Geographic Analysis of Product Warranty Data

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Background

• Location is an obvious factor in most warranty analysis projects.

• Geographic analysis of warranty information is a unique application of GIS and can provide valuable insight into product problems that cannot be achieved via spreadsheet methods.

• GIS enables linking of product warranty information with factors inherent to the geography in which products are used.
Pretend that you are the new CEO of Durable Beach Ball Company (DBBC)…

• Every working day is like a day at the beach.
  – Sales are growing 20% per year.
  – Profits are growing faster!
  – Product quality is high. Only a few percent of beach balls are ever returned for durability issues.
  – DBBC just introduced fifteen new beach ball models this spring.
  – Introduced a new warranty policy of seven carefree summers with your beach ball or DBBC will provide a new ball for free. The prior warranty policy was one year of coverage.
Key Business Characteristics…

• DBBC controls its own distribution to end sellers. You know exactly where your beach balls are being sold.
• DBBC Warranty returns department reviews all beach balls sent back for repair. Publishes a monthly report on problems, repair rates, and warranty costs.
• Each beach ball has its own serial number.
• DBBC is based in Minnetonka, MN.
• Life is Good!
Then the phone rings…

• Main retailer in Indonesia is having problems with your beach balls.

• Balls are being returned to the store where the balls were purchased for a “slow leak” condition. The beach balls are somehow deflating in four – five hours after full inflation.
You React …

• It must be a local problem?! There have *never* been problems in Indonesia in the past.
• Florida has always been *ok*. California too.
• No big problems in Acapulco or Cancun.
• All quiet in Turkey and Antarctica.
• Once there was a small problem in Brazil and Australia once, but it went away.
• Or at least you *thought* the problem went away...
Gather Data

- You instruct the quality department to gather all the sales and warranty returns information **globally** for the last ten years.
- You ask the quality department to look for “anomalies.”
Map the Results

• Your quality department is smart and decides that instead of using a spreadsheet to evaluate the warranty data that this time they will use their newly purchased GIS to make the map.
• Sales Map – counts by country
• Returns Map – counts by country
Sales by Country
Returns by Country
Do the Maps Make Sense?

- Sales and returns data suggest that the biggest problems are in the United States, Brazil, India, China, and Russia. These countries are where most of the beach balls are sold.
- You instruct the quality department to make a new map, but this time using a statistical approach to analyze the returns.
Return Rate/1000 Sold by Country
Chi-Squared Residuals*

- CS = (Observed – Expected) / Sqrt (Expected)
- Assume a uniform distribution of returns based on sales.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Sales</th>
<th>% of Sales</th>
<th>Returns</th>
<th>% of Returns</th>
<th>Expected</th>
<th>Delta</th>
<th>% More Than Expected</th>
<th>CS Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Indonesia</td>
<td>471,186</td>
<td>4.2%</td>
<td>7,657</td>
<td>5.3%</td>
<td>5,969</td>
<td>1,688</td>
<td>28.3%</td>
<td>21.85</td>
</tr>
<tr>
<td>2</td>
<td>South Africa</td>
<td>101,585</td>
<td>0.9%</td>
<td>1,748</td>
<td>1.2%</td>
<td>1,287</td>
<td>461</td>
<td>35.8%</td>
<td>12.85</td>
</tr>
<tr>
<td>3</td>
<td>Nigeria</td>
<td>243,072</td>
<td>2.1%</td>
<td>3,718</td>
<td>2.6%</td>
<td>3,079</td>
<td>639</td>
<td>20.7%</td>
<td>11.51</td>
</tr>
<tr>
<td>4</td>
<td>India</td>
<td>2,236,522</td>
<td>19.8%</td>
<td>29,930</td>
<td>20.9%</td>
<td>28,330</td>
<td>1,600</td>
<td>5.6%</td>
<td>9.51</td>
</tr>
<tr>
<td>5</td>
<td>Argentina</td>
<td>84,492</td>
<td>0.7%</td>
<td>1,373</td>
<td>1.0%</td>
<td>1,070</td>
<td>303</td>
<td>28.3%</td>
<td>9.25</td>
</tr>
<tr>
<td>6</td>
<td>Guinea</td>
<td>156,050</td>
<td>1.4%</td>
<td>2,387</td>
<td>1.7%</td>
<td>1,977</td>
<td>410</td>
<td>20.7%</td>
<td>9.22</td>
</tr>
<tr>
<td>229</td>
<td>Norway</td>
<td>10,821</td>
<td>0.1%</td>
<td>10</td>
<td>0.0%</td>
<td>137</td>
<td>-127</td>
<td>-92.5%</td>
<td>-10.82</td>
</tr>
<tr>
<td>230</td>
<td>Vietnam</td>
<td>178,038</td>
<td>1.6%</td>
<td>1,702</td>
<td>1.2%</td>
<td>2,255</td>
<td>-553</td>
<td>-24.5%</td>
<td>-11.65</td>
</tr>
<tr>
<td>231</td>
<td>Finland</td>
<td>12,578</td>
<td>0.1%</td>
<td>12</td>
<td>0.0%</td>
<td>159</td>
<td>-147</td>
<td>-92.5%</td>
<td>-11.67</td>
</tr>
<tr>
<td>232</td>
<td>Sweden</td>
<td>21,821</td>
<td>0.2%</td>
<td>21</td>
<td>0.0%</td>
<td>276</td>
<td>-256</td>
<td>-92.5%</td>
<td>-15.37</td>
</tr>
<tr>
<td>233</td>
<td>Canada</td>
<td>71,006</td>
<td>0.6%</td>
<td>68</td>
<td>0.0%</td>
<td>899</td>
<td>-832</td>
<td>-92.5%</td>
<td>-27.73</td>
</tr>
<tr>
<td>234</td>
<td>Russia</td>
<td>379,569</td>
<td>3.4%</td>
<td>363</td>
<td>0.3%</td>
<td>4,808</td>
<td>-4,445</td>
<td>-92.5%</td>
<td>-64.11</td>
</tr>
</tbody>
</table>

Chi-Squared Residuals by Country
Chi-Squared Residuals Histogram

Percent of Total Countries

Residual

Understand the Cause

- Connect beach ball durability to factors related to the environments in which beach balls are used.
- Typical usage environments – beach, stadium, indoors…
- Color of the beach ball, color of the beach sand, solar conditions, pollution, water quality, localized shark activity.
Ultra Violet Exposure Conditions

Source: NASA, Total Ozone Mapping Spectrometer
Connect

• Overlay maps of returns and residuals with the ultra violet exposure map.
• GIS enables you to connect your product returns data to a wide range of environmental data.
UV and Return Counts

Beach Ball Returns UV Irradiance
(Units) (mW/m²)
- 0 - 572
- 573 - 1,790
- 1,791 - 3,527
- 3,528 - 7,900
- 7,901 - 21,030
- 21,031 - 72,687

- 0 - 60
- 60 - 120
- 120 - 180
- 180 - 240
- 240 - 300
- 300 - 360
- 360 - 420
- > 420

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UV & CS Residuals
Assess The Area Affected

• What proportion of the beach ball market is affected by high levels of UV?

• Are we testing our products the way that they are used in the market?

• Link beach ball sales volumes to UV levels.
Sales and UV Level

Beach Ball Sales
(Units)
- 0 - 17,612
- 17,613 - 55,087
- 55,088 - 108,527
- 108,528 - 243,072
- 243,073 - 647,083
- 647,084 - 2,236,522

UV Irradiance
(mW/m²)
- 0 - 60
- 60 - 120
- 120 - 180
- 180 - 240
- 240 - 300
- 300 - 360
- 360 - 420
- > 420
Connect Sales to UV Level

[Image of ArcToolbox interface with selected 'Extract Values to Points' tool and corresponding window showing the input and output settings.]

- Input point features: Beach Ball Sales
- Input raster: UV Irradiance
- Output point features: C:sales_to_uv.shp
- Interpolate values at the point locations (optional)
- Append all the input raster attributes to the output point features (optional)

[Image of ArcGIS software interface showing the ArcToolbox window with the 'Extract Values to Points' tool expanded.]
## Resulting Table

<table>
<thead>
<tr>
<th>CNTRY NA_1</th>
<th>SALES</th>
<th>RETURNS</th>
<th>RASTERVALU</th>
<th>RNDRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesia</td>
<td>471186</td>
<td>15314</td>
<td>32</td>
<td>29</td>
</tr>
<tr>
<td>Iran</td>
<td>160484</td>
<td>5216</td>
<td>27</td>
<td>1</td>
</tr>
<tr>
<td>Iraq</td>
<td>52354</td>
<td>1702</td>
<td>27</td>
<td>1</td>
</tr>
<tr>
<td>Ireland</td>
<td>12540</td>
<td>408</td>
<td>27</td>
<td>1</td>
</tr>
<tr>
<td>Isle of Man</td>
<td>178</td>
<td>6</td>
<td>27</td>
<td>1</td>
</tr>
<tr>
<td>Israel</td>
<td>14237</td>
<td>463</td>
<td>27</td>
<td>1</td>
</tr>
<tr>
<td>Italy</td>
<td>144772</td>
<td>4705</td>
<td>27</td>
<td>1</td>
</tr>
<tr>
<td>Jamaica</td>
<td>6049</td>
<td>106</td>
<td>27</td>
<td>1</td>
</tr>
</tbody>
</table>

Record: 102

Show: All, Selected

Records (1 out of 248 Selected.)
Summarize on UV Level
Additional Methods: Higher Resolution Analysis

- Repeat the analysis, but this time just for Indonesia.
- Is there a specific location where the problem seems to peak?
- By understanding the characteristics of the “worst” location you can design a more robust product.
- Are the results what you expected?
Additional Methods: Time

• Is there a seasonal issue with beach ball failure?
• You may need to create an animation of the warranty returns by time and location.
• Could the UV dose be cumulative?
Caveats and Pitfalls

• Data, Data, Data…
• Data quality and quantity issues may be a problem.
• Levels of aggregation too course/too fine (Modifiable Areal Unit Problem – MAUP).
• Data from multiple sources may not be easy to integrate.
• It may take time to complete the analysis.
Data, Better Data, and Good Data

• What do you want to know?
  – Repair location?
  – Repair rate?
  – Cost per unit sold?
  – Changes in problem extent in time and space?

• Depending on the completeness and accessibility of your corporate sales and warranty information you may or may not be able to easily create maps of repair locations and warranty rates.
Other Examples of Geographic Warranty Analysis

- Automotive Industry
- Building Products Industry
- Human Health
Summary: Benefits of a Geographic Approach to Warranty Analysis

• Potentially limit total costs associated with fixing a field issue. Reduced warranty costs in the future.
• Enables understanding of the condition(s) leading to the field issue(s).
• Better understanding of where your products may not be meeting customer requirements.
• Long term customer satisfaction improvement if future products are designed to better tolerate customer usage conditions.
References

1. Dykes, Jason and David Unwin, Maps of the Census: A Rough Guide, 1998, Department of Geography, University of Leicester, United Kingdom
   http://www.geog.le.ac.uk/jad7/AGOCG/
2. Environmental Systems Research Institute (ESRI), 2005 USA