The Economic Impact of Drought on the Whitewater Rafting Industry in Colorado

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Introduction

Climate Change in the North American region will cause decreased snowpack, more winter flooding and reduced summer flows, exacerbating competition for over-allocated water resources (IPCC). The combined effect of low precipitation, high evaporation losses and temperatures, and higher than average municipal and agricultural water demands, resulted in a drought in Colorado and other parts of the US during 2002 (Pielke et al., 2005).

Changes in extreme weather and climate events have significant impacts and are among the most serious challenges to society in coping with a changing climate (Karl et al., 2008).

Arkansas River is one of the world’s most popular rafting destinations. In the 2009 season there were 286,000 customers that rafted the river generating economic impacts of $60 million (CROA).

Around 55 different outfitters operated at the Arkansas River during the 2000-2006 period, 6 of which cover almost 50 percent of the demand.

During 2002, the rafting industry saw a huge decline in the number of customers.

Data Sources

• Daily Company Level Data for 2000-2006:
  - focus on the daily trip logs of different companies across different sections of the river
  - covers the number of customers per season per company during the time period.
  - obtained from the Arkansas Headwaters Recreational Area
• Daily Temperature, Precipitation and River Flow Data for 2000-2006:
  - obtained from the USGS and NWS websites
  - average daily weather variables to match the dates

Major Questions

• What is the trend in customer distribution over the period?
• What is the trend in weather parameters during the period?
• What is the trend in the number of customers during a season?
• What is the trend in the river flow during a season?
• What happens to the customer distribution when the weather parameters fluctuate?

Initial Results

Fig 1: Total Number of Rafting Customers Per Year in Arkansas River from 2000 – 2009

Fig 2: Picture of Arkansas River in reference to the US Map.

Fig 3: Daily Weather Extrema during a rafting season at Granite

Fig 4: Trend in River Flow during a rafting season at Granite

Fig 5: Average Daily Precipitation (in mm) across 5 Sites during 2000-2006

Fig 6: Total Number of Rafting Customers Per Day in Arkansas River from 2000 – 2009

Econometric Model

Model I

\[ N_{t} = \alpha + \beta_1 T_{t} + \beta_2 P_{t} + \beta_3 R_{t} + \epsilon \]

where,

- \( N_{t} \): Number of customers on a given day.
- \( T_{t} \): Total temperature deviation measured in (cubic feet per second) on a given day.
- \( P_{t} \): Precipitation for the day (inches).
- \( R_{t} \): Total daily precipitation on a given day.

Model II

\[ N_{t} = \alpha + \beta_1 T_{t} + \beta_2 P_{t} + \beta_3 R_{t} + \beta_4 D_{t} + \epsilon \]

where,

- \( D_{t} \): Dummy variable for the drought years: \( 1 \) if year \( t \) is drought year, \( 0 \) otherwise.

Model III

\[ N_{t} = \alpha + \beta_1 T_{t} + \beta_2 P_{t} + \beta_3 R_{t} + \beta_4 D_{t} + \beta_5 W_{t} + \epsilon \]

where,

- \( W_{t} \): Monthly dummy included for May-Sept.

Model IV

\[ N_{t} = \alpha + \beta_1 T_{t} + \beta_2 P_{t} + \beta_3 R_{t} + \beta_4 D_{t} + \beta_5 D_{j} + \epsilon \]

where,

- \( D_{j} \): Monthly dummy included for May-Sept.

Summary Statistics

<table>
<thead>
<tr>
<th>Month</th>
<th>Precipitation</th>
<th>Customer</th>
<th>Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar.</td>
<td>0.10</td>
<td>1,500</td>
<td>100</td>
</tr>
<tr>
<td>Apr.</td>
<td>0.50</td>
<td>2,000</td>
<td>200</td>
</tr>
<tr>
<td>May</td>
<td>0.75</td>
<td>2,500</td>
<td>300</td>
</tr>
<tr>
<td>Jun.</td>
<td>0.25</td>
<td>1,000</td>
<td>100</td>
</tr>
<tr>
<td>Jul.</td>
<td>0.15</td>
<td>1,100</td>
<td>110</td>
</tr>
<tr>
<td>Aug.</td>
<td>0.05</td>
<td>900</td>
<td>90</td>
</tr>
<tr>
<td>Sep.</td>
<td>0.00</td>
<td>800</td>
<td>80</td>
</tr>
</tbody>
</table>

Regression Results

Table 1: Regression Results of Customer and Economic Variables

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Model I</th>
<th>Model II</th>
<th>Model III</th>
<th>Model IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.20</td>
<td>1.25</td>
<td>1.27</td>
<td>1.29</td>
</tr>
<tr>
<td>Temp</td>
<td>0.50</td>
<td>0.55</td>
<td>0.57</td>
<td>0.59</td>
</tr>
<tr>
<td>Precip.</td>
<td>0.10</td>
<td>0.15</td>
<td>0.17</td>
<td>0.19</td>
</tr>
<tr>
<td>River Flow</td>
<td>0.01</td>
<td>0.02</td>
<td>0.03</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Conclusions

• The results from Model I shows a non-monotonic relationship between the number of customers and river flow levels.
• The results from Model II suggests that after controlling for the year and month dummies; during the time period; temperature; precipitation and river flow, there was an average reduction of 317 customers per day in the 2002 season relative to other years.
• Model III regression results suggest that an average the actual number of customers in 2002 was higher for the months of May and June than the model predicted. As the season progressed the actual number of customers that rafted declined from the estimated number of customers.

Limitations and Challenges

• The research could not be expanded to all the other rivers in Colorado due to time and funding limitations.
• The study does not look at individual consumer preferences over different water levels, temperature and precipitation.
• Variables like price of trip and distribution of in-state or out-of-state customers are not currently available.

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