Exploring Influence Range of Tainan City
Using Electronic Toll Collection Big Data

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OUTLINE

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Exploring Influence Range of Tainan City Using Electronic Toll Collection Big Data

**ITS**
Electronic Toll Collection (ETC) is one of Intelligent Transportation System (ITS) applications.

**ETC**
Starting point, end point, distance and travel time of vehicle on the national freeway No.1 and No.2

**79%**
Sedan occupied 79% of intercity transportation. Represent intercity behavior.

Administrative regions, demographic area and socio-economic activities. Not imply the close interactivity inside the living area, nor reflects daily traffics.
• Explores the dynamic phenomenon of intercity through analyzing the OD and quantity.
• Analyzes the interaction between Tainan and other counties by calculating trip volume and visualizing through GIS.
• The finding not only has a more precise outcome, but also could be applied to land use arrangement.
LITERATURE REVIEW  Living Area

- **Definition**
  - The influence scope of socio-economic activities such as work-related, housing, schooling, shopping, leisure and medical care.  
  Council for Economic Planning and Development, Executive Yuan, Taiwan, 1995

- **Purpose**
  - Allocate appropriate land use
  - Develop different industries
  - Create local competitive advantage

- **Strategic Plan for National Spatial Development**
  - A spatial planning strategic proposal from the perspective of Taiwan
  - There are seven living areas in Taiwan.

Proposes a new point of view about living area, and compares and explores the current living area in order to be closer to the actual situation.
Application

- The theoretical basis of living area. Activities in living areas were classified into the following three kinds.

  Daily activities: such as going to school, employment, purchase of daily necessities, from local to local center.

  Weekly activities: such as entertainment, recreation, social, purchase of optional supplies, from local center to the regional center.

  Seasonal activities: such as sightseeing, purchase of special supplies, for private special affairs, from the regional center to national central city.

- The government plans "local living areas" based on Central Place Theory, and references local history, industry, population, geographical environment and urban functions as regional planning and promotes effective use of land.
The 5th Taiwan Area Comprehensive Transportation Planning Research Series
- Intercity Travel Survey and Preliminary Analysis 》(2015)

- Ministry of Transportation and Communications R.O.C (hereinafter referred as MOTC) conducted the intercity travel behavior questionnaire of Taiwan area in 2013.
- Investigated OD, purpose, preference of the transportation, occupancy rate and passengers' basic Information.
- Date Type: Tuesday to Thursday, Monday and Friday, Saturday and Sunday, respectively. Festival and continuous holiday was excluded from the investigation.

1. Travel Purposes


- People almost have only one travel purpose and choose one transportation in an intercity travel.

2. Intercity Transportation

- Bus: Has a role to play in the medium and long-distance travel.
- Sedan: Has good accessibility and mobility, and account a large number of intercity transportation.
- Truck: The traffic volume on weekday is twice as much as it on weekend. It is contrary to other transportation.
3. Purpose

The main purpose of intercity travel is "visiting relatives and friends"; "Commercial affairs" is significantly higher than other purposes in Tuesday to Thursday; "commuting" on Monday and Friday is higher than other days.

4. Length

The length of travel is mainly 20-50 km on weekdays, mostly 50-100 km on weekends.

5. Frequency:

Trips on weekdays are more than weekends’.

The combination of different types of cars, dates, length and other characteristics of trips have a specific significance. This study can be based on travel characteristics to speculate the purpose of travel.
Tainan City

October 20, 2015 (Tuesday) to October 22, 2015 (Thursday)
October 17, 2015 (Saturday) to October 18, 2015 (Sunday)

Interchange Service Area

15 km buffer from the interchange is adopted as an interchange service area.

Data

The original route data of ETC

• Detection Time 、ID 、Vehicle Type and Trip Length
• Data Type : csv

<table>
<thead>
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<th></th>
<th>VehicleType</th>
<th>DetectionTime_O</th>
<th>GantryID</th>
<th>DetectionTime_D</th>
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<td>2015/10/20 08:58</td>
<td>03F1022S</td>
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</tr>
<tr>
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<td>31</td>
<td>2015/10/20 08:03</td>
<td>01F2425N</td>
<td>2015/10/20 08:03</td>
<td>01F2425N</td>
<td>3.2</td>
<td>Y</td>
<td>2015-10-20 08:03:58+01F2425N</td>
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<td>03F0158S</td>
<td>2015/10/20 08:09</td>
<td>03F0217S</td>
<td>11.7</td>
<td>Y</td>
<td>2015-10-20 08:06:01+03F0158S; 2015-10-20 08:06:47+</td>
</tr>
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<td>2015/10/20 08:03</td>
<td>01F3525S</td>
<td>2015/10/20 08:07</td>
<td>01F3590S</td>
<td>13.4</td>
<td>Y</td>
<td>2015-10-20 08:03:17+01F3525S; 2015-10-20 08:05:35+</td>
</tr>
</tbody>
</table>

October 20, 2015 (Tuesday), 8:00 a.m., the original route data of ETC
A living sub-area may cover several administrative districts and freeway interchanges.

“Special municipality, provincial city and their neighboring administrative regions” or “county-level city”

Tainan living sub-area (hereinafter referred as Tainan City) included An-Ding interchange, Yong-Kang interchange, Da-Wan interchange and Tainan interchange.

- Establishing Intercity Trip Model
- Merge and calculate the same OD of each trip
- Sort and visualize the number of transportation
- Build a Database of Service Area
- Calculate the residential, commercial and industrial land use areas

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**METHOD**

- A living sub-area may cover several administrative districts and freeway interchanges.

*“Special municipality, provincial city and their neighboring administrative regions” or “county-level city”*

Tainan living sub-area (hereinafter referred as Tainan City) included An-Ding interchange, Yong-Kang interchange, Da-Wan interchange and Tainan interchange.

Tools: Python, Excel

- The original route data of ETC are recorded independently.
- Analyzed data by Python and Excel to become ordered and meaningful information.
- The same OD of each trip were merged and calculated.

## Phase 1: Data Collection and Preprocessing

### Establish Intercity Trip Model

#### The Principle of Selecting the Interchange for Analysis

#### Merge and calculate the same OD of each trip

#### Sort and visualize the number of transportation

### Build a Database of Service Area

#### Calculate the residential, commercial and industrial land use areas

### Phase 2: Data Analysis and Interpretation

<table>
<thead>
<tr>
<th>起點</th>
<th>起點縣</th>
<th>起點轄市</th>
<th>送到點</th>
<th>送到縣</th>
<th>送到轄市</th>
<th>聯絡車5</th>
<th>小客車31</th>
<th>小貨車32</th>
<th>大客車41</th>
<th>大貨車42</th>
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<td>萬華縣</td>
<td>01F0079N (新竹系統-新竹(南))</td>
<td>新竹市</td>
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<td>145</td>
<td>9</td>
<td>27</td>
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<td>01F0321N (鳳山-內灣)</td>
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<td>01F0155N (內基-高鐵)</td>
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<td>24</td>
<td>2244</td>
<td>702</td>
<td>23</td>
<td>73</td>
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<tr>
<td>4</td>
<td>01F0155S (內基-內城)</td>
<td>台北市</td>
<td>01F0375S (高鐵-新莊(北))</td>
<td>新北市</td>
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<td>955</td>
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<td>2</td>
<td>37</td>
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<td>5</td>
<td>01F0528S (鳳山-楊梅)</td>
<td>高雄市</td>
<td>01F0666S (高雄中正-三多路)</td>
<td>高雄市</td>
<td>658</td>
<td>2323</td>
<td>1002</td>
<td>52</td>
<td>463</td>
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<tr>
<td>6</td>
<td>01F0666S (中臺南林系統)</td>
<td>雲林縣</td>
<td>01F0688S (新營-臺南系統-新營)</td>
<td>臺南市</td>
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<td>35</td>
<td>23</td>
<td>0</td>
<td>12</td>
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<td>7</td>
<td>01F3642N (高雄-楠梓系統)</td>
<td>台南市</td>
<td>01F3227N (大橋-永康)</td>
<td>臺南市</td>
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<td>961</td>
<td>255</td>
<td>2</td>
<td>36</td>
<td></td>
</tr>
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<td>8</td>
<td>03F0234S (中和-土城)</td>
<td>新北市</td>
<td>03F003S (三重-環狀系統)</td>
<td>新北市</td>
<td>47</td>
<td>4979</td>
<td>1076</td>
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<td>9</td>
<td>03F1036S (桃園-大溪)</td>
<td>龜山縣</td>
<td>03F1015S (大頭-中港系統)</td>
<td>台中市</td>
<td>51</td>
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<td>292</td>
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<td>78</td>
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<td>10</td>
<td>01F0664S (平鎮系統-新明)</td>
<td>桃園市</td>
<td>01F0611S (桃園系統-楊梅)</td>
<td>桃園市</td>
<td>235</td>
<td>4393</td>
<td>1333</td>
<td>38</td>
<td>268</td>
<td></td>
</tr>
</tbody>
</table>
**METHOD**

Tools: Excel, GIS

- Selected the interchanges for analysis and sorted the number of transportation by Excel.

- Visualized by GIS.

<table>
<thead>
<tr>
<th>D_Interchanges</th>
<th>Number of Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaohsiung</td>
<td>15963</td>
</tr>
<tr>
<td>Madou</td>
<td>13023</td>
</tr>
<tr>
<td>Xinying</td>
<td>12429</td>
</tr>
<tr>
<td>Luzhu</td>
<td>10848</td>
</tr>
<tr>
<td>Kaohsiung Science</td>
<td>10571</td>
</tr>
<tr>
<td>Nanzi</td>
<td>9478</td>
</tr>
<tr>
<td>Gangshan</td>
<td>5897</td>
</tr>
<tr>
<td>Xiaying</td>
<td>4340</td>
</tr>
<tr>
<td>Chiayi</td>
<td>2825</td>
</tr>
</tbody>
</table>

The Principle of Selecting the Interchange for Analysis

Establishing Intercity Trip Model

Merge and calculate the same OD of each trip

Sort and visualize the number of transportation

Build a Database of Service Area

Calculate the residential, commercial and industrial land use areas
Tool: GIS

- After selecting An-Ding interchange, Yong-Kang interchange, Da-Wan interchange and Tainan interchange to be analyzed, the area of analysis (15 km buffer from the interchanges) is delineated.

- Calculated the residential, commercial and industrial land uses by GIS, and a database is built to support the research.
Sedan

**Tuesday to Thursday**

- Most sedans are traveling short-distance.
- The trips from Tainan arrive at Tainan local centers such as Madou, Xinying, Kaohsiung and Chiayi.
- The trips to Tainan start from Kaohsiung, Madou, Xinying, Chiayi and other places.
- Lands uses around the interchanges which sedans often contact are residential and commercial.

**Weekends**

- The primary arrival locations from Tainan are Tainan local centers such as Madou, Xinying and Kaohsiung.
- The trips to Tainan start from Kaohsiung, Madou, Xinying, Chiayi and Taichung.
- The trips to the interchanges which are near the sightseeing spots increased.
**RESULT**

**Bus**

- The buses can reach middle to long distance from Tuesday to Thursday, and the metropolitan areas are significant.
- The primary arrival locations from Tainan are Kaohsiung, Taichung, Taipei and so on.
- The trips to Tainan start from Taichung, Kaohsiung, Taipei, Madou, Xinying and other places.

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**Weekends**

- Buses travel on weekends with medium to long distance distances, which are more significant than weekdays.
- The primary arrival locations from Tainan are Taipei, Taichung, Kaohsiung, Chiayi, Madou and Xinying.
- The trips to Tainan start from Taipei, Taichung, Kaohsiung, Chiayi, Madou and Xinying.
**Result**

**Pick-up**

- **Tuesday to Thursday**
  - Pick-up is mainly short to medium distance.
  - The primary arrival locations from Tainan are Madou, Xinying, Kaohsiung, Chiayi and so on.
  - The trips to Tainan start from Madou, Xinying, Kaohsiung, Chiayi and other places.

- **Weekends**
  - Pick-up is mainly short distance on Saturday and Sunday.
  - The primary arrival locations from Tainan are Madou, Xinying, Kaohsiung, Chiayi, Taichung and so on.
  - The trips to Tainan start from Madou, Xinying, Kaohsiung and Chiayi.
Truck

Tuesday to Thursday

- Trucks travel mainly from short distance.
- The primary arrival locations from Tainan are Madou, Xinying, Kaohsiung, Chiayi, Yunlin and Changhua and so on.
- The trips to Tainan start from Madou, Xinying, Kaohsiung, Chiayi, Yunlin, Changhua and other places.

Weekends

- Trucks travel mainly on medium and short distances.
- The primary arrival locations from Tainan are Madou, Xinying, Kaohsiung, Chiayi and Yunlin.
- The trips to Tainan start from Madou, Xinying, Kaohsiung, Chiayi and Yunlin.
Trailer

- Trips to the vicinity of the industrial area are significant.
- The primary arrival locations from Tainan are Madou, Xinying, Kaohsiung, Taichung and so on.
- The trips to Tainan start from Madou, Xinying, Kaohsiung, Changhua, Taichung and other places.

Tuesday to Thursday

- Trips to Tainan are Madou, Xinying, Kaohsiung, Taichung and so on.
- The trips to Tainan start from Madou, Xinying, Kaohsiung, Changhua, Taichung and other places.

Weekends

- The primary arrival locations from Tainan are Madou, Xinying, Kaohsiung and Taichung.
- The trips to Tainan start from Madou, Xinying, Kaohsiung and Taichung.
Characteristics of Vehicles - Tuesday to Thursday

- On the same date type, each type of transportation of Tainan is very similar to the OD and the number of trips, indicating that there is round-trip relationship.
- Tainan has a significant influence on the neighboring administrative regions, including Kaohsiung, Chiayi, Yunlin, Changhua and Taichung.

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Regions</th>
<th>Purposes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedan</td>
<td>Kaohsiung downtown area and its industrial areas, Madou, Xinying, Chiayi</td>
<td>Commuting to Work, Commercial Affairs, Visiting Relatives and Friends</td>
<td>Travel purposes can be speculated according to the questionnaire data of MOTC.</td>
</tr>
<tr>
<td>Bus</td>
<td>Taipei, Taichung, Kaohsiung.</td>
<td>Commuting to Work, Commercial Affairs, Visiting Relatives and Friends</td>
<td></td>
</tr>
<tr>
<td>Pick-up Truck</td>
<td>Kaohsiung city and its industrial areas, Madou, Xinying, Chiayi</td>
<td>Industrial freight, commercial freight or home delivery according to the land use</td>
<td>The main land use around the interchanges is industrial.</td>
</tr>
<tr>
<td>Trailer</td>
<td>Madou, Xinying, Kaohsiung, Changhua, Taichung</td>
<td></td>
<td>The trailer has more trips for the long distance, with the cargo type and volume.</td>
</tr>
</tbody>
</table>
Characteristics of Vehicles - Weekends

- The vehicles except the bus are less than weekdays, but the trips of sedan to tourist areas increase.
- The purposes of trips are "leisure and entertainment" and "tourism and business trip".
- Cargo transportation is less than twice as weekdays.

Living Areas

- Tainan influence area reaches to Kaohsiung.
- Currently, Yunlin, Chiayi and Tainan are the same living area, and Kaohsiung is another’s.
- The trips between Tainan and Kaohsiung are even more than Madou and Xinying, and trips between Tainan and Yunlin are rare.
- The range of the current living area is arguable.


Restrictions

• Taiwan ETC is currently only located on north-south freeway, the scope of this study is limited to districts where ETC is located.
• It is unable to analyze the district which is not located within any interchange service area.
→ The study can grasp which district Tainan City influence, but cannot judge which district is not affected.

Conclusion

• The living area should not be divided completely according to the boundary of the administrative area, and the range should be different with the purpose, date type and time.
• The influence area can be designated into commuter, freight, tourism etc., and different influence area may overlap. It is also prone to reshape the influence range when data updating.
Thank you for listening😊