Inter-district Migration Patterns and Trends
Within the City of Berlin, Germany

by

Michael Tiefelsdorf
Department of Geography
The Ohio State University
Columbus, Ohio, 43210
U.S.A.
tiefelsdorf.1@osu.edu

Gerhard O. Braun
Department of Geography
Free University of Berlin
Malteserstr 74-100
12249 Berlin
Germany

A copy of this presentation can be viewed at http://geog-www.sbs.ohio-state.edu/faculty/tiefelsdorf/berlinmig
Introduction

Key Research Questions:

- Are the two migratory sub-systems in the Eastern and Western parts of unified Berlin converging towards a joint equilibrium?
- Is the underlying urban structure reflected in the internal urban migration pattern?

Data:

- Internal annual migration among the 23 districts of Berlin for the accounting years 1991 to 1997

Background

- Closed system perspective, i.e., neglecting of external migration patterns

Method

- Log-linear modeling within the doubly constrained gravity framework accounting for time, distance and migratory subsystems
- Residual analysis with respect to the underlying urban structure
Definition of the Migratory Subsystems

- The annual migration tables

\[
\begin{pmatrix}
0 & m_{E\rightarrow E} & m_{E\rightarrow W} \\
m_{E\rightarrow E} & 0 & m_{W\rightarrow W} \\
m_{W\rightarrow E} & m_{W\rightarrow W} & 0
\end{pmatrix}
\]

among the 23 districts of Berlin can be logically been broken up into four sub-tables, each reflecting a distinct spatial interaction subsystem.

- Analyzing these four subsystems simultaneously allows investigating whether both parts of Berlin are converging towards a joint equilibrium after the unification.

<table>
<thead>
<tr>
<th>Subsystems</th>
<th>Spatial Partitions</th>
<th>Table Partitions</th>
</tr>
</thead>
</table>
| **East⇌East:** | ![Diagram](EastEastDiagram.png) | \[
\begin{pmatrix}
0 & m_{E\rightarrow E} & 0 \\
m_{E\rightarrow E} & 0 & 0 \\
0 & 0 & 0
\end{pmatrix}
\] |
| - $\overline{d}_{E\rightarrow E} = 9.9$ km |
| - 11 districts |
| **West⇌West:** | ![Diagram](WestWestDiagram.png) | \[
\begin{pmatrix}
0 & 0 & m_{W\rightarrow W} \\
0 & 0 & m_{W\rightarrow W} \\
0 & m_{W\rightarrow W} & 0
\end{pmatrix}
\] |
| - $\overline{d}_{W\rightarrow W} = 9.8$ km |
| - 12 districts |
| **East⇌West:** | ![Diagram](EastWestDiagram.png) | \[
\begin{pmatrix}
0 & 0 & m_{E\rightarrow W} \\
0 & 0 & 0 \\
0 & 0 & 0
\end{pmatrix}
\] |
| - $\overline{d}_{E\rightarrow W} = 14.8$ km |
### Specification of the Migration Model

- The internal migration within each district are excluded by *structural zeros*
- *Origin and destination constraints* have been imposed so that the estimate in-migration and out-migration figures match the empirical observed ones.
- The effect-coding scheme has been employ to allow comparison of the estimated parameters with respect to the grand-mean.
- The indices of the four-way interaction table are
  - $i$ for the origin,
  - $j$ for the destination,
  - $s$ for the spatial subsystem, and
  - $t$ for the accounting period.
- The specification of the log-linear migration model is:
  \[
  \ln(\hat{\mu}_{ijs}) = \hat{\lambda} + \hat{\lambda}_i + \hat{\lambda}_j + \hat{\lambda}_s + \hat{\lambda}_{st} + \hat{\lambda}_{d} \cdot d_{ij} + \hat{\lambda}_{dij} \cdot d_{jj}
  \]

<table>
<thead>
<tr>
<th>$\hat{\mu}_{ijs}$</th>
<th>Dependent variable <em>estimated interaction</em> in the four-way table</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\hat{\lambda}$</td>
<td><em>Grand-mean</em> against which all variations are measured</td>
</tr>
<tr>
<td>$\hat{\lambda}_i$</td>
<td><em>Origin specific factor</em> (ensures the origin constraint $\hat{\mu}<em>{i+} = m</em>{i+}$)</td>
</tr>
<tr>
<td>$\hat{\lambda}_j$</td>
<td><em>Destination specific factor</em> (ensures the destination constraint $\hat{\mu}<em>{+j} = m</em>{+j}$)</td>
</tr>
<tr>
<td>$\hat{\lambda}_s$</td>
<td><em>Subsystem specific factor</em> captures the variation of each spatial subsystem around the grand-mean (ensures constraint $\hat{\mu}<em>{+s} = m</em>{+s}$)</td>
</tr>
<tr>
<td>$\hat{\lambda}_t$</td>
<td><em>Time specific factor</em> captures the variation of each accounting period around the grand-mean (ensures constraint $\hat{\mu}<em>{+t} = m</em>{+t}$)</td>
</tr>
<tr>
<td>$\hat{\lambda}_{st}$</td>
<td><em>Time-subsystem specific statistical interaction</em> captures the specific variation around an accounting period $t$ and spatial subsystem $s$</td>
</tr>
<tr>
<td>$\hat{\lambda}<em>{d} \cdot d</em>{ij}$</td>
<td><em>Overall distance term</em> with a distance co-variable</td>
</tr>
<tr>
<td>$\hat{\lambda}<em>{dij} \cdot d</em>{jj}$</td>
<td><em>Origin specific distance term</em> with $d_{jj} = d_{ij}$</td>
</tr>
</tbody>
</table>
Temporal Trends

- The population in both parts of the City of Berlin is decreasing since 1995.

- This is primarily due sub-urbanization, i.e., migration from the city into its surrounding periphery. For the first time do people in the Eastern and Western parts of the city have the choice to reside outside the city limits.

- This loss of population opens up new opportunities on Berlin's the real estate market and rental apartment sector. Consequently, the migration volume within the city is increasing as well.

- The migration volume within Berlin is systematically increasing since the unification

Parameter $\lambda_t$ of the log-linear migration model
Global and Origin-Specific Friction of Distance

- The distance is based on the district's population centroids (i.e., excluding lakes and forests).

- The estimated distance parameters $\hat{\lambda}_d$ and $\hat{\lambda}_{d|i}$ are measured overall accounting periods (1991–1997).

- The larger the distance, the less the propensity to migrate (i.e., $\hat{\lambda}_d = -0.11$).

- However, by breaking the global distance parameter into distance bands, some degree of non-linearity is apparent.

- The origin specific distance parameters $\hat{\lambda}_{d|i}$, $i \in \{1, \ldots, 23\}$, measure the district specific variation around the overall distance parameter $\hat{\lambda}_d$.

- Some Western districts indicate short range migration

- Most Eastern districts indicate longer range migration
Fusion of the East/West Migratory Subsystems

1. Research Question: Convergence Towards a Joint Equilibrium

**Overall Years**

- The internal, subsystem specific, base level migration propensity is larger than expected within the Eastern and the Western parts.
- Compared to the Eastern part people in the Western part are more mobile.
- In contrast, the interaction levels across the subsystem boundaries are below expectation. This indicates that *psychological barriers* are still present.

![Temporal Trends Graph](image_url)

- However, the gaps among the interaction within and across the subsystems are narrowing over time.

![Temporal Trends Graph](image_url)

- The estimated time-space interaction parameter $\hat{\lambda}_{st}$ captures the variation around each accounting period $\hat{\lambda}_t$ and spatial subsystem base levels $\hat{\lambda}_s$. 
2. Research Question: Impact of Urban Structure

Basic Assumptions:

- Migration decisions are not independent from the urban structure
- Migration decisions follow a spatial sequence within urban sectors
- Outward forces are usually stronger than inward forces

Consequences:

- A migration model that ignores the urban structure under-predicts the flows along the sectors. Therefore, the residuals are positive, i.e., $m_{ij} > \hat{\mu}_{ij}$.
- In contrast, residuals along concentric rings are negative, i.e., $m_{ij} < \hat{\mu}_{ij}$.

This mis-specification of the model can be tested by comparison of the average residual magnitude within each urban migration sub-graphs.
**Specification of Sektorial Centrifugal Links**

- Theoretical considerations help to determine from all possible links a subset of links in accordance with the underlying urban theory.

---

**Temporal Trends in the Centrifugal Network Residuals**

- The 506 residuals of the full network have a mean of zero.
- Do the selected residuals of the centrifugal network exhibit a specific pattern in line with the urban structure?

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean of Residuals</th>
<th>observed Moran's $I_0$</th>
<th>Normal approximation (z-score)</th>
<th>exact probability Pr($I$&lt;$I_0$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>-0.3419</td>
<td>0.2209</td>
<td>1.7666</td>
<td>0.9531</td>
</tr>
<tr>
<td>1992</td>
<td>-0.2566</td>
<td>0.4614</td>
<td>3.6737</td>
<td>0.9981</td>
</tr>
<tr>
<td>1993</td>
<td>-0.1565</td>
<td>0.2341</td>
<td>1.8706</td>
<td>0.9602</td>
</tr>
<tr>
<td>1994</td>
<td>0.2195</td>
<td>-0.0647</td>
<td>-0.4981</td>
<td>0.3106</td>
</tr>
<tr>
<td>1995</td>
<td>0.5359</td>
<td>0.2272</td>
<td>1.8166</td>
<td>0.9567</td>
</tr>
<tr>
<td>1996</td>
<td>0.9272</td>
<td>0.8749</td>
<td>6.9515</td>
<td>0.9999</td>
</tr>
<tr>
<td>1997</td>
<td>1.9717</td>
<td>1.2354</td>
<td>9.8095</td>
<td>0.9999</td>
</tr>
</tbody>
</table>

- Discussion:
  - Negative signs of the residual means and inconsistent network autocorrelation for 1991 to 1994 indicate that the migratory system of Berlin was in a chaotic state with respect to the urban structure.
  - However, there is a consistent trend towards a centrifugal migration pattern and the system appears to be stable since 1995.
### Conclusions

#### Results

- A *mental wall* still separates the Eastern and the Western parts of Berlin. However, the economic and psychological barriers are slowly disappearing.
- After the perturbation (with respect to migration) of the unification, the migration patterns within and between Berlin's subsystems seem to *stabilize at a new steady state*.
- *Urban structure again matters* and migration follows a sectorial pattern.

#### Shortcomings

- *Push and pull factors* such as economic information and the housing stock characteristics have been ignored. This is, in parts, due to a lack of relevant variables.
- The continuing trend of *sub-urbanization* beyond the city limits has been ignored due to a lack of spatially disaggregated migration information.

#### Extensions

- Migration data among the 23 districts of Berlin for the accounting years 1998 as well as 1999 are available and data for 2000 will become available soon.
- The analysis will be repeated with these additional years. It is expected that the presented trends towards a new steady state will persist.
- This will be the last analysis of this kind, because
  - The parameters and constraints of the city have changed again after the *de facto* move of the German government from Bonn to Berlin.
  - The city council of Berlin has decided as of 2001 to merge hierarchically the 23 districts of Berlin into 12 new administrative units. It is hoped that this move will save the city administrative and financial overhead.