Climate Change and the Time Series and Distributional Properties of Weather Factors Influencing California Viticulture

Don Cyr (Faculty of Business, Brock University, Canada, dcyr@brocku.ca), Robert Eyler and Michael Visser, (Department of Economics, Sonoma State University)


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Weather Contracts

What are Weather Contracts?
- Weather contracts are financial contracts such as options and futures with payoffs based on the observation of a weather variable at a government weather station. Weather contracts are useful in hedging the cost of weather related risks not typically covered by weather insurance.

How Do They Differ From Weather Insurance?
- Weather insurance is typically designed to cover major catastrophic weather events such as hail damage. Weather insurance involves filing a claim and providing proof of damage in order to be compensated.

History of Weather Contracts
- 1996: First weather contract based on temperature written between Enron Corporation and Koch Power and Light.
- 1998: Exceptionally warm winter weather sparks interest in weather contracts on the part of the energy industry.
- 1999: Chicago Mercantile Exchange starts trading standardized weather contracts on a few major US cities.
- 1999 – Weather Risk Management Association Established
- 2003 – Current: Over the Counter (OTC) market grows as financial intermediaries realize the potential size of the weather contract market and its usefulness to many firms and sectors.
- 2006: United Nations World Food Program purchases a US$ 900,000 contract to hedge against low rainfall in Ethiopia over the growing season that would ultimately lead to famine and the need for intervention.
- 2007: The Climate Corporation (formerly WeatherBill), an innovative online supplier of OTC market weather contract.
- 2010: CME starts trading rainfall contracts on nine US cities.

Over the Counter (OTC) Weather Contracts: Can be designed for very specific weather variables and locations.

Issues Remaining In the Use of OTC Weather Contracts
- What is the appropriate pricing model for a weather contract?
- What is the optimal design of a weather contract for a specialized use such as viticulture?
- What is the appropriate distributional assumptions for weather variable modeling?

Climate Change – Increasing Volatility of Weather

Viticulture – myriad of weather risks

The viticulture industry faces a variety of weather related risks which weather contracts could be used to hedge:

<table>
<thead>
<tr>
<th>Some Weather Related Risk Factors</th>
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<tr>
<td>Excessive Cold - Winter Damage</td>
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<tr>
<td>- Excessive Heat</td>
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<tr>
<td>- Frost</td>
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<tr>
<td>- Cool Rainy Conditions</td>
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<td>- Heavy Rain</td>
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<td>- Early Frost</td>
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November - March | April - May | June - August | Sept - Oct

Research Question – Has Climate Change Impacted the Stochastic Properties of Important Weather Related Measures (Growing Degree Days) for California Viticulture

DATA

Growing Degree Days: April to September 1960 – 2010

DISTRICTS
- Santa Barbara (5 weather stations)
- Napa (2 stations)
- Sonoma (5 stations)

Time Series Analysis with outlier (pulse and Level shift) detection analysis

RESULTS

Notable changes in stochastic process of growing degree days:
- Statistically significant level shift (Sonoma, Santa Barbara)
- Significant increase in volatility and time series pulse outlier from late 1980’s to early 1990’s onward.

Modelling of weather variables for pricing of weather contracts may best be captured with a mixed jump diffusion process due to increase in extreme, seasonally based, weather events.