Optimizing the Shopping Center Mix: A GIS based Analysis

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Motivation

‘Ironically, real estate as a discipline espouses the supremacy of location while employing economic tools designed for a spaceless world.’

Source: Dubin, Pace and Thibodeau (1999)

- Shopping centers ‘suggest’ the GIS-use – due to monitoring customers’ behavior
- Two of the main problems of Shopping Center management: The optimization of the tenant mix at all and the arrangement of shops by a given optimal tenant mix

Central scope of this study is
‘to solve the problem of the ideal tenant placement within the shopping centers by using GIS analysis’
1 Literature Review

Category Concentration (Carter/Haloupek 2002; Yuo 2010)
- Non-anchor stores of the same retail category tend to be dispersed
  ⇒ GIS can identify a concentration of retail categories within the shopping center

- The pass ratio declines from the center of a shopping center
  ⇒ GIS can identify ‘dead spots’ within the shopping center

Coupling Potential (Brown 1992, Yuo 2004)
- Shops of the same retail category have a higher coupling potential than those of different
- Proximity of shops suggests a higher coupling potential
  ⇒ GIS can identify coupling potentials within the shopping center
2 Research Design and Results: Data

Attribute Data

- German Shopping Center with about 60,000 m² selling space and about 140 shops

- Customer survey: N = 1,163
  - Survey of the coupling potential: Customer had to draw their routes
    \[ n \times n \text{ coupling matrix (customer shopping sequence is not regarded)} \]

Geometric Data

- Polyline network \(\Rightarrow\) ArcGIS 'Network Dataset'

Integration of customer survey data into GIS (spatial database)

\[ \Rightarrow \text{A GIS connects non-spatial database information with a matching geometry} \]
2 Research Design and Results: Category Concentration

‘Non-anchor stores of the same retail category tend to be dispersed’

Clumping method (OKABE/FUNAMOTO 2000)
- Radius: 16.5 m
- Overlapping of Buffer as decision criterion
- Min. 3 shops of the same category
- NACE classification (47)
  ⇒ Clump

Results
- Food-cluster (47.2)
- Fashion-cluster (47.5)
- Body & health-cluster (47.7)
Kernel Density Estimator

- Integration over an area
- Volume above the area represents the probability of customer-presence

The higher the probability surface the higher the customer density

⇒ GIS-enables to detect ‘dead spots’
'The pass ratio declines from the center of a shopping center'
Research Design and Results: Pass Ratio (3)

‘The pass ratio declines from the center of a shopping center’

Passersby frequency and distance from mall-center (mall sections)

\[ y = 0.3524 - 0.001x \]

\[ R^2 = 0.1822 \]

\[ p\text{-Value} = 0.001 \]
‘Shops of the same retail category have a higher coupling potential than those of different’
‘Spatially proximate shops have a higher coupling potential than spatially separate shops’

<table>
<thead>
<tr>
<th></th>
<th>All Retailers</th>
<th></th>
<th>Retailers with other goods</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Similar Shop</td>
<td>Dissimilar Shop</td>
<td>Similar Shop Type</td>
<td>Dissimilar Shop Type</td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td>Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatially Proximate</td>
<td>132,0</td>
<td>83,7</td>
<td>30,8</td>
<td>66,2</td>
</tr>
<tr>
<td>Spatially Separate</td>
<td>143,2</td>
<td>105,2</td>
<td>66,7</td>
<td>84,9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Food</th>
<th></th>
<th>Fashion</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Similar Shop</td>
<td>Dissimilar Shop</td>
<td>Similar Shop Type</td>
<td>Dissimilar Shop Type</td>
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<tr>
<td></td>
<td>Type</td>
<td>Type</td>
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<tr>
<td>Spatially Proximate</td>
<td>69,1</td>
<td>75,6</td>
<td>198,4</td>
<td>94,4</td>
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<tr>
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<td>36,5</td>
<td>71,4</td>
<td>217,8</td>
<td>122,5</td>
</tr>
</tbody>
</table>

Cutting value for proximate: Mean value of shop-to-shop distance = 127.6 m
Value standardization: Mean value of coupling potential = 100
### Discussion

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Non-anchor stores of the same retail category</strong> tend to be dispersed</td>
<td>![X]</td>
</tr>
<tr>
<td>⇒ based on the clumping approach food, fashion and body &amp; health stores tend to be clustered – due to the complex SC floorplan (c.f. Yuo 2010)</td>
<td>![X]</td>
</tr>
<tr>
<td><strong>The pass ratio</strong> declines from the center of a shopping center</td>
<td>![✓]</td>
</tr>
<tr>
<td>⇒ Regression, kernel density estimation and visual analysis of the pass ratio confirm a decline of the pass ratio from the mall-center</td>
<td>![✓]</td>
</tr>
<tr>
<td><strong>Shops of the same retail category</strong> have a higher coupling potential than those of different</td>
<td>![−]</td>
</tr>
<tr>
<td>⇒ The results of Brown 1992 cannot be confirmed for all retail categories (e.g. food)</td>
<td>![−]</td>
</tr>
<tr>
<td><strong>Proximity of shops</strong> suggests a higher coupling potential</td>
<td>![−]</td>
</tr>
<tr>
<td>⇒ The results of Brown 1992 can only be for the examined category food</td>
<td>![−]</td>
</tr>
</tbody>
</table>
Methodic perspective:

- GIS-use simplifies sophisticated (spatial) SC analyses, like clumping method or kernel density estimator
  - GIS-use is the basic tool to automate the SC research and thus ideal tenant arrangement

- An integration of the dimension ‘time’ is neccessary

Content perspective:

- **Data Survey:** Automated survey of passersby frequency
- **Sample:** Number of assessed Shopping Centers has to be extended
- **Target Variable:** The results have to be confirmed by focusing rental data

**GIS can be assessed as a fundamental application to analyze and optimize the shopping center mix within the shopping center research**
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Georeferenced Shopping Center Plan

Digital Floor Plan & Network

Spatial Database
- Coupling Matrix
- Distances
- Shop Sizes
- Retail Categories
- Central Point

Presentation / Visualization
- Network Statistics
- Regression
- Kernel Density Estimator

Analysis

Modell Builder / Route Solver

Customer Survey

Analogue Routes

Digital Waypoints

Digital Routes

Customer Flow

Other Sources of Information

Retailer Survey

INPUT MANAGEMENT
\[
\hat{f}_{K,h}(x) = \frac{1}{nh} \sum_{i=1}^{n} K_i(x)
\]

\textbf{K: Kernel function} \hspace{1cm} \textbf{n: Sample size} \hspace{1cm} \textbf{h: Bandwidth}

The kernel function is:

\[
K_i(x) = 3\pi^{-1} \left(1 - \left(\frac{x-x_i}{h}\right)^2\right)^2 \quad \text{if } \left(\frac{x-x_i}{h}\right)^2 < 1
\]

\[
K_i(x) = 0 \quad \text{otherwise}
\]

\[x_i: \text{Location of } \text{i}^{\text{th}} \text{ observation}\]
\[ \hat{C}_{ij} = \beta_{0j} + \beta_j \cdot C_{i+} \]

\( \hat{C}_{ij} = \text{estimated coupling between shops } i \text{ and } j \)
and \( i \neq j \)

The residuals of this regression provide information about the relative coupling behavior.

\[ \varepsilon_{ij} = C_{ij} - \hat{C}_{ij} \]

\( \hat{C}_{ij} = \text{estimated coupling between shops } i \text{ and } j \)
\( C_{ij} = \text{observed coupling between shops } i \text{ and } j \)
\( \varepsilon_{ij} = \text{Residual value} \)
and \( i \neq j \)
Source: Okabe/Funamoto 2000

Back Up
Table 1. Critical numbers $n_i^*(r_j)$ of clumps with respect to a clump size $i = 1, \ldots, 10$ and a clump radius $r_j, j = 1, \ldots, 16$ in a 1000m by 1000m square

<table>
<thead>
<tr>
<th>$r_j$</th>
<th>$i = 2$</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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<tbody>
<tr>
<td>0.00</td>
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</table>

Source: Okabe/Funamoto 2000