State-of-the-art Freight Transport Modelling

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INTRODUCTION TO TRANSPORT PLANNING

LAND USE – TRANSPORT INTERACTION

TRAFFIC SYSTEM

ACTIVITY SYSTEM

MOBILITY SYSTEM

INTERACTION AMONG SYSTEMS IS DYNAMIC, NON-STABLE, NON-STRUCTURED
EVERY SYSTEM HAS DIFFERENT PERSPECTIVE OF TIME AND RESOURCES:

TRAFFIC SYSTEM
- DIRECT, REACTIVE, VERY SHORT TERM, LOCAL IMPACT

MOBILITY SYSTEM
- INDIRECT, REACTIVE/ANTICIPATIVE
- LONG TERM, REGIONAL IMPACT

ACTIVITY SYSTEM
- INDIRECT, ANTICIPATIVE, VERY
- LONG TERM, REGIONAL/MACRO IMPACT
INTRODUCTION TO TRANSPORT PLANNING

- LAND USE MODEL
- TRIP GENERATION
- TRIP DISTRIBUTION
- MODE CHOICE / MODE SPLIT
- MODE CHOICE / MODE SPLIT
Land Use Model
\[ X_i^p = f(C_i^p) \]

Trip Generation Model
\[ T_i^p = f(C_i^p) \]

Trip Distribution Model
\[ T_{ij}^p = f(C_{ij}^p) \]

Modal Split Model
\[ T_{ij}^{pm} = f(C_{ij}^{pm}) \]

Network Assignment Model
\[ T_{ij}^{pnr} = f(C_{ij}^{pnr}) \]
TRANSPORTATION MODELING
Siapa?
Kemana?
Menggunakan moda transportasi apa?
Melalui rute yang mana?

Sumber: Parikesit, D, 2010
The **DEVELOPED METHODOLOGY** is attempting to:

1) Integrating (internalized) the spatial model into transportation model
2) combining the **economics activities** driving freight movement (commodity-based model) and the **vehicle movement** (trip-based model).
TRANSPORT DEMAND MODELS
(Source: Menendez et al, 2004)

Transport Demand Models

Aggregate Models
- Split Model (Costs, Modes, Goods charact)
  - Dynamic Transport Demand

Neoclassic Model (Derived Demand)

Disaggregate Models
- Inventory Model (Profit Max)
- Behavioural Model (Utility Max)
  - Demand Elasticity
## EXISTING vs PROPOSED METHODOLOGY

<table>
<thead>
<tr>
<th>The existing methodology</th>
<th>Proposed methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial data driving the freight transportation considered as EXOGENOUS FACTOR</td>
<td>Spatial data as ENDOGENOUS FACTOR</td>
</tr>
<tr>
<td>Focusing on transportation modelling only (trip-based) or only modelling the amount of freight (commodity-based)</td>
<td>Integration of spatial and transportation modelling</td>
</tr>
<tr>
<td>Trip generation, trip distribution, mode split, and route assignment is conducted in several stages (and sequences)</td>
<td>Trip distribution, mode split, and route assignment are conducted simultaneously</td>
</tr>
<tr>
<td>Only capture commodity flow (commodity-based) or capture vehicle trip only (trip-based)</td>
<td>Capture the flow of commodity and vehicle trip</td>
</tr>
<tr>
<td>Generally focusing on uni-modal or multimodal transportation</td>
<td>Possible to apply the inter-modal transportation</td>
</tr>
<tr>
<td>Unable to capture the vehicle movement (commodity-based)</td>
<td>Able to track the vehicle movement</td>
</tr>
</tbody>
</table>

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STAGES OF DEVELOPING METHODOLOGY

1. The first methodology of regional transportation planning: 7 stages
   (final) first research methodology.docx
2. The latest methodology of regional transportation planning: 10 stages
   (final) developed methodology.docx

REGIONAL ECONOMIC ACTIVITIES
(VALUE ADDED OF PRODUCTION)

PRODUCTION OF GOODS AND SERVICES

MOVEMENT OF GOODS AND TRANSPORTATION SERVICES (COMMODITY FLOW)

COMMODITY FLOW BY SPECIFIC TRANSPORTATION MODES

IDENTIFICATION OF TYPE AND LOCATION OF TRANSPORT INFRASTRUCTURES

PERFORMANCE OF TRANSPORTATION INFRASTRUCTURES

GOVERNMENT REGULATIONS, FINANCE, HUMAN RESOURCES MANAGEMENT, ETC.

PRIVATE (DESICION MAKER)

PRIVATE (DESICION MAKER)

PUBLIC (DESICION MAKER)
The developed methodology for regional freight transportation planning consists of ten stages to be considered:

I. Selection of commodity using Regional Income (RI) model;

II. Conducting observation surveys and initial data collection;

III. Conducting Revealed Preference surveys on:
   a) commodity production and distribution by interviewing shippers;
   b) commodity distribution by interviewing carriers;
   c) trip characteristics and transportation attributes by interviewing shippers and carriers;

IV. Construction of GIS geo-database by using ArcGIS;

V. Spatial modelling by simulating and mapping of geographical location of selected commodity using ArcGIS;

VI. Validation of spatial model;

VII. Transportation modelling of selected commodity using ArcGIS by considering Generalized Cost (GC) of mode/destination combination for all factory locations;

VIII. Checking of Generalized Cost (GC);

IX. Identification of issues/bottlenecks (identification of type and location of transport infrastructures);

X. Applying alternatives/scenarios into the model.
<table>
<thead>
<tr>
<th>DATA</th>
<th>TYPE</th>
<th>METHOD</th>
<th>TOOLS</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commodity chain</td>
<td>Primary</td>
<td>Interview</td>
<td>Questionnaire</td>
<td>Shippers</td>
</tr>
<tr>
<td>Logistics node/facs</td>
<td>Primary</td>
<td>Interview, field survey</td>
<td>Questionnaire</td>
<td>Shippers, Port Authority, Others</td>
</tr>
<tr>
<td>Area of resources and manufacturers</td>
<td>Primary</td>
<td>Interview, field survey</td>
<td>Questionnaire</td>
<td>Shippers</td>
</tr>
<tr>
<td>Vehicles characts</td>
<td>Primary</td>
<td>Interview, field survey</td>
<td>Questionnaire</td>
<td>Shippers, carriers</td>
</tr>
<tr>
<td>Travel distance and route</td>
<td>Primary</td>
<td>Interview, field survey</td>
<td>Questionnaire GPS, others</td>
<td>Shippers, carriers</td>
</tr>
<tr>
<td>Travel time</td>
<td>Primary</td>
<td>Interview, field survey</td>
<td>Questionnaire GPS, others</td>
<td>Shippers, carriers</td>
</tr>
<tr>
<td>Travel cost</td>
<td>Primary</td>
<td>Interview, field survey</td>
<td>Questionnaire</td>
<td>Shippers, carriers</td>
</tr>
<tr>
<td>Data GIS</td>
<td>Primary</td>
<td>GIS analysis</td>
<td>ArcGIS 9.3.1 and 10.1</td>
<td>RBI, field/survey</td>
</tr>
<tr>
<td>Other data</td>
<td>Secondary</td>
<td>Literature collection</td>
<td></td>
<td>National/ Province Institut.</td>
</tr>
</tbody>
</table>
STAGES OF DATA COLLECTION AND ANALYSIS

Secondary data collection and preparation of QS form

Training of surveyors for O-D and RP surveys

O-D (observation) surveys (road & port)

Data analysis and model development

RP Surveys to shippers

RP Surveys to carriers
**Building GIS Geo-Database**

Builds the important spatial and transportation data (GIS geo-database) that can be applied directly to the program/software of transport planning and or modeling (ArcGIS, CUBE, etc.).

<table>
<thead>
<tr>
<th>No</th>
<th>Data</th>
<th>Format</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Kabupaten (Regency) map</td>
<td>Geo-database</td>
<td>2010-2012</td>
</tr>
<tr>
<td>2.</td>
<td>Kecamatan (Sub-district) map</td>
<td>Geo-database</td>
<td>2010-2012</td>
</tr>
<tr>
<td>3.</td>
<td>Desa (Village) map</td>
<td>Geo-database</td>
<td>2010-2012</td>
</tr>
<tr>
<td>4.</td>
<td>Oil palm plantation and attributes</td>
<td>Geo-database</td>
<td>2010-2012</td>
</tr>
<tr>
<td>5.</td>
<td>Road networks and attributes</td>
<td>Geo-database</td>
<td>2010-2012</td>
</tr>
<tr>
<td>6.</td>
<td>Main river network and attributes</td>
<td>Geo-database</td>
<td>2010-2012</td>
</tr>
<tr>
<td>7.</td>
<td>River centerline</td>
<td>Geo-database</td>
<td>2010-2012</td>
</tr>
<tr>
<td>8.</td>
<td>Land use data</td>
<td>Geo-database</td>
<td>2010-2012</td>
</tr>
<tr>
<td>10.</td>
<td>Special ports</td>
<td>Geo-database</td>
<td>2011-2012</td>
</tr>
<tr>
<td>11.</td>
<td>Railways link 1A, 1B, 2, 3, 4A, 4B</td>
<td>Geo-database</td>
<td>2011-2012</td>
</tr>
</tbody>
</table>
1. Model 2010: to integrate the spatial into transportation modelling
2. Model 2011 and 2012: to apply the concept of inter-modality into spatial and transportation models
3. Model 2013: to predict the likely effects of (planned) railways as an alternatives of (future) freight transportation
OPTIONS OF TRANSPORTATION NETWORKS

1. CPO Factory → Road → General Port
2. CPO Factory → Road → River Port → River → General Port
3. CPO Factory → Road → Station → Rail → General Port
4. CPO Factory → Road → Station → Rail → River Port → River → General Port
## CASE STUDIES AND VEHICLES CONSIDERED IN THE MODELS

<table>
<thead>
<tr>
<th>Year</th>
<th>Transportation networks</th>
<th>Number of general port</th>
<th>Number of special port</th>
<th>Number of CPO factories</th>
<th>Analysis results</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Road and river</td>
<td>2</td>
<td>0</td>
<td>113</td>
<td>CPO factory Shortest route</td>
</tr>
<tr>
<td>2011</td>
<td>Road, dry river, rainy river Intermodal road- dry river Intermodal road- rainy river</td>
<td>2</td>
<td>0</td>
<td>277</td>
<td>CPO factory Shortest route</td>
</tr>
<tr>
<td>2012</td>
<td>Road, dry river, rainy river Intermodal road - dry river Intermodal road- rainy river</td>
<td>2</td>
<td>11</td>
<td>281</td>
<td>CPO factory Shortest route O-D Cost, and GC</td>
</tr>
<tr>
<td>2013</td>
<td>Road, river, rail, Intermodal road-river, Intermodal road-rail, Intermodal rail-river, Intermodal rail-rail-river</td>
<td>4</td>
<td>11</td>
<td>281</td>
<td>CPO factory Shortest route O-D Cost GC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transport mode</th>
<th>Capacity (T)</th>
<th>Operational speed (km/hour)</th>
<th>Travel cost (Rp/T/km)</th>
<th>Time value (Rp/T/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max</td>
<td>Average</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tank-Truck</td>
<td>7, 8, 10, 12, and 15</td>
<td>45</td>
<td>20 - 40</td>
<td>1500</td>
</tr>
<tr>
<td>Barge</td>
<td>1000, 2000, and 3000</td>
<td>45</td>
<td>30 - 35</td>
<td>300</td>
</tr>
<tr>
<td>Dr. Noor Mahmudah</td>
<td>3000 KL</td>
<td>60</td>
<td>50</td>
<td>1200</td>
</tr>
</tbody>
</table>
1. General activities of commodity considered:

- **PALM PLANTATION** → **CPO FACTORY** → **PORT**

2. Stages of modelling:

   a) Definition of CPO factories
   b) Determination of the shortest route
   c) Determination of O-D cost matrices
   d) Calculation of modal competition
   e) Calculation of generalized cost (in terms of travel cost and travel time)

3. Utility function and logit model:

\[
V_m = \beta_0 + \beta_1 \text{ Fare} + \beta_2 \text{ TTime} + \beta_3 \text{ Climate}
\]

\[
P_{\text{road}} = \frac{\exp(-V_{\text{road}})}{(\exp(-V_{\text{road}}) + \exp(-V_{\text{river}}) + \exp(-V_{\text{mix}}))}
\]

\[
P_{\text{river}} = \frac{\exp(-V_{\text{river}})}{(\exp(-V_{\text{road}}) + \exp(-V_{\text{river}}) + \exp(-V_{\text{mix}}))}
\]

\[
P_{\text{mix}} = \frac{\exp(-V_{\text{mix}})}{(\exp(-V_{\text{road}}) + \exp(-V_{\text{river}}) + \exp(-V_{\text{mix}}))}
\]
The analysis results are:
   a. spatial location of origin and destination (trip generation);
   b. origin-destination matrices (trip distribution);
   c. the shortest routes (mode split and route assignment); and
   d. utility function and probability in choosing certain transport mode.

**Utility function for truck:**

\[ U_{\text{truck}} = 3.383 - 0.007 \text{ Travel Cost} + 0.021 \text{ Travel Time} + 2.889 \text{ Climate} \]

\[ t\text{-test} = (16.758) \quad (57.325) \quad (13.866) \quad (13.560) \]

\[ R^2 = 0.618 \]

**Utility function for barge:**

\[ U_{\text{barge}} = 21.477 - 0.010 \text{ Travel Cost} - 0.001 \text{ Travel Time} \]

\[ t\text{-test} = (1.288) \quad (1.676) \quad (0.811) \]

\[ R^2 = 0.801 \]

The generalized cost is calculated using formula: \( C_{ij} = T C_{ij}^{m,r} + T T_{ij}^{m,r} \cdot V o T \)

\( C_{ij} \): generalized cost (Rp/T)

\( T C_{ij}^{m,r} \): fare from \( i \) to \( j \) on link \( r \) for mode type \( m \) (Rp/T)

\( V o T \): value of time (Rp/T/hour)

\( T T_{ij}^{m,r} \): total travel time spent from \( i \) to \( j \) on link \( r \) for mode type \( m \) (hour)
The recommended network for CPO transportation is intermodal ROAD-RAIL-RIVER by considering THE LOWEST AVERAGE GENERALIZED COST.
Generalized Cost = $C_{ij} = (T_{Cij}^{m,r} + T_{ij}^{m,r} \cdot \text{VoT})$

Generalized Cost of Road Networks

Generalized Cost of River Networks

Generalized Cost of Intermodal Road-River Networks

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Generalized Cost = \( C_{ij} = (TC_{ij}^{m,r} + TT_{ij}^{m,r} \cdot VoT) \)

**GC of Road Networks along Rail Link 1A**

Generalized cost (Rp/T) vs. CPO Factory Number

**GC of River Networks along Rail Link 1A**

Generalized Cost (Rp/T) vs. CPO Factory number

**GC of Railways Link 1A**

Generalized cost (Rp/T) vs. CPO Factory number

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GENERALIZED COST (GC) OF THE NETWORKS (2013)

GC of Intermodal Road - River Networks along Rail Link 1A

Generalized Cost (Rp/T)

GC of Intermodal Road - Rail Networks along Rail Link 1A

Generalized cost (Rp/T)
GENERALIZED COST (GC) OF THE NETWORKS (2013)

GC of Intermodal Rail - River Networks along Rail Link 1A

GC of Intermodal Road - Rail - River Networks along Rail Link 1A
ACCESS OF CPO FACTORIES TO ROAD NETWORKS

Access of CPO Factories to the Road Networks in Central Kalimantan

Projection: Universal Transverse Mercator
Datum: World Geography System
Zone: 48 M

Legend
- Good
- Moderate
- Collector Road
- Bad
- General Port
- Special Port

Prepared by: Noor Mahmudah
07/281523/STK/00182

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YOGYAKARTA
2012
Several intermodal transportation models have been analyzed to convince the integration of spatial and transportation modeling by using the existing transportation infrastructures (such as road and river networks, ports, etc.).

The modeling analysis of CPO transportation in Central Kalimantan Province using geographical information system (GIS) showed that intermodal transportation, especially combination of road-river networks, is the best alternative obtained from the models. In order to have a more robust model and to predict the likely effect of new transport infrastructures to the cost efficiency (in term of generalized cost), hence, it is required to analyze a future scenario.

To do so, a case study of spatial and transportation modeling by integrating inter-modality concept between the existing transportation networks and planned railways in Central Kalimantan is also conducted by using ArcGIS. By considering all networks (road, river, railways, and intermodal networks), the reasonable minimum generalized cost (GC) to be applied in the field is a combination of road-rail-river networks.
THANK YOU