Session 2A: Asst Prof. Dr. Sittha Jaensirisak

Presentation entitled:
Strategic Modeling for Sustainable Urban Transportation and Land Use Development in Bangkok

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Sittha Jaensirisak (PhD) is an assistant professor in transport engineering at Ubon Ratchathani University. He received a master degree from University of Newcastle upon Tyne, UK, and PhD from Institute for Transport Studies (ITS), University of Leeds, UK. His experiences include: study of acceptability and effectiveness of London Congestion Charging, prediction of travel demand on for examples: a new motorway, high speed train and bus rapid transit (BRT), estimation of values of travel time and other service attributes for public transport, traffic impact assessment of land development, and city planning. He also has experience in organising workshops and training courses on sustainable transport and land use planning in the Mekong Region, including: Cambodia, Laos, Thailand and Vietnam. Currently, he is working on development of integrated transport and land use modelling for Bangkok, and national freight modelling for Thailand.

STRATEGIC MODELING FOR SUSTAINABLE URBAN TRANSPORTATION AND LAND USE DEVELOPMENT IN BANGKOK

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Since rapid growth of urbanization in many large Asian cities such as Bangkok, attention has recently been paid to the concept of a "sustainable transportation system" (STS) in urban areas that both improves quality of life and makes efficient use of the available resources (Emberger et at., 2008; Sumalee and Emberger, 2008). Many cities have made efforts to develop an STS, but it has proved difficult to achieve.

Transport and land use policy formulation is a difficult process, particularly in a complex and rapidly-changing city especially if, as is usually the case, the policy makers have no guidance of any kind. To formulate effective policies, these countries need an understanding of how the urban land use and transport system works and interacts and the longer term consequences of failing to follow the sustainability path. They have to be equipped with a scientific approach and a knowledge of the policy options available to them, and guidance on how to use these to formulate a strategy to achieve both efficiency and sustainability.

To understand all of these issues, the technical level of an analytical approach (using some kind of quantitative model) to formulate the problem and define the best sustainable policy is also highly advanced.

This study aims to develop a user-friendly tool for pre-appraisal of the sustainability of urban transport and land use development (e.g. bus rapid transit and mass transit railway systems) in Bangkok. The analytical core of this research is a pre-appraisal planning tool, which combines an innovative strategic land use/transport model utilizing global and temporal-spatial data available from developing cities and an optimization model. This research appears to be the first devoted exclusively to the initial sketch planning topic for appraisal of social, financial and environmental sustainability of land use and transport systems with taking account the effects of integrated land use and transport development simultaneously. This tool will also be useful for the evaluation of the future transit oriented development (TOD) in Bangkok in which there is a large scale future plan to extend the transit network in Bangkok in the next decade. The interaction of this rapid expansion of transit system, land-value, land-use, and financial implication is very critical to achieve a sustainable urban development in Bangkok.

Strategic Modelling for Sustainable Urban Transportation and Land Use Development in Bangkok

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List of members and research assistants

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Motivation

- In the past, countries have strived their economic development in the expenses of the social harmony and environment.
- Increasing concern on sustainable development
- Important for the of land use and transport system
- Thus, there is a need to develop a practical and theoretically sounded land use and transport model for the pre-appraisal of different land-use or transport policies

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Outline

- Bangkok network
- Modelling framework
  - The MARS model
  - The I-Mode model
- Model calibration
- Results and discussions
- Conclusion

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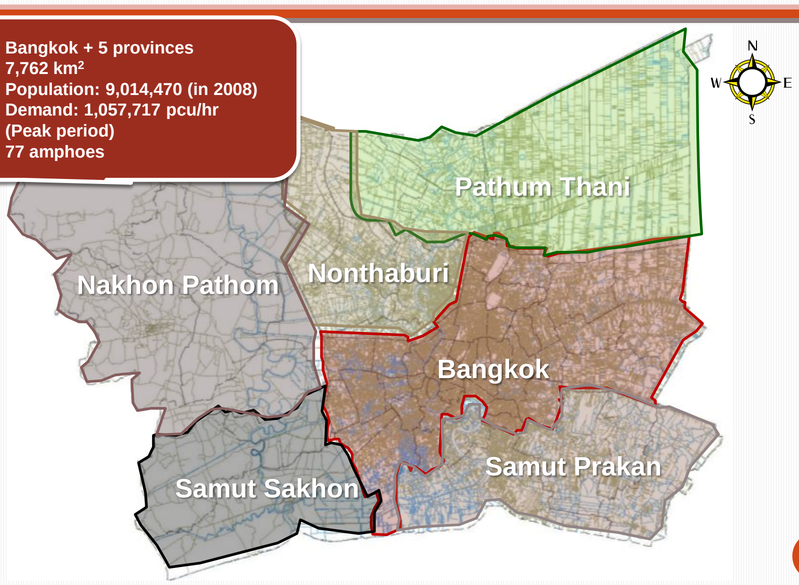
Bangkok Network

- Bangkok + 5 provinces
- 7,762 km^2
- Population: 9,014,470 (in 2008)
- Demand: 1,057,717 pcu/hr (Peak period)
- 77 amphoes



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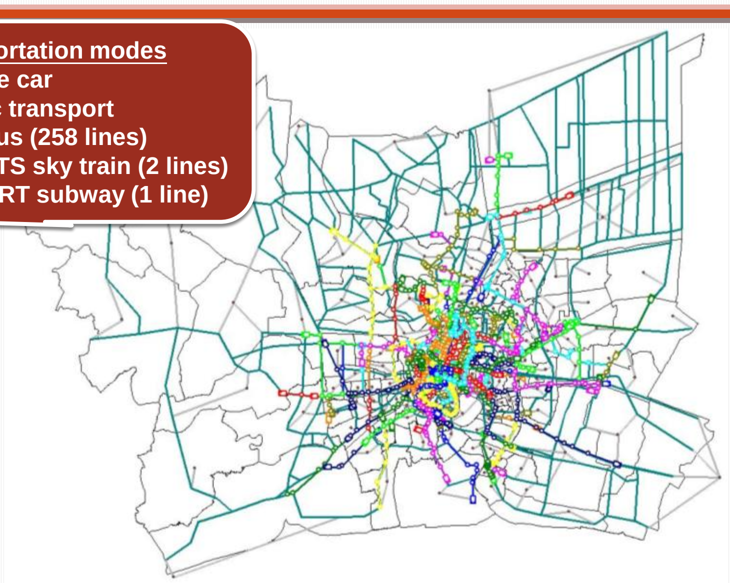
Bangkok Network - Bangkok network coded in EMME 3.3.1

<u>Transportation modes</u>
- Private car
- Public transport
  - Bus (258 lines)
  - BTS sky train (2 lines)
  - MRT subway (1 line)



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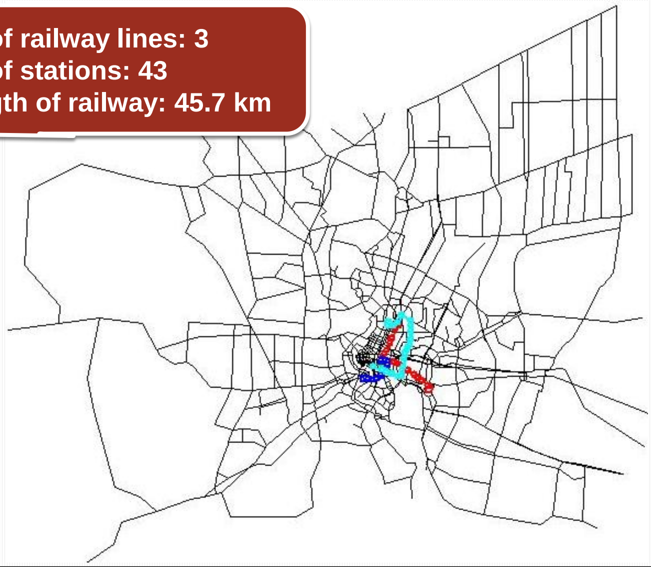
Bangkok Network - BTS and MRT Network in 2010

- Number of railway lines: 3
- Number of stations: 43
- Total length of railway: 45.7 km



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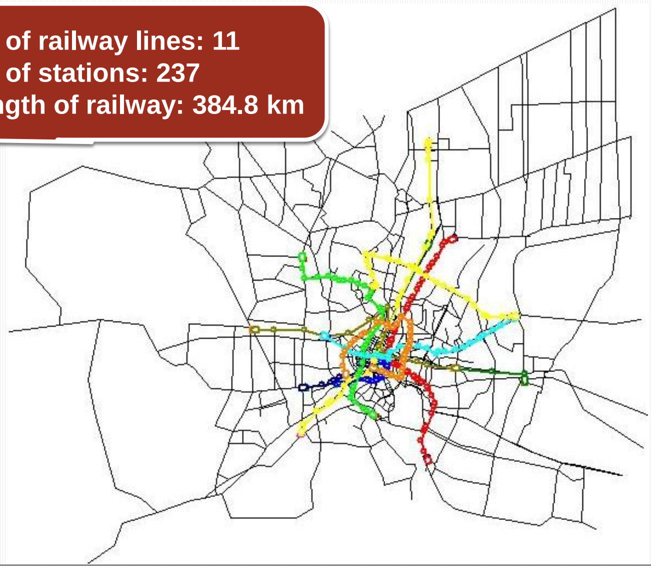
Bangkok Network - BTS and MRT Network in 2019

- Number of railway lines: 11
- Number of stations: 237
- Total length of railway: 384.8 km



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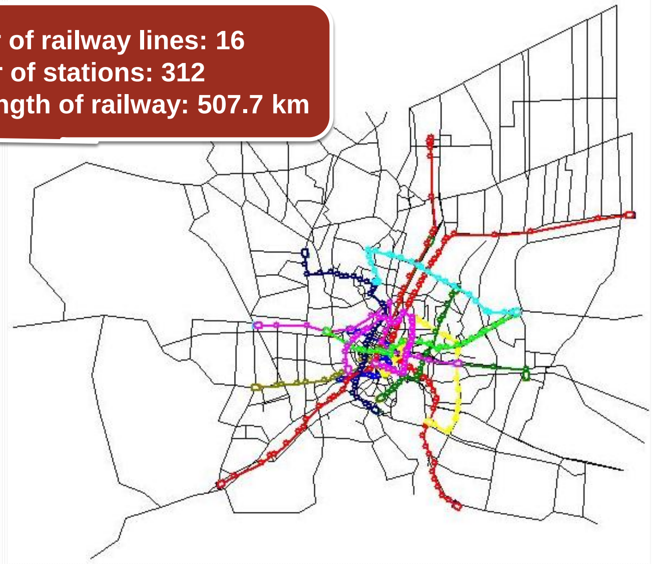
Bangkok Network - BTS and MRT Network in 2029

- Number of railway lines: 16
- Number of stations: 312
- Total length of railway: 507.7 km



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Modelling framework

- Aim: Develop a tool to evaluate the sustainability of different urban transport and land use developments for the Bangkok metropolitan Area
- MARS – Metropolitan Activity Relocation Simulator developed by Paul Pfaffenbichler
- ...but, the travel costs in MARS are determined by a calibrated function (friction factor), without equilibrium assignment

$\Rightarrow$ Replace the travel time estimation module in MARS by an equilibrium model

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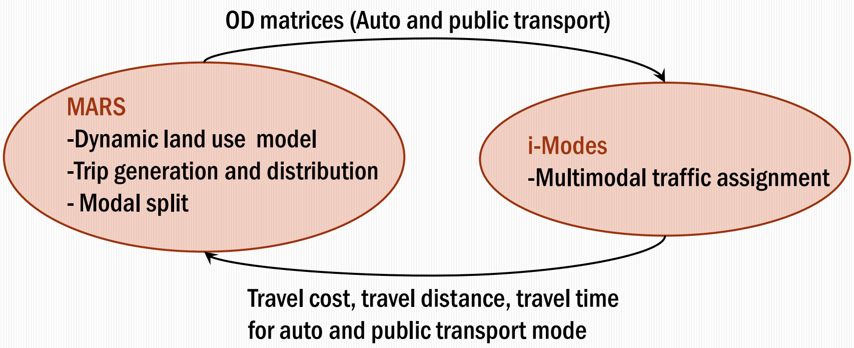
Modelling framework

- An integrated MARS and i-Modes framework is adopted
- i-Modes - Integrated multi-modal transport model for Bangkok developed by Sumalee et al.



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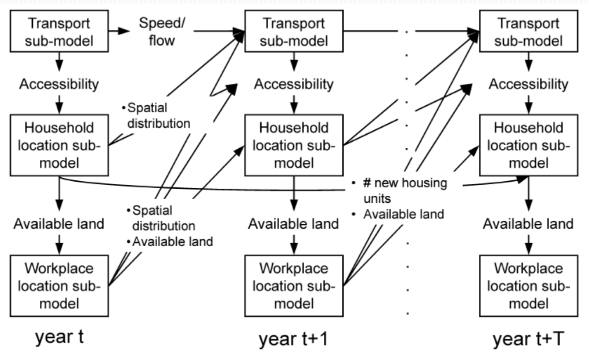
The MARS Model

- A land use and transport interaction model (Part of the transport sub-model will be replaced by I-Mode in this study)
- Time-marching model:



Source: Pfaffenbichler, P. C. 2003. The strategic, dynamic and integrated urban land use and transport model MARS (Metropolitan Activity Relocation Simulator).

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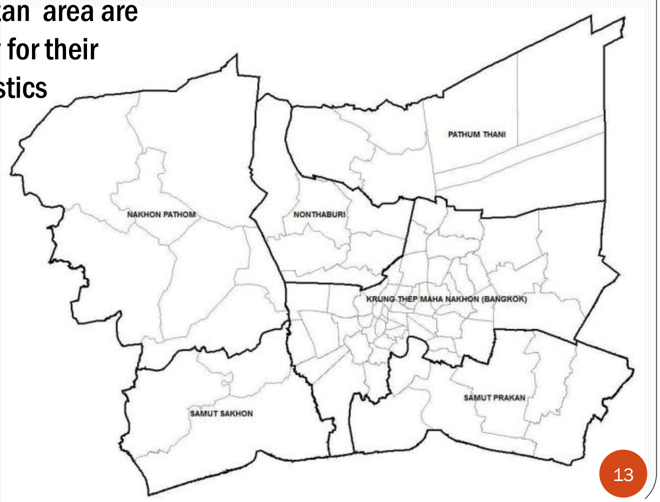
The MARS Model

- Each of the 77 amphoes in the Bangkok metropolitan area are modeled separately for their land use characteristics



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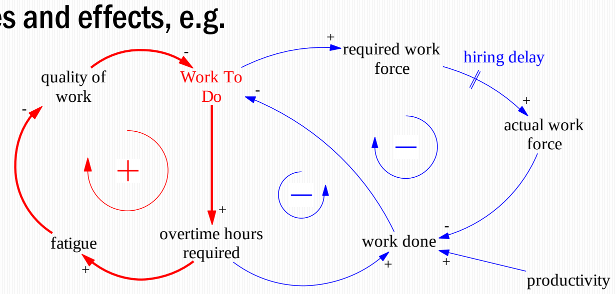
The MARS Model

- Aims to predict the changes of land use and transport pattern under different policy implementations
- Work at a highly spatial aggregation level
- Built in Causal Loop Diagram (CLD) for a clear representation of causes and effects, e.g.



- VENSIM is used for implementation

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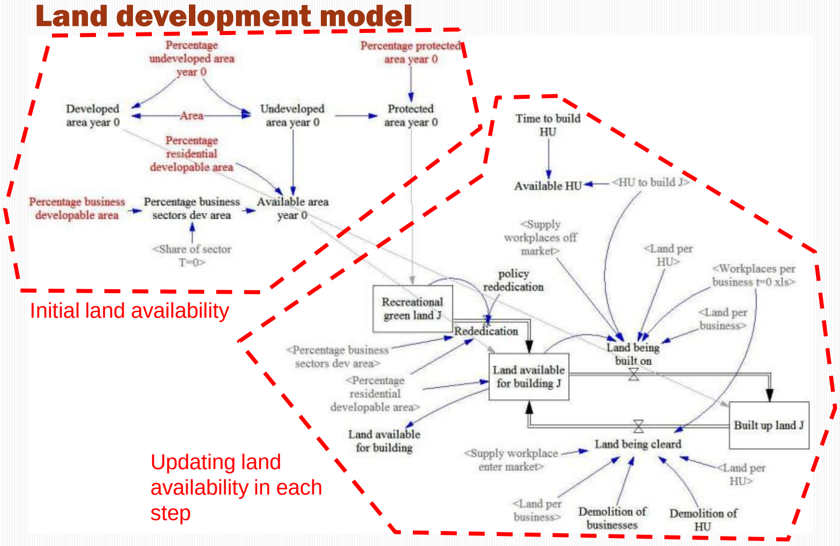
The MARS Model



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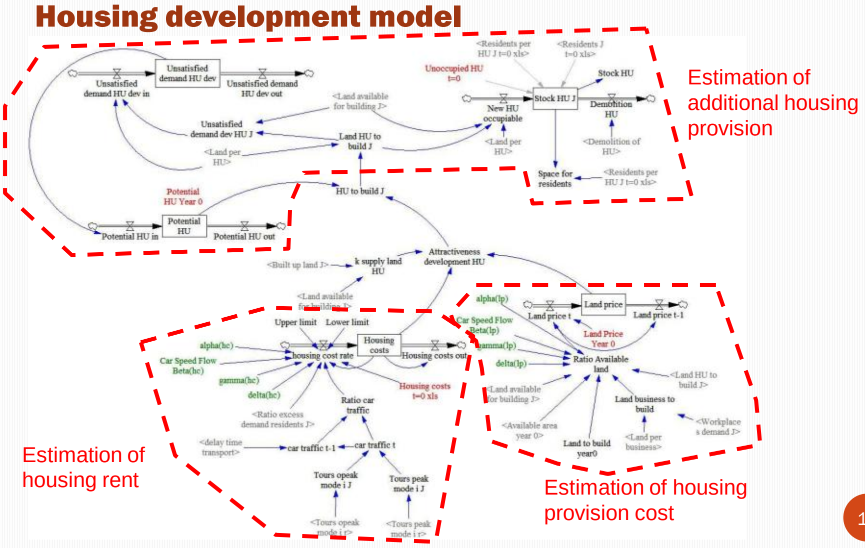
The MARS Model



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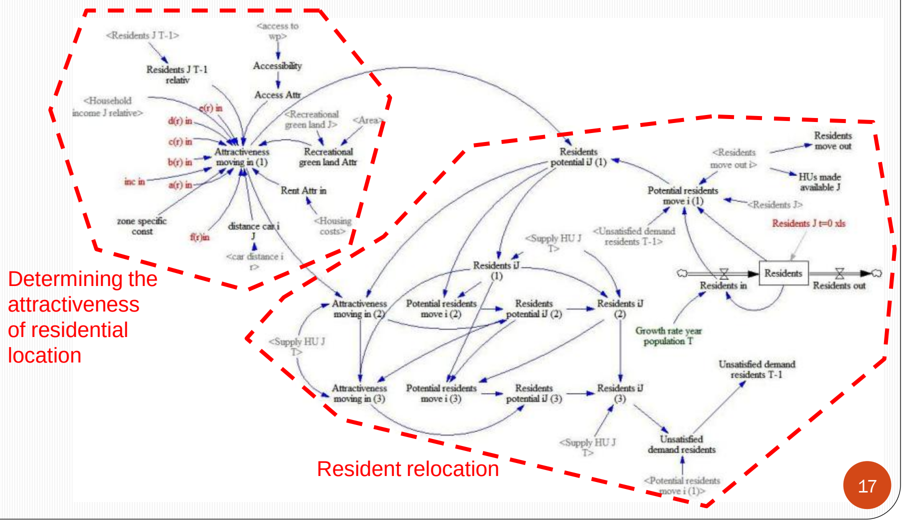
The MARS Model

Residential location model



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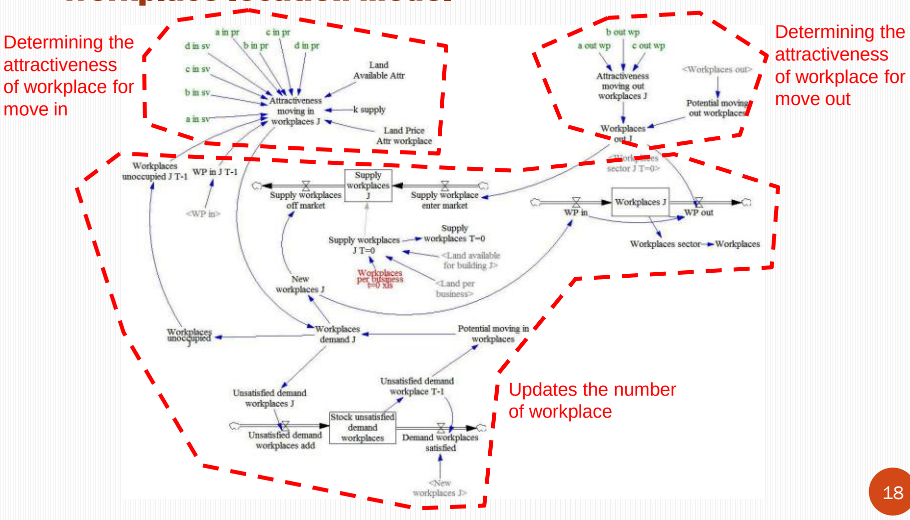
The MARS Model

Workplace location model



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The MARS Model

Trip generation, distribution and modal split

- Trip generation, trip distribution and modal split is also considered in the MARS model
- Take in the distribution of workplace and resident from the land-use sub-models.
- Gives the auto and public transport OD matrix for the multimodal assignment in i-MODE

Land use sub-models → (Workplace, Resident) → Trip generation, distribution and modal split → (Auto OD, Public transport OD) → Assignments in i-MODE

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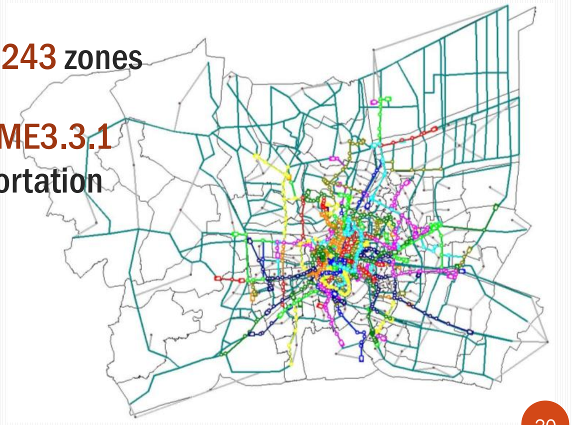
The I-Modes Model

- Developed in Sumalee et al (2010) for Bangkok Metropolitan Area (243 zones and 4,598 links)
- Implemented in EMME3.3.1
- Multi-modal transportation model
  - Private car
  - Bus
  - BTS and MRT



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Modelling framework

Data aggregation and disaggregation

- MARS and I-Mode have different of details
  - MARS is at strategic/planning level with 77 zones
  - I-Mode is at detail/operational level with 243 zones (nodes)
  - Aggregating the outputs (e.g. travel times/costs) from I-Mode to input in MARS
  - Average, which weighted by the corresponding demand, of the outputs
  - Disaggregating the OD matrices (auto and public transport) from MARS to input in I-Mode
  - Distributed in proportion to the OD demands calibrated in the base case

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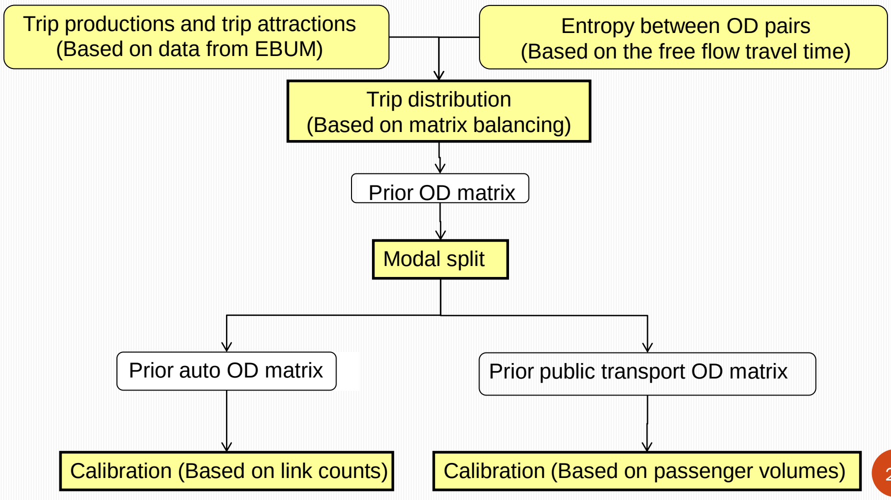
Model calibration

Calibration of the current transport model



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Model calibration

Calibration of the current transport model

- Standard OD demand adjustment algorithms adopted in EMME tends to overfit the observed counts in this study
- Overfit of counts will cause a bias allocation of demand to the OD pairs that contribute to the observed counts
- Thus, the OD patterns from trip generation and distribution is disrupted
- Thus, an lower bound is set for each OD demand during the calibration.
- Different lower bounds are consider , because
  - If the bound is too low, the OD pattern does not preserved
  - If the bound is too high, the observed counts may not be fitted

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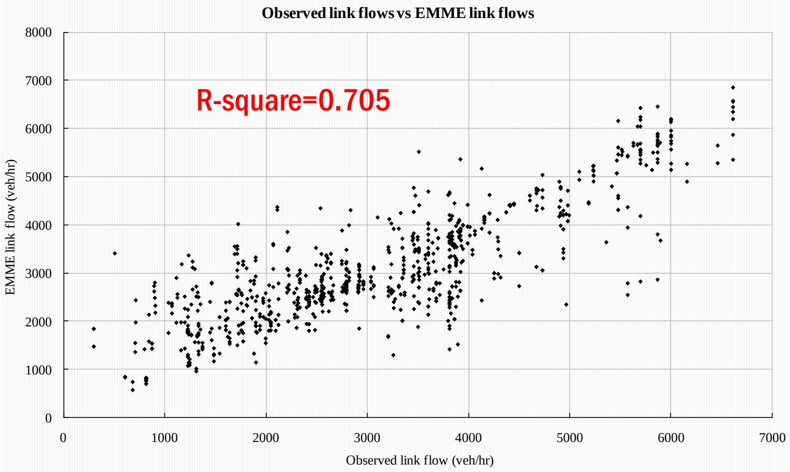
Model calibration

Observed vs EMME link flows (Year 2007)



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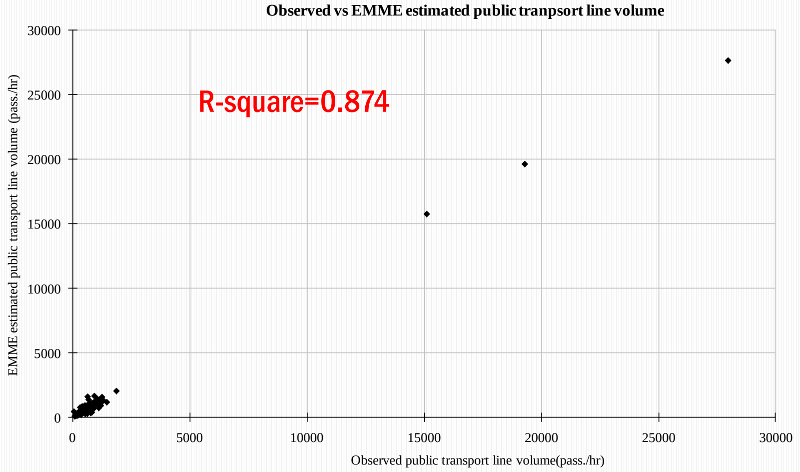
Model calibration

Observed vs EMME public transport line volume (Year 2007)



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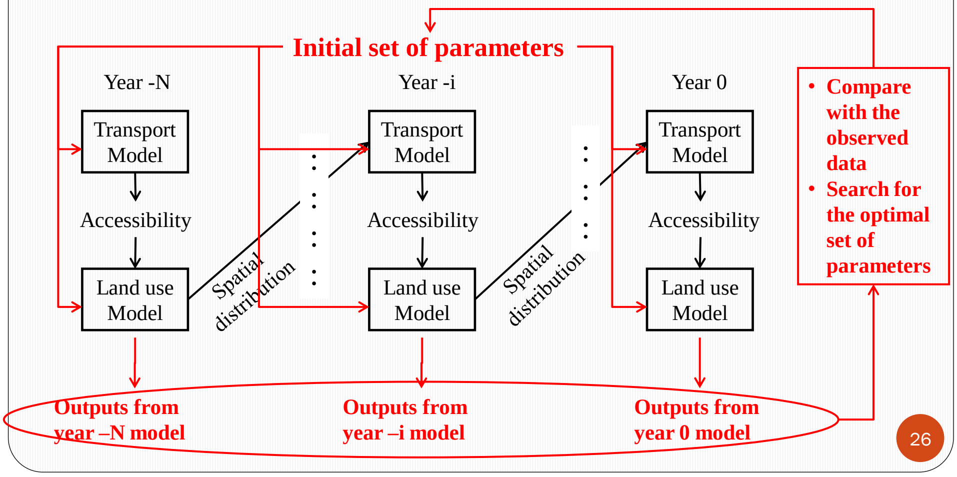
Model calibration

Calibration of the time marching model (MARS)

Backcasting approach is adopted in model calibration



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Results and discussions

- The calibrated time-marching model is solved for the period 2011 to 2040
- Impacts of two different scenarios are considered
  - Extension of railway network
  - Implementation of road pricing

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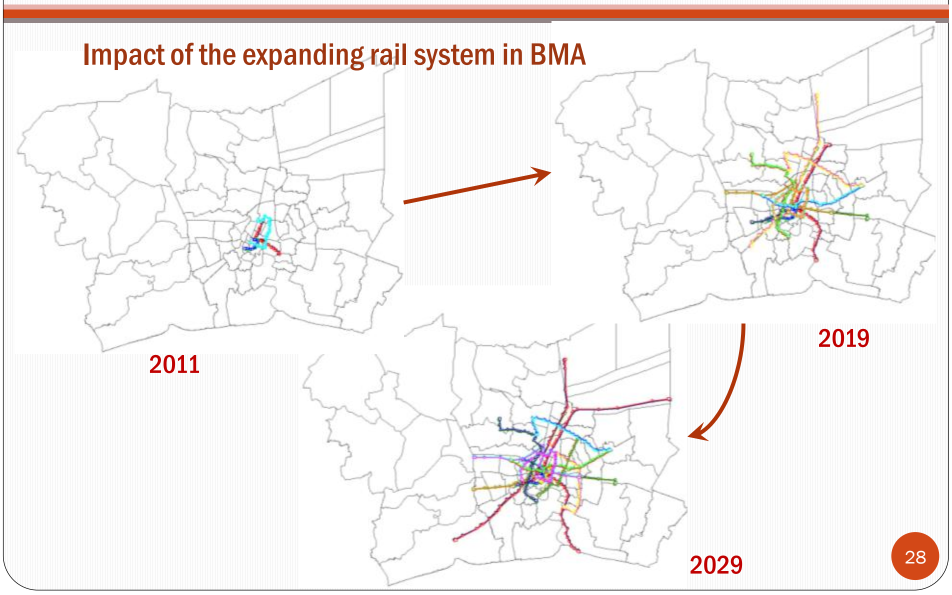
Results and discussions

Impact of the expanding rail system in BMA



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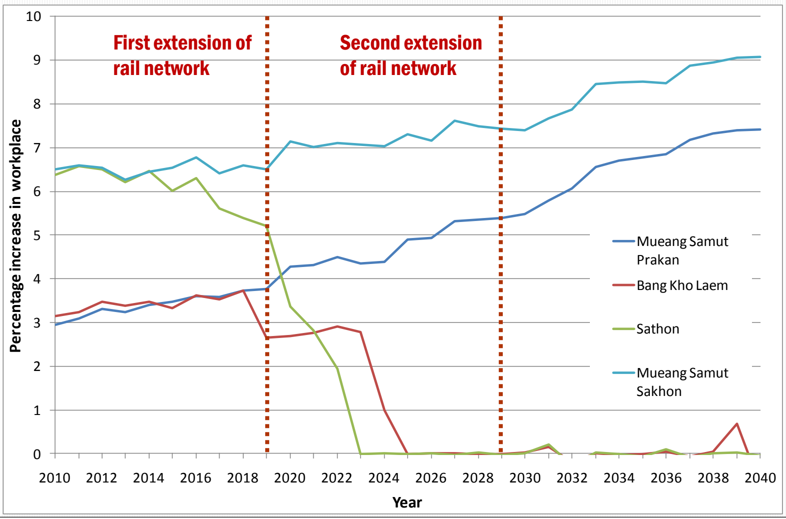
Results and discussions

Impact of the expanding rail system in BMA - Workplace



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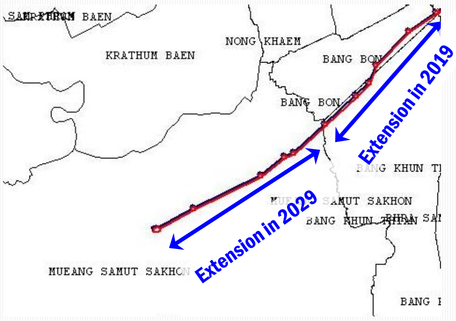
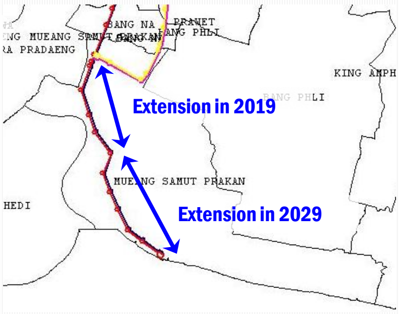
Results and discussions

Impact of the expanding rail system in BMA - Workplace





Mueang Samut Sakhon **Mueang Samut Prakan**

Expansion of railway network increase the accessibility of the connected zone to attracted more workplace
(Percentage increase in workplace increases)

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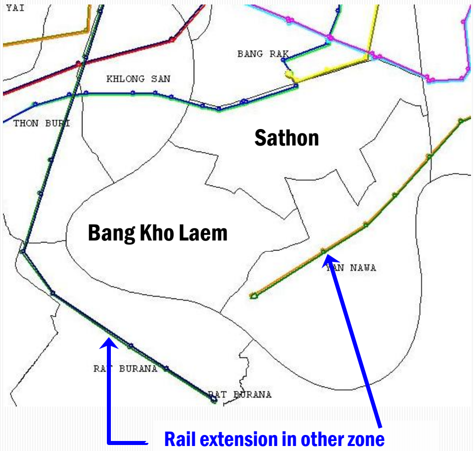
Results and discussions

Impact of the expanding rail system in BMA - Workplace

- **No extension of rail in these zones**
- **Extension of rail in the neighbor zones**
- **Decreases the attractiveness of the zone**
- **Attract less workplace to move in**
- **Increasing rate in workplace decreases**



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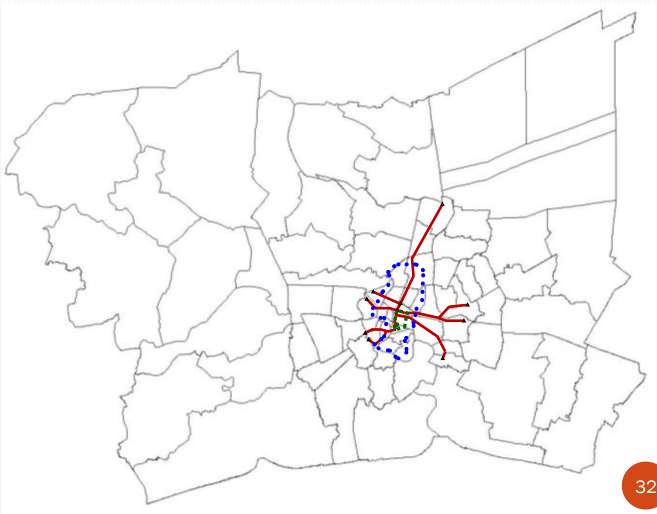
Results and discussions

Impact of road pricing in BMA



Radial toll
2 baht/km

Outer cordon
50 baht

Inner cordon
30 baht

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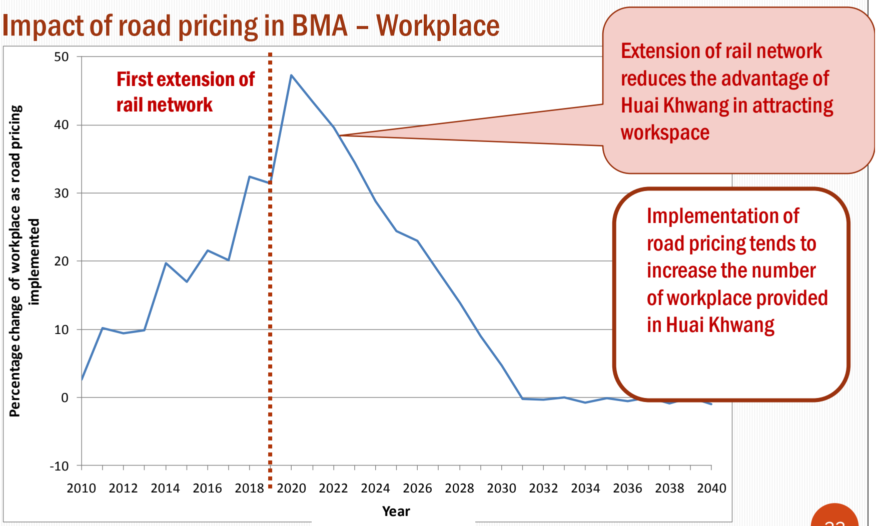
Results and discussions

Impact of road pricing in BMA – Workplace



Huai Khwang

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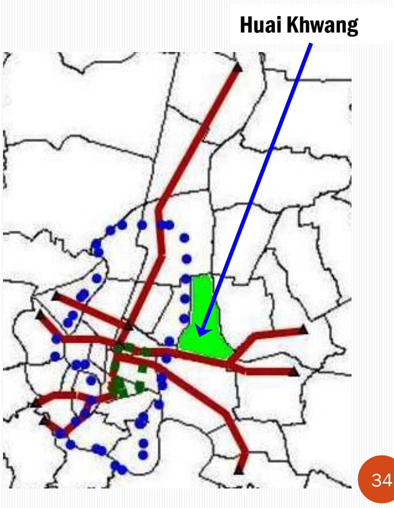
Results and discussions

Impact of road pricing in BMA – Workplace

- Close to the central area of BMA → More attractive to business than other locations
- Just outside the outer cordon → Possible for travelers to avoid paying toll
- Extension of rail network provides other mean to enter the charged area without toll → Attractiveness of Huai Khwang reduces



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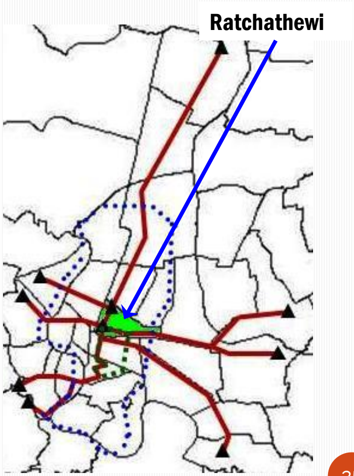
Results and discussions

Impact of road pricing in BMA – Workplace

- **Located within the outer cordon**
- **Travelers have to pay additional toll when traveling to Ratchathewi by car**



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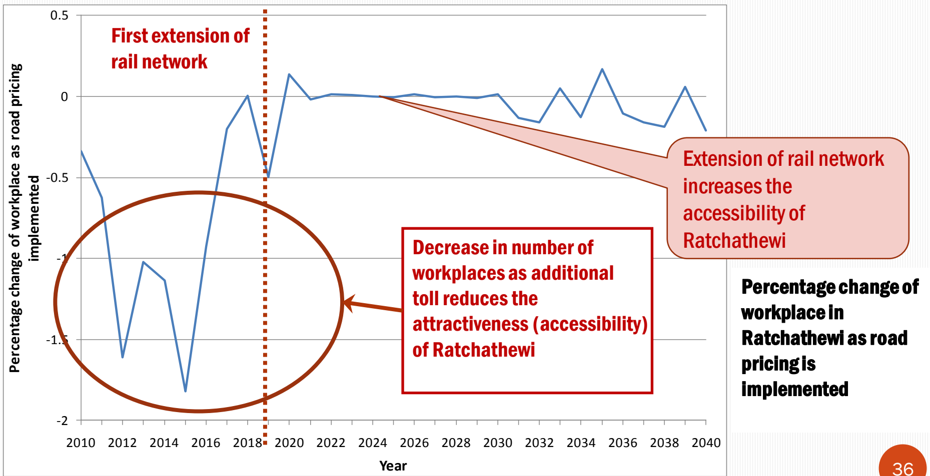
Results and discussions

Impact of road pricing in BMA – Workplace



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Conclusions

- A combined land use and transport model is formulated and calibrated for the BMA
- Model results show that expansion of rail network could increase the accessibility of a zone and attract more residents and workplaces
- Road pricing reduces the attractiveness of a zone on residents and workplace
- More tests will be completed for different land use policies

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