Quantitative, Spatial, Mapping, and Visualization Plan-Making Methods

AICP EXAM REVIEW

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Session Outline

Introduction (5 min)

A. Basic statistics concepts (5 min)
B. Forecasting methods (5 min)
C. Population analysis and projection (10 min)
D. Economic analysis (10 min)
E. Maps, charts, and visualization (5 min)
F. GIS and spatial analysis (10 min)
Example of a plan-making methods question

<table>
<thead>
<tr>
<th>Industry</th>
<th>Local Employment</th>
<th>National Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>3%</td>
<td>6%</td>
</tr>
<tr>
<td>Y</td>
<td>10%</td>
<td>7%</td>
</tr>
<tr>
<td>Z</td>
<td>11%</td>
<td>3%</td>
</tr>
</tbody>
</table>

5. Listed above are two types of employment percentages for industries X, Y, and Z in a metropolitan area. The local employment for each industry is listed as a percent of total local employment, and the national employment in each industry is listed as a percent of total national employment. Under the location quotient method, an economic planner can assign which of these industries to the export sector of the metropolitan area? Y and Z only
Basic methods bibliography

Berke, P., Godschalk, D. & Kaiser, E. (2006). *Urban land use planning* (5th ed.). Urbana: University of Illinois Press. (This classic text also has excellent, brief overviews of various plan-making methods. It is the best single plan-making review source.)

A. Statistics
Types of data

- Four types of measurement scales
  - Nominal
  - Ordinal
  - Interval
  - Ratio

- Primary data vs. secondary data
- Enumeration or census vs. sample
Measures of central tendency

- **Mean**
  - Sum of items divided by Count of items

- **Median**
  - Sort items high to low
  - Select middle item, or average of two middle items

- **Mode**
  - What value occurs most often?
  - Bimodal distributions
Measures of dispersion

- **Range**
  - High value minus low value

- **Interquartile range**
  - $75^{th}$ percentile value minus $25^{th}$ percentile value

- **Variance**
  - Subtract the mean from each value
  - Square each difference
  - Sum the squares of the differences and divide by the number of cases

- **Standard deviation**
  - Take the square root of the variance
  - Can relate to original units
B. Forecasting methods

- Intuitive methods
  - Delphi technique
  - Scenario writing

- Trend extrapolation methods
  - Assume future change of same amount added or subtracted per year (or decade)
  - Assume future change of same percentage increase (or decrease) per year (or decade, or any period)
  - Regression methods to fit lines or curves
Regression terms

- **Dependent variable or y variable:** the variable being predicted or explained
- **Independent variable(s) or x variable(s):** the variable(s) used to predict or explain
- **How many variables used to predict?**
  - Bivariate regression (one x variable)
  - Multiple regression (two or more x variables)
Regression

- Assumes a straight line can be used to describe the relationship between the independent (x) variable and the dependent (y) variable.

- $y = a + b \times x$ (or $y = m \times x + b$)

- a is the line’s y intercept

- b is the line’s slope

- $R^2$ measures how well the line fits the data and ranges from 0.0 to 1.0
Bivariate regression

We want to predict the number of autos per household.

This is our data for 10 census tracts.

Income is listed in thousands of dollars.

<table>
<thead>
<tr>
<th>Tract</th>
<th>x Avg HH Income</th>
<th>y Avg # of Autos per HH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.0</td>
<td>0.3</td>
</tr>
<tr>
<td>2</td>
<td>8.5</td>
<td>0.8</td>
</tr>
<tr>
<td>3</td>
<td>10.2</td>
<td>1.2</td>
</tr>
<tr>
<td>4</td>
<td>11.4</td>
<td>1.3</td>
</tr>
<tr>
<td>5</td>
<td>15.6</td>
<td>1.5</td>
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<tr>
<td>6</td>
<td>20.5</td>
<td>2.0</td>
</tr>
<tr>
<td>7</td>
<td>22.9</td>
<td>1.8</td>
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<tr>
<td>8</td>
<td>26.3</td>
<td>2.2</td>
</tr>
<tr>
<td>9</td>
<td>29.6</td>
<td>2.1</td>
</tr>
<tr>
<td>10</td>
<td>34.8</td>
<td>2.5</td>
</tr>
</tbody>
</table>
Household Income vs. Auto Ownership

\[ y = 0.359 + 0.065x \]

- Predicted value of \( y \) when \( x = 0 \):
  - Households with $0 in income average 0.359 cars

- Predicted change in \( y \) for a one unit change in \( x \):
  - For each extra $1,000 in income we add 0.065 cars per household
Multiple regression uses more than one x variable

- $y$ (house sale price) = $b_1 \times \text{Square footage} + b_2 \times \text{Number of bedrooms} + b_3 \times \text{Number of bathrooms} + b_4 \times \text{Accessibility to employment} + b_5 \times \text{Location in historic district}$

- When an x coefficient ($b$) is positive, higher values of x lead to higher values of $y$; when negative, lower
C. Population analysis and projection

- An **estimate** is an indirect measure of a present or past condition that cannot be directly measured.
- A **projection** (or prediction) is a conditional statement about the future.
- A **forecast** is a judgmental statement of what the analyst believes to be the most likely future.
Non-component projection methods

- Extrapolation with graphs
- Time series regression, with time (year) as the independent (x) variable
- Ratio methods comparing to similar areas
- Share methods using proportions of regional or state projections
Time series regression to project US population

US Population

\[ y = -3777.7 + 2.0222 \times x \]

Predicted change in \( y \) for a one unit change in \( x \)

Each year, we add 2.02 million people.
Cohort component models

- We divide the population into cohorts by age (often five years), sex, and race/ethnicity.
- Population change is subdivided into three components: births, deaths, migrants.
- Calculate birth rates, survival rates, and migration rates for a recent period.
- Extend those rates into the future, possibly adjusting them upward or downward.
- Birth and death data is readily available; migration data is difficult, primary source is American Community Survey.
Migration notes

- Migration can be projected as a function of changes in employment, or
- If net migration = in-migration minus out-migration
- Then net migration can be estimated by the residual method:

2000 population: 100,000
2010 population: 120,000
2000 to 2010 births: 5,000
2000 to 2010 deaths: 3,000

How many 2000 to 2010 net migrants? +18,000
D: Economic analysis

(1) Economic base theory

- Assumes two kinds of industry
  - Basic or export: sells to customers outside the area of analysis
  - Service or non-basic: sells to customers within the area

- Economic base multiplier
  - Total employment / basic employment
  - A multiplier of 4.0 says that 4 total jobs are created for every additional basic job
(2) Location quotients

- LQs compare the local concentration of employment in an industry to the national employment in that industry.

\[ LQ_i = \left( \frac{\text{Local employment in industry } i}{\text{Total local employment in all industries}} \right) \div \left( \frac{\text{National employment in industry } i}{\text{Total national employment in all industries}} \right) \]
More on location quotients

- Alternate formula: \( LQ_i = \frac{\text{Local percent of employment in industry } i}{\text{National percent of employment in industry } i} \)

- Interpreting LQs
  - If \( LQ_i \) is greater than 1.0 we can assume an export or basic industry
  - If \( LQ_i \) is less than 1.0 we can assume we import some goods or services
  - If \( LQ_i = 1.0 \), the region produces just enough to serve the region, and no more
Calculating basic employment

1. We can use LQs to estimate total basic employment
   - Use only industries whose LQ is greater than 1.0
   - For industry i basic employment is \((1 - 1/LQ_i) \times \text{Local industry employment}\)
   - Add basic employment for all industries

2. Or you can assign entire industries to either basic or service:
   - Which is manufacturing?
   - Which is local government?
(3) Shift share analysis

Shift share analysis interprets changes in an industry’s local employment (over a period of x years) in terms of three components:

- **National share**: how much would local industry employment have changed if it mirrored the change in total national employment.
- **Industry mix**: how much additional would it have changed if it mirrored the difference between national industry employment and national total employment.
- **Local shift**: how many additional jobs did the local industry gain or lose, presumably due to local competitive advantage or disadvantage.
Each sale of a commodity (transaction) requires multiple inputs, including raw inputs, parts, and labor.

Sales of any one commodity ripple back through the economy, creating sales of many different commodities.

IO is useful for understanding the linkages between different industries, especially industries upstream and downstream from a target industry.
## Industry-by-Industry Total Requirements

(Total requirements, direct and indirect, per dollar of delivery to final demand, at producers' prices)

### Table

<table>
<thead>
<tr>
<th>Supplying Industry</th>
<th>Purchasing Industry</th>
<th>Agric.</th>
<th>Mining</th>
<th>Utilities</th>
<th>Const.</th>
<th>Manuf.</th>
<th>Whole.</th>
<th>Retail</th>
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<tbody>
<tr>
<td></td>
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<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>T010 Total industry output requirement</strong></td>
<td><strong>2.36</strong></td>
<td><strong>1.90</strong></td>
<td><strong>1.78</strong></td>
<td><strong>2.02</strong></td>
<td><strong>2.41</strong></td>
<td><strong>1.51</strong></td>
<td><strong>1.54</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table coefficients show how many dollars (.43) of input from the supplying industry (Manuf.) are required to produce $1.00 of output from the purchasing industry (Const.).
E. Maps, charts, and visualization

- Basic types of maps used by planners
  - USGS topographic (quad sheets)
  - Cadastral or parcel
  - Census geography (tracts, block groups)
  - Utilities (water, sewer, electricity, communication)
  - Zoning
  - Subdivision plat
Basic types of charts

- Bar chart
- Height of bar shows value for that category (year)
Basic types of charts

- Histogram (frequency distribution)
- Height of bar shows count of cases in within the category range
Basic types of charts

- Line chart (with multiple series)
Basic types of charts

- Scattergram (or xy graph)
- Each case has an x value (horizontal axis) and a y value (vertical axis)
Basic types of charts

- Pie chart: proportions of a whole
Six principles for visualization and map design

- **Visual contrast**: use colors for map features that are easily distinguishable
  [https://sashat.me/2017/01/11/list-of-20-simple-distinct-colors](https://sashat.me/2017/01/11/list-of-20-simple-distinct-colors)

- **Legibility**: Symbols must be distinct and text large enough for readers or everyone in the audience
Six principles for visualization and map design

▪ Balance: arrange map elements so neither left nor right dominates the page
▪ White space: arrange elements to eliminate large areas of empty space
▪ Simplicity: choose map elements to reinforce the map's story, argument, or theme
▪ Highlighting: use drop shadows, feature outlines, and subtle backgrounds
F. GIS and spatial analysis

- Review a list of GIS terms, for example http://blog.getchee.com/25-important-gis-terms

- Understand basic mapping concepts, including:
  - Scale
  - Projections
  - Coordinate systems, in particular
    - Geographic coordinates (longitude and latitude)
    - Universal transverse Mercator (UTM) and
    - State plane coordinate systems
Land suitability analysis

- LSA was popularized by Ian McHarg in *Design with Nature*.
- It is used in land use planning to determine areas more or less suitable for different land uses.
- It was originally done with physical Mylar maps, which were overlaid on a light table.
- It is now conducted GIS systems capable of overlaying multiple polygon layers.
Assign a suitability-related score to each category in each layer. Determine a weight (importance) for each layer. Multiply each polygon’s score times its layer’s weight. Overlay the three input layers with GIS. Add the weighted scores for each small polygon. The resulting small polygon outlined in blue then has an overall suitability score of 11.
Good luck on the exam! Don't forget your slide rule. And may you all score highly suitable on the planner suitability analysis.