Types of Contract

- * Swaps
- * Forward contracts
- * Options (call / put)

Example of HDD-based Swap

HDD Swap (or Forward)

Purpose: Gas Ltd hedges against warm winter

Location / station La Guardia Airport, NY

User Gas Ltd (paying floating rate, receiving fixed rate)

Dealer Enron (paying fixed rate, receiving floating rate)

Accumulation Period January 1 - 31, 2001

Tick Size \$5,000 per HDD

Fixed Rate 1,000 HDD

Floating Rate The realized HDD: 956 HDD

Settlement at Maturity
(cash flow to user) $(1,000 - 956) \times 5,000$
= \$220,000

The Contract

Difference between weather derivatives and insurance:

1. Derivatives cover low-risk, high-probability events, while insurance covers high-risk, low-probability events (e.g. warm winter vs. earth quake)
2. Derivative holders do not have to file a claim and prove damages to receive a payout
3. A business can hedge against a competitor, but not insure against it
E.g., Orange grower in California can purchase weather options to hedge against bumper crop in Florida
4. A derivative can be undone, but insurance can't.

The Contract

Difference between weather derivatives and other financial derivatives:

1. Financial derivatives usually used to hedge price risk, while weather derivatives used to hedge volume risk
2. Weather derivatives' underlying is mother nature, free of manipulation; in contrast financial prices can be manipulated
3. Weather derivatives' underlying can be forecasted with certain degree of accuracy
4. Weather variables are not traded, so direct hedge for weather derivatives does not exist

Application in Investments

Diversification should be the major motivation
variance reduction keeping same return level
expand efficient frontier

Low liquidity and high bid-ask spread are
impediments taking large positions difficult.

Need organized changes and broader participation
by general investment community
potential solution: offer standard contracts
on temperature indices (such as LIFFE's)
rather than on specific cities temperature

What is the correlation level?

Correlation between Stock Market Index and Temperature

<u>Market Index</u>	<u>Location</u>	<u>Correlation</u>
NYSE Composite	New York	-0.0590
TSE300	Toronto	-0.0571
FTSE100	London	-0.0258
All Ordinaries	Sydney	-0.0068

Note:

1. Daily temperature and returns, Jan 1993 - Dec 1999
2. Negative correlation driven by winter days

Correlation of Returns between International Stock Market Indices

	NYSE Composite	TSE300	FTSE100	All Ordinary
NYSE Composite	1.0000			
TSE300	0.9930	1.0000		
FTSE100	0.9530	0.9467	1.0000	
All Ordinaries	-0.9414	-0.9358	-0.8864	1.0000

Note: Calculation based on monthly average returns and temperature, Jan 1993 - Dec 1999 (averaging over daily observations)

Correlation of Temperature between US Cities

	Atlanta	Chicago	Dallas	New York	Philadelphia
Atlanta	1.0000				
Chicago	0.8847	1.0000			
Dallas	0.8777	0.9038	1.0000		
New York	0.8966	0.8964	0.8443	1.0000	
Philadelphia	0.9125	0.8970	0.8455	0.9853	1.0000

Note: Daily temperature, Jan 1979 - Dec 1998

Correlation of Temperature between International Cities

	New York	Toronto	London	Sydney
New York	1.0000			
Toronto	0.9930	1.0000		
London	0.9530	0.9467	1.0000	
Sydney	-0.9414	-0.9358	-0.8864	1.0000

Note: Monthly average temperature, Jan 1993 - Dec 1999

Conclusions

- Effective instruments to hedge volume risk
- Growing markets
- Particular importance to energy / power companies
- Growing interests from other sectors (e,g, restaurants)
- Potential for augmenting investments funds
 - low correlation, high diversification benefits
 - no liquid market, must buy and hold
 - one-sided market (more buyers than sellers)
 - more awareness needed