

A strategic dynamic model for integrating housing and transport interactions

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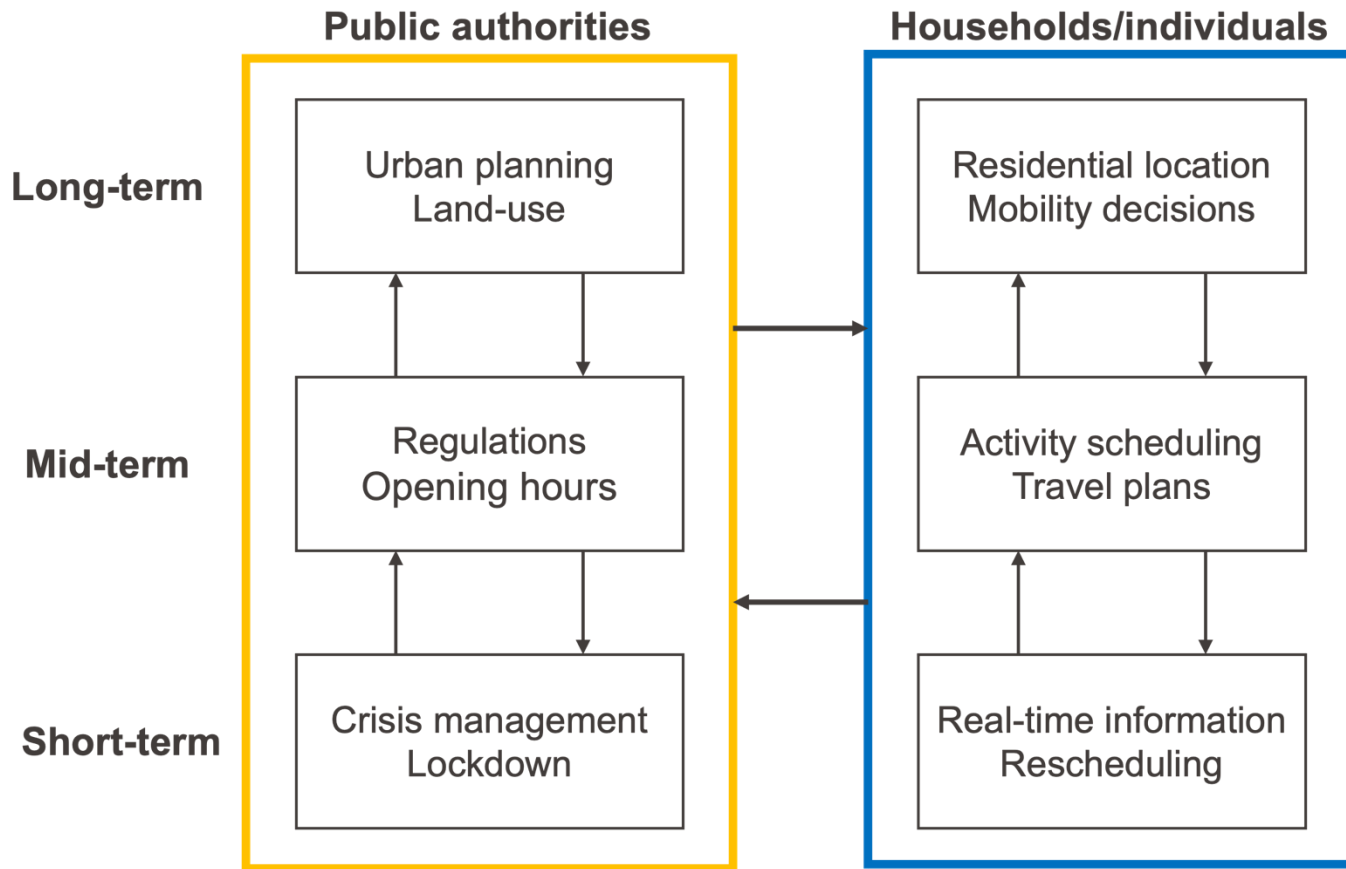
Tim Hillel

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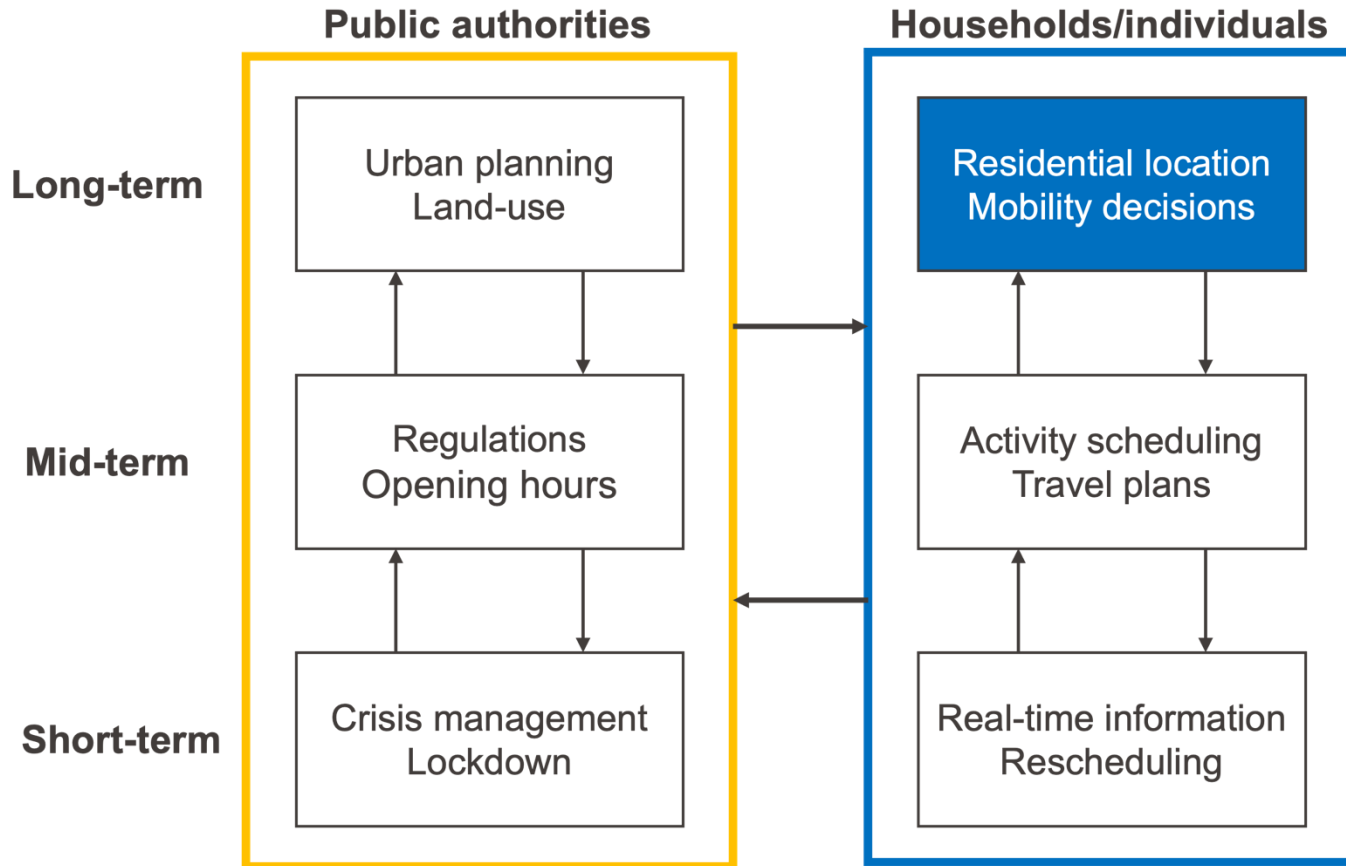


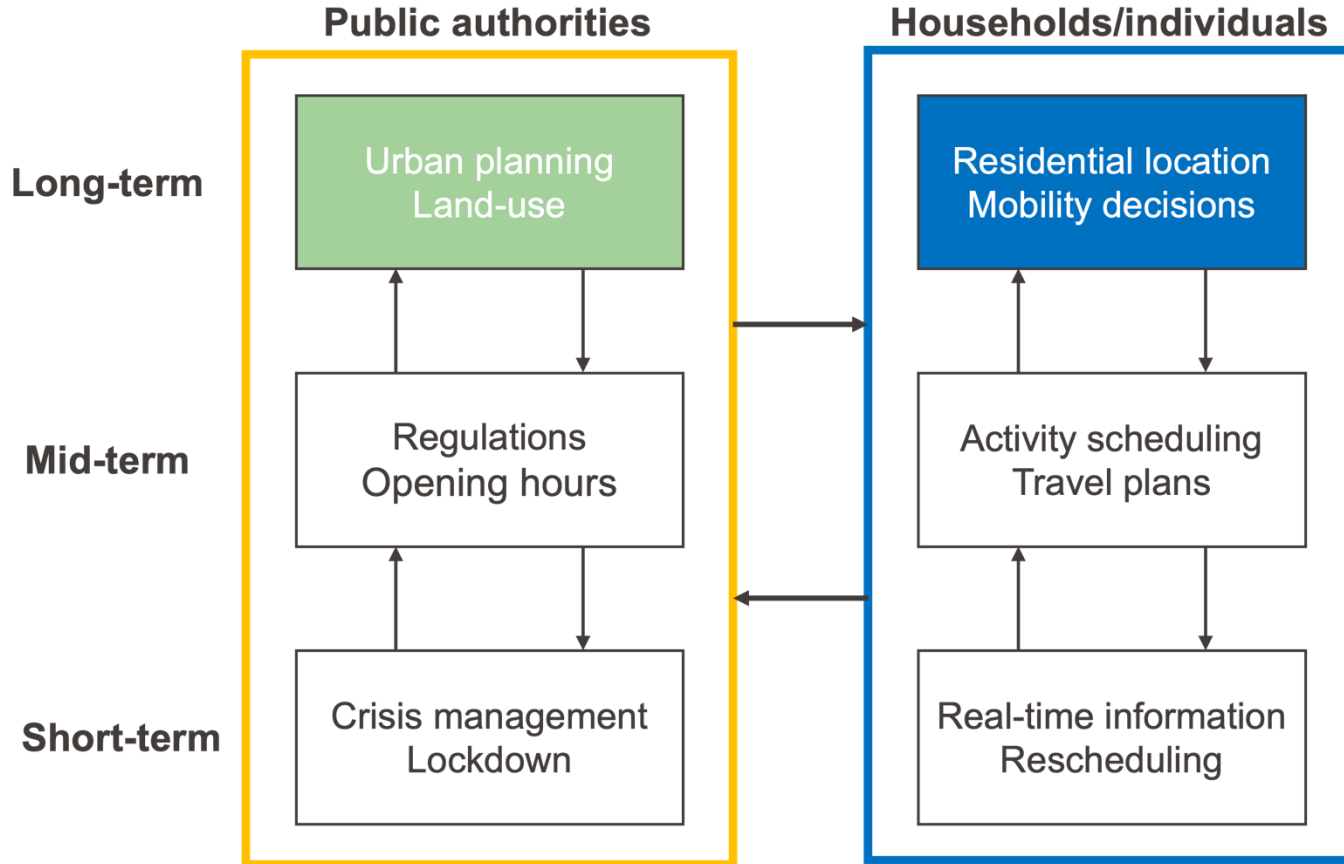
- Motivation
- Model framework and methodology
- Application
- To conclude and future work

- Think of an urban area where individuals are living in.
- The urban context is a combination of choices:
 - Different time horizons.
 - Choices of household/individuals.
 - Choices of public authorities.
- Thus, there are various decisions made at different temporal, spatial, and hierarchical level.



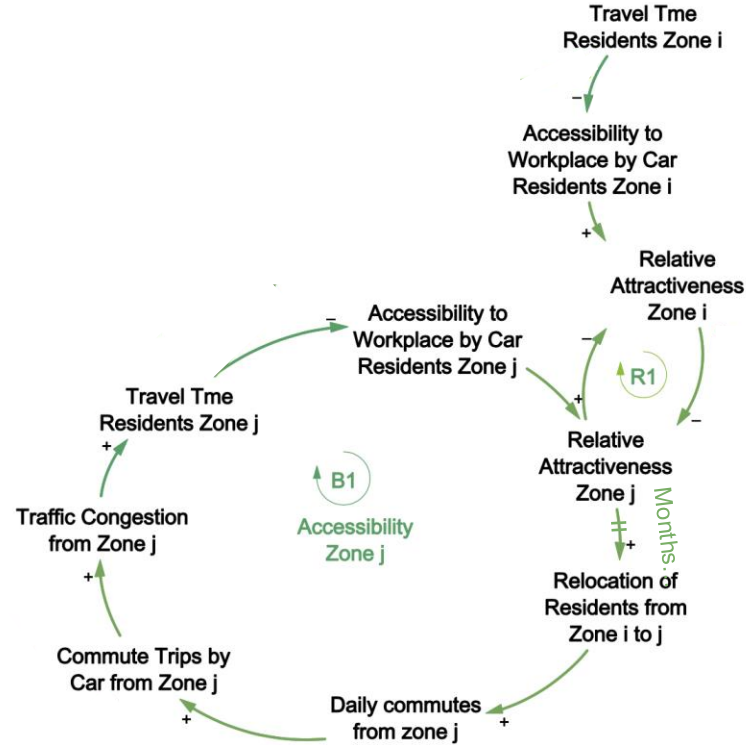
- Urban areas face **challenges** stemming from the interplay of **transport** and **land-use developments**, such as:
 - Congestion,
 - Accessibility issues,
 - Increasing housing prices,
 - Housing shortage,
 - Relocation of residents, and
 - Migration.
 - Effective urban planning demands a “What if?” forecasting capability to predict the **development paths** for a given region **over time**.
 - Thus, for a structured decision-making process, we need a **comprehensive model** accounting for their interrelations
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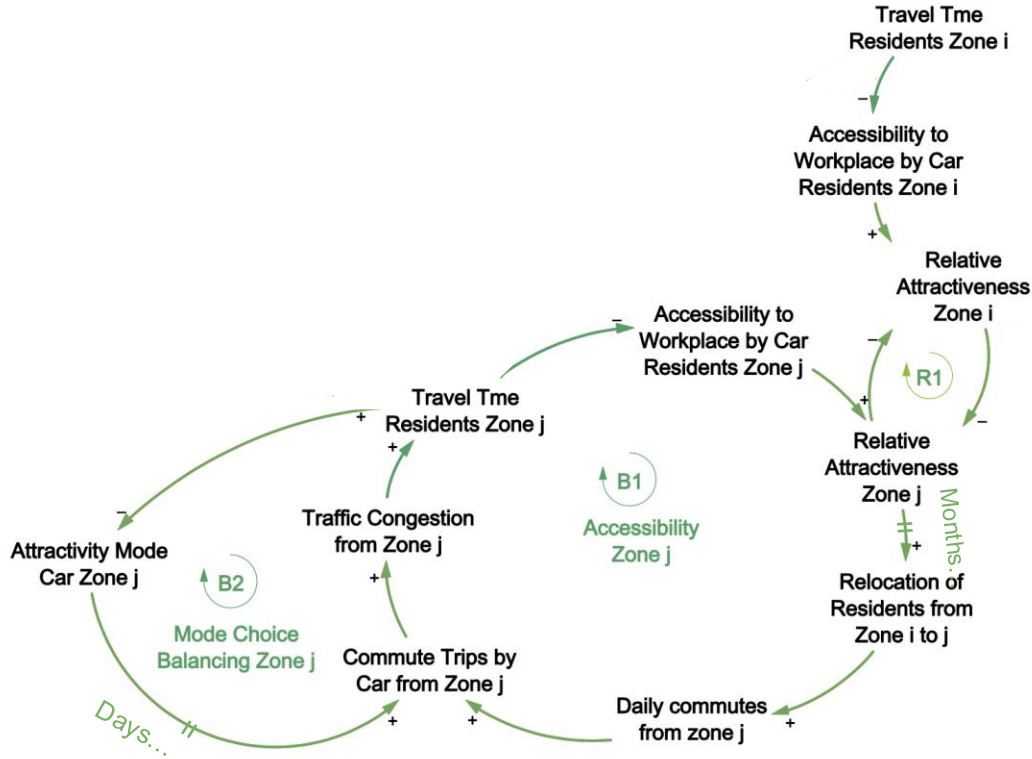


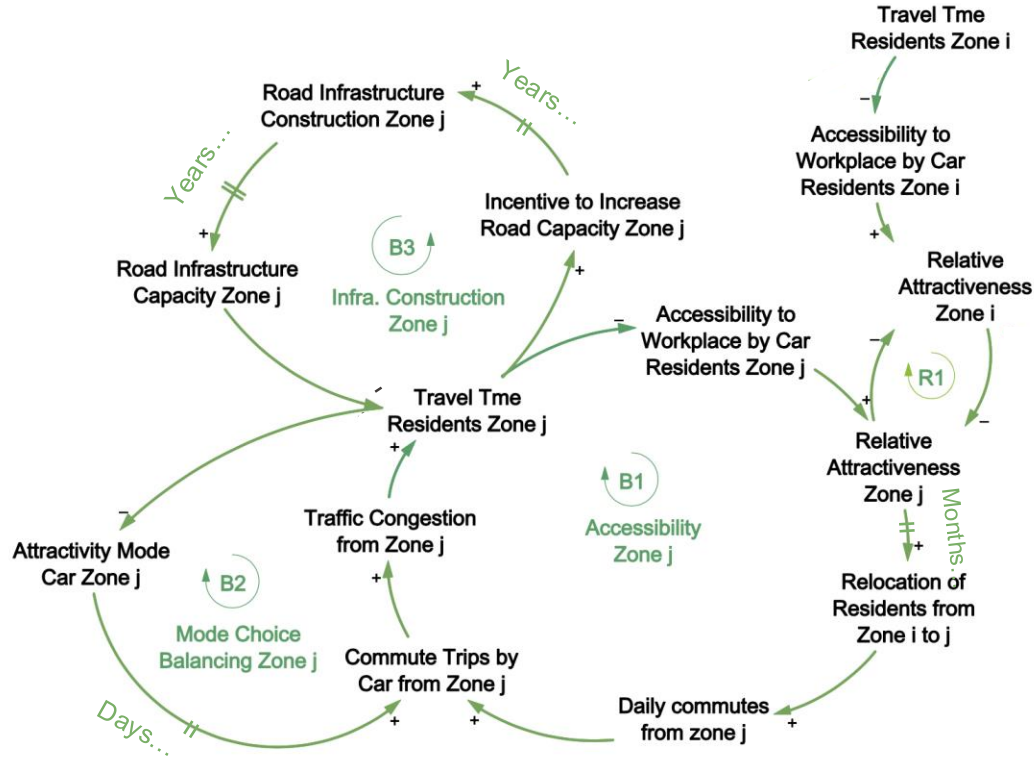


- Help tell a story about the system.
- Easily illustrates the mental model.
- Communicate the important feedbacks responsible for a problem.

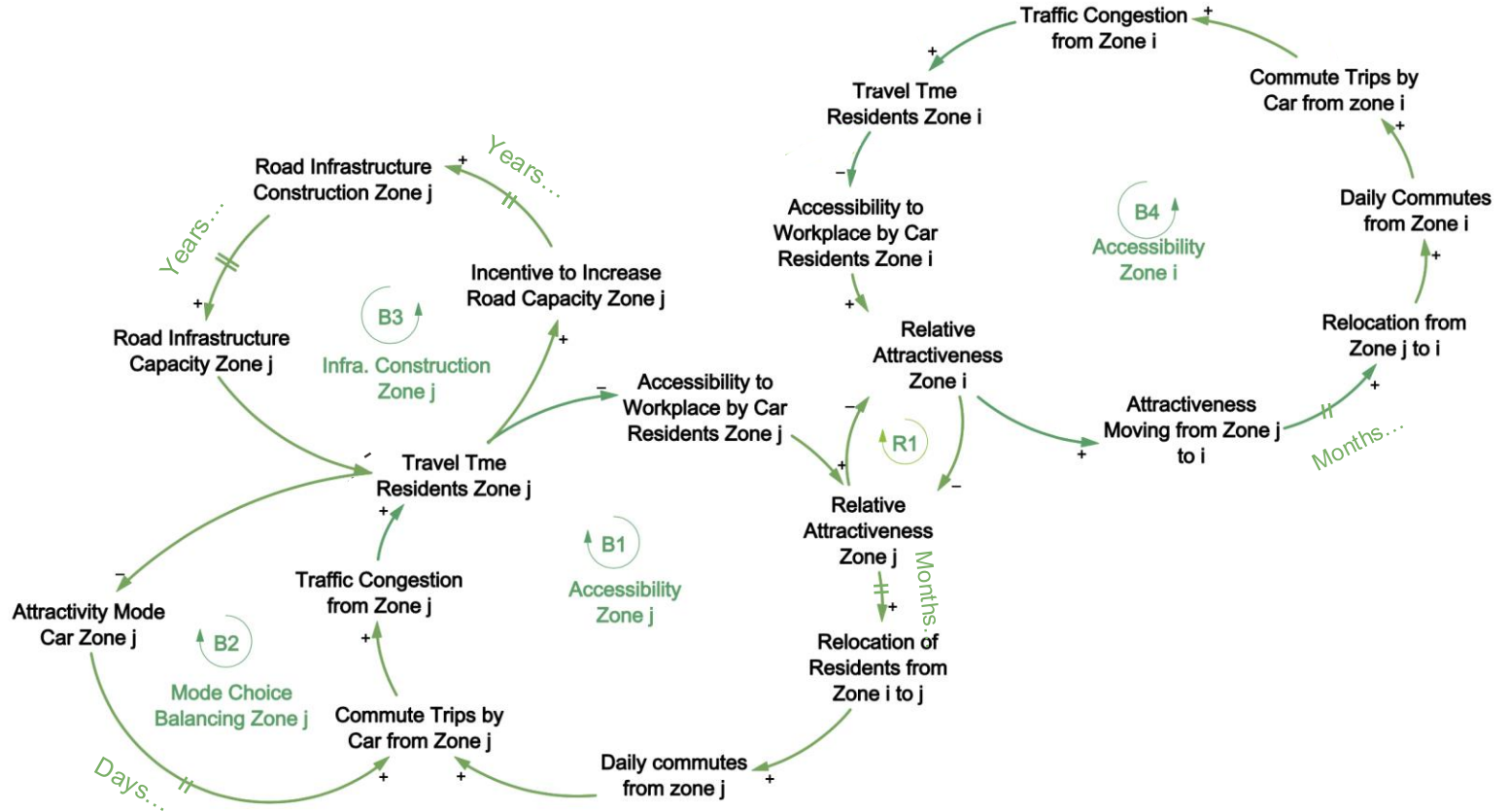




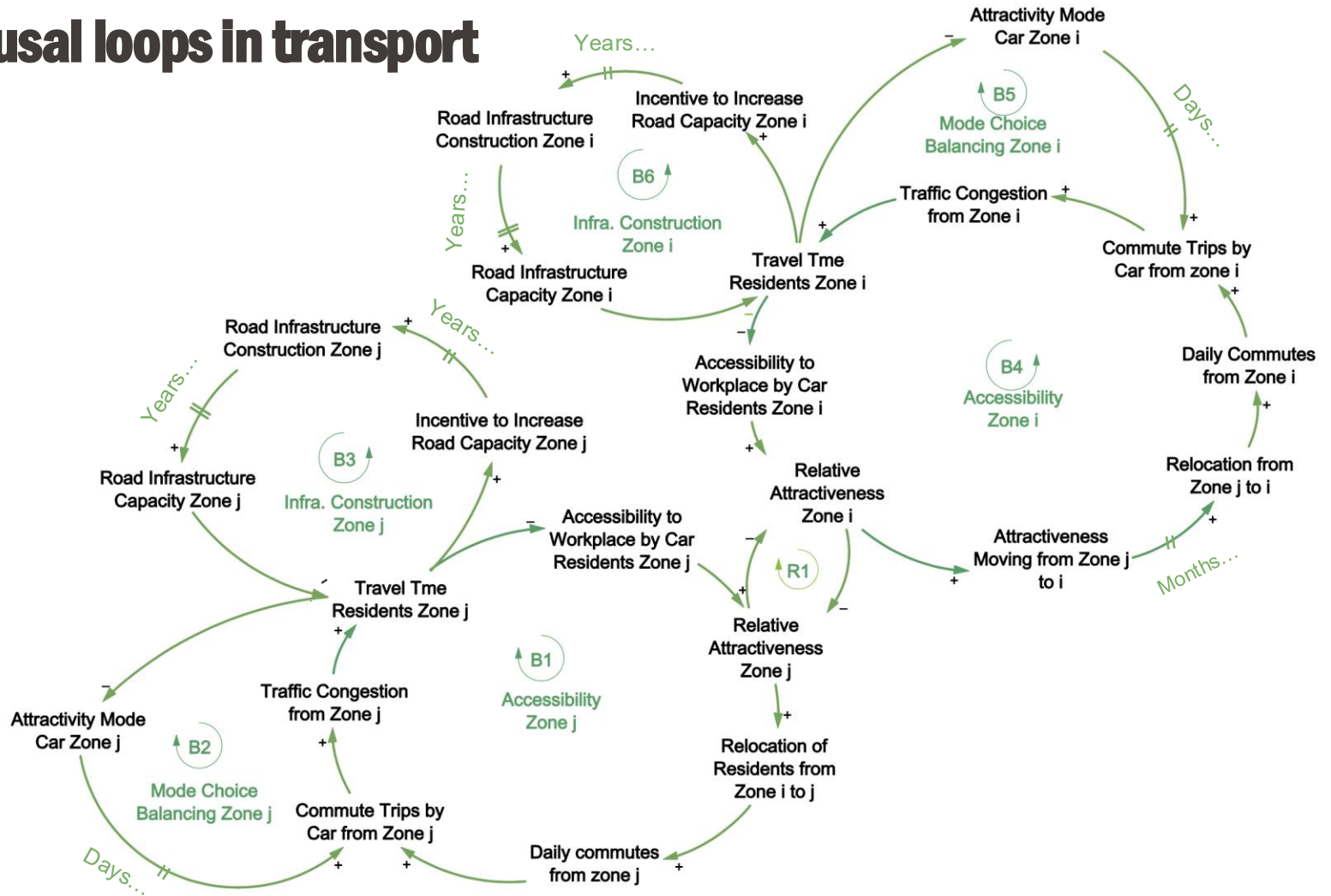


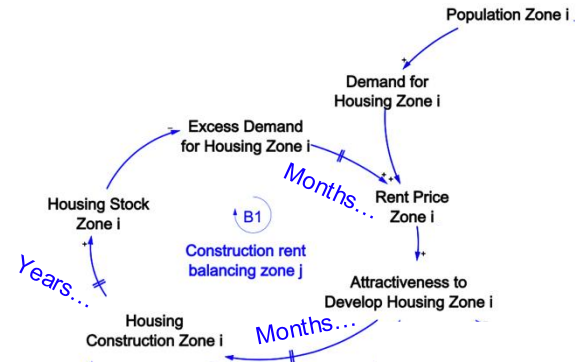


Causal loops in transport



Causal loops in transport

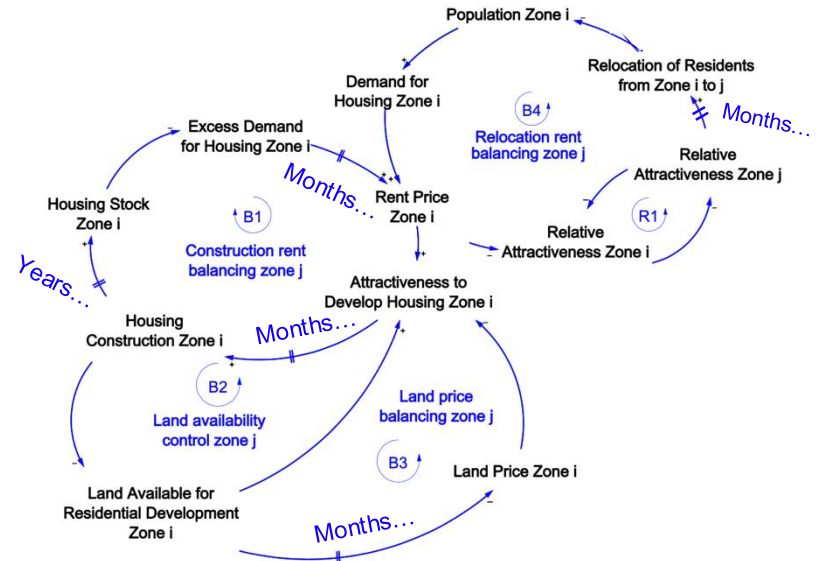




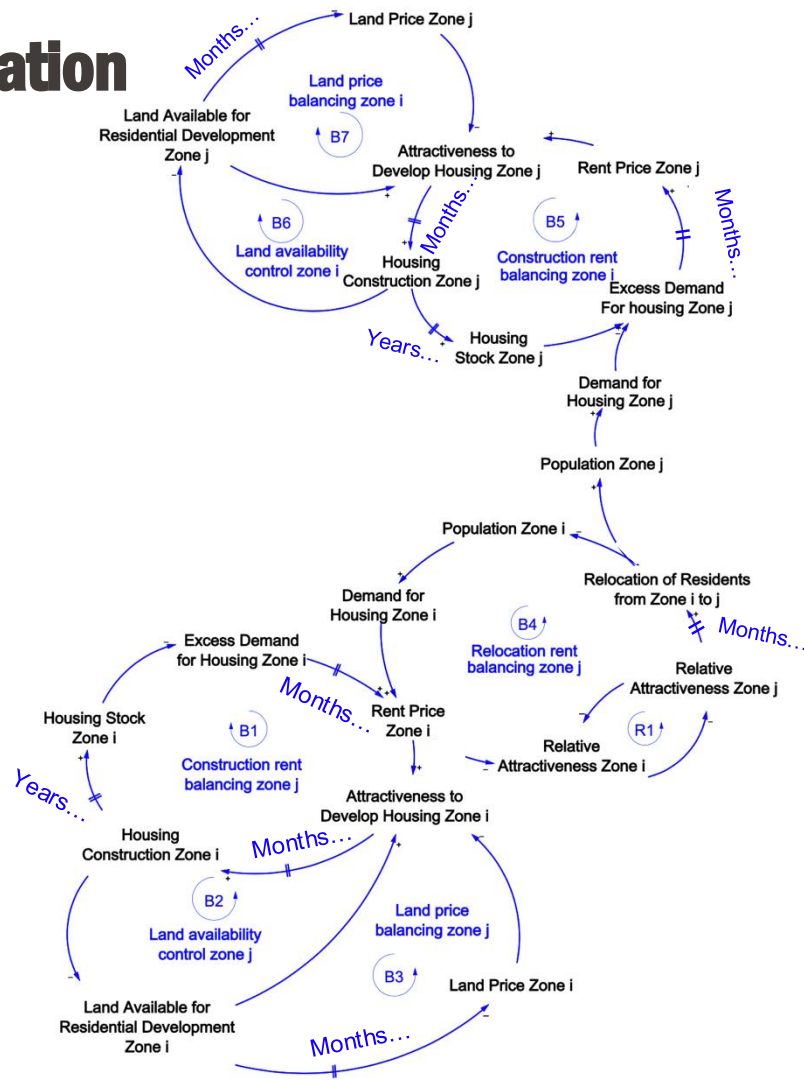
Causal loops in residential location



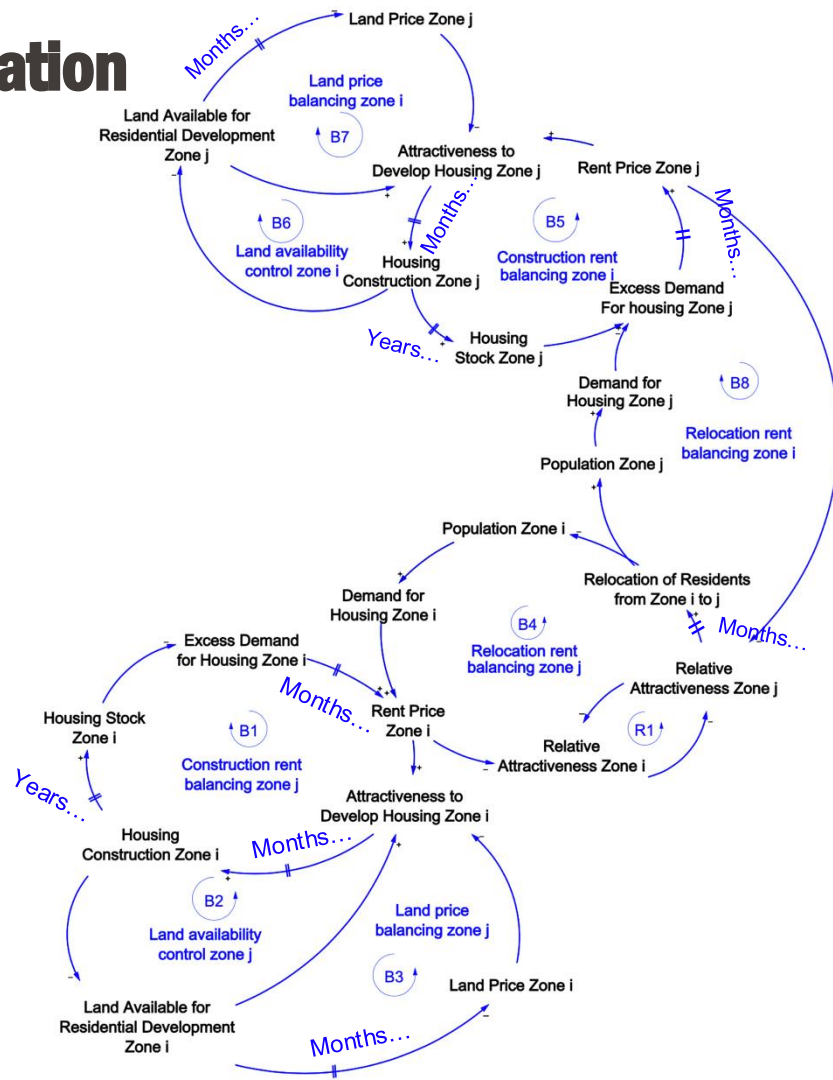
Causal loops in residential location



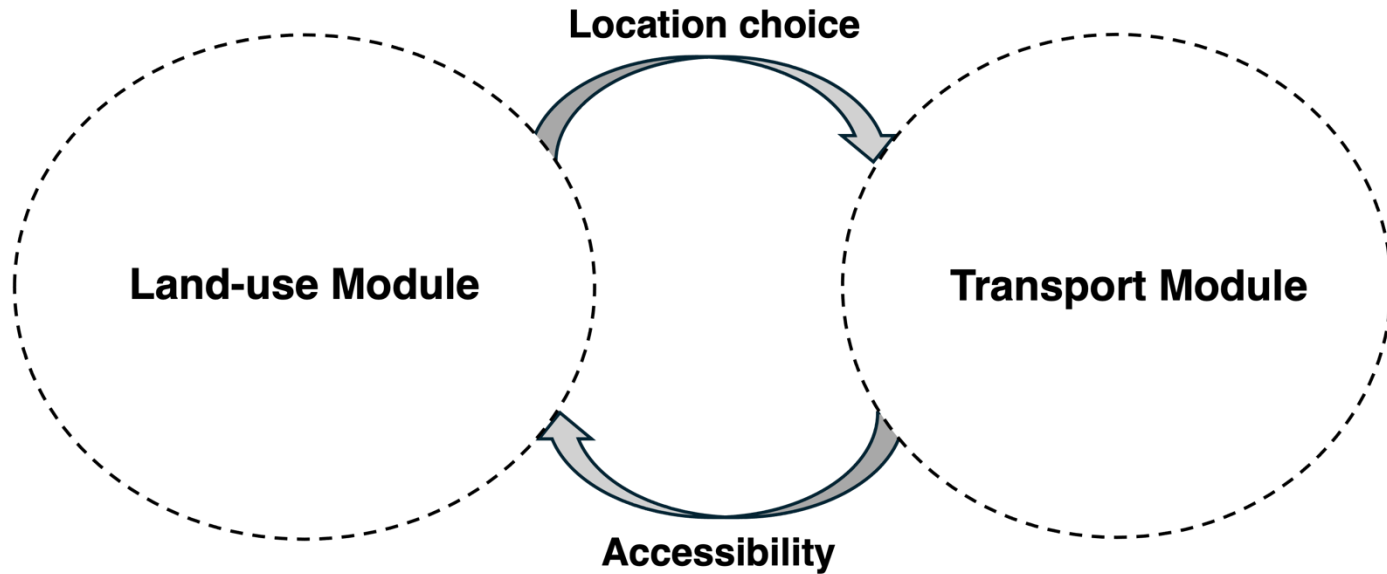
Causal loops in residential location

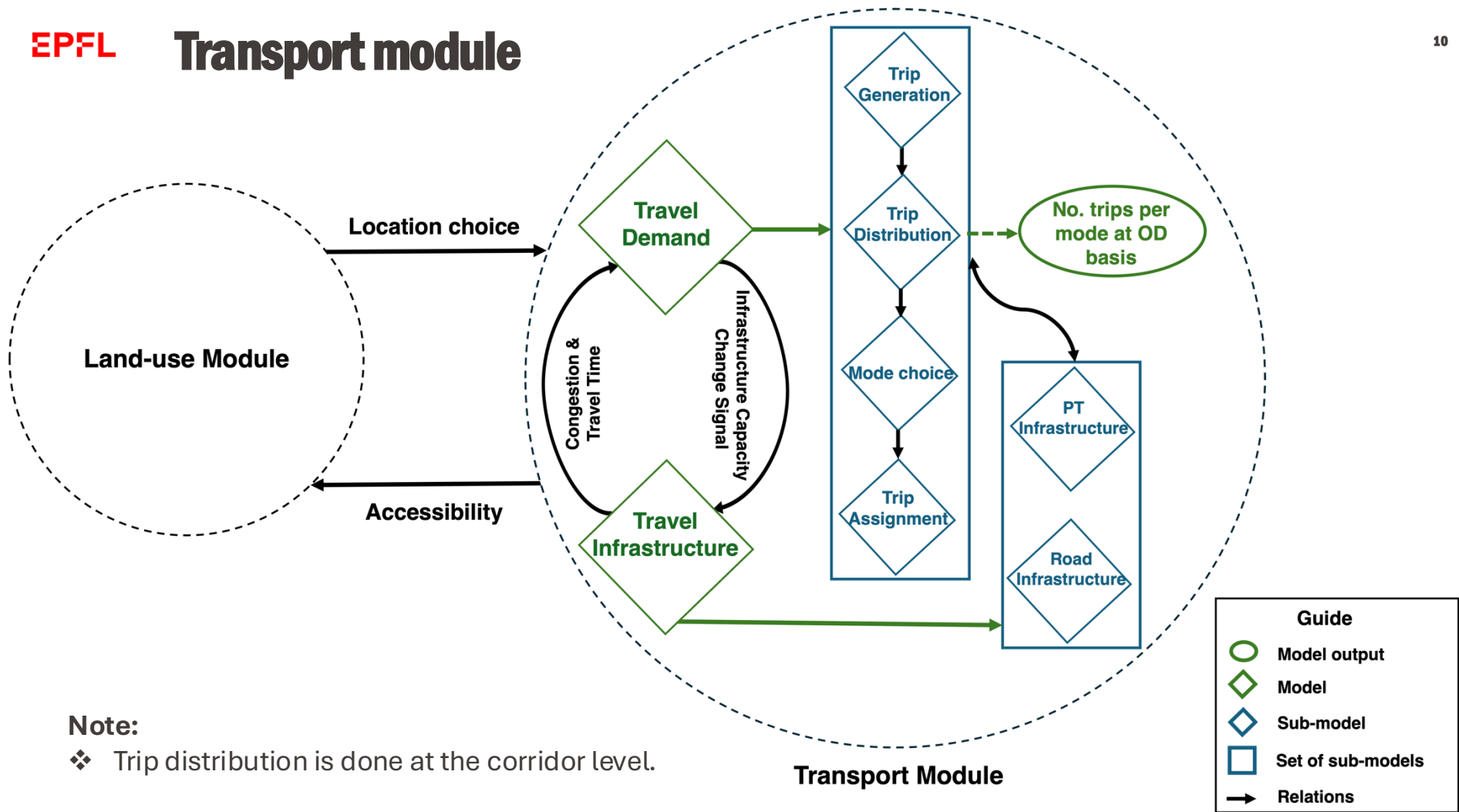


Causal loops in residential location

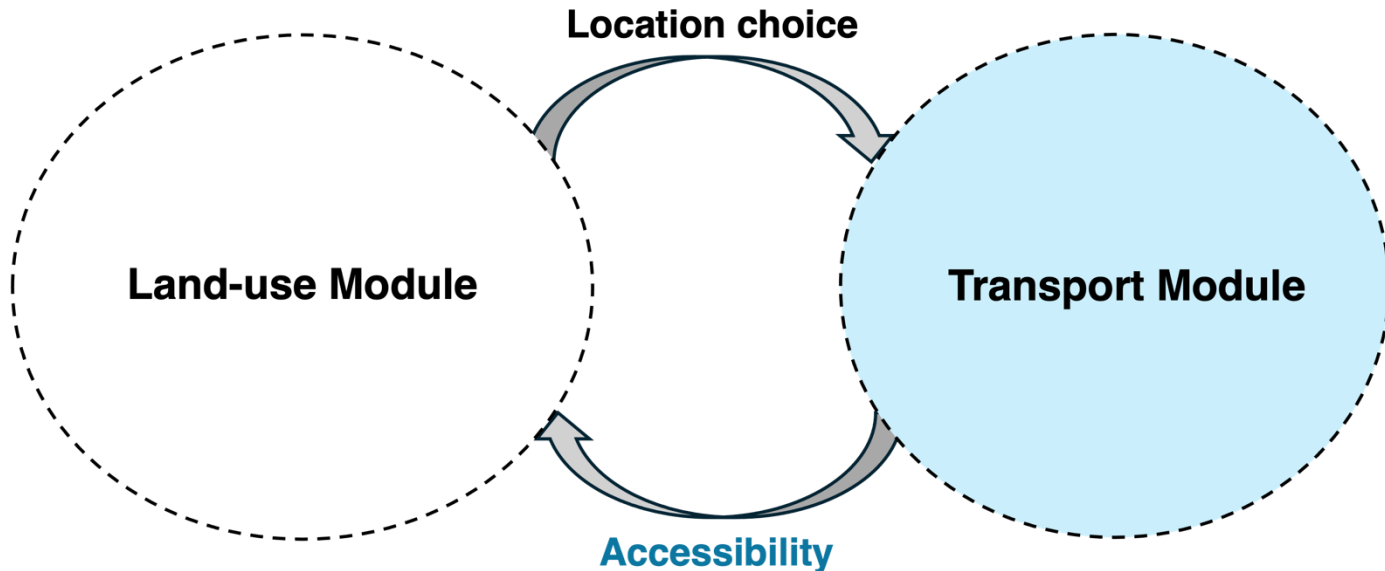


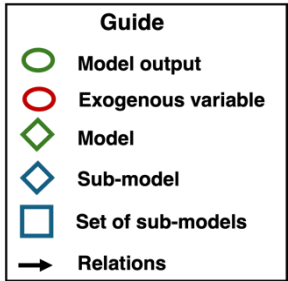
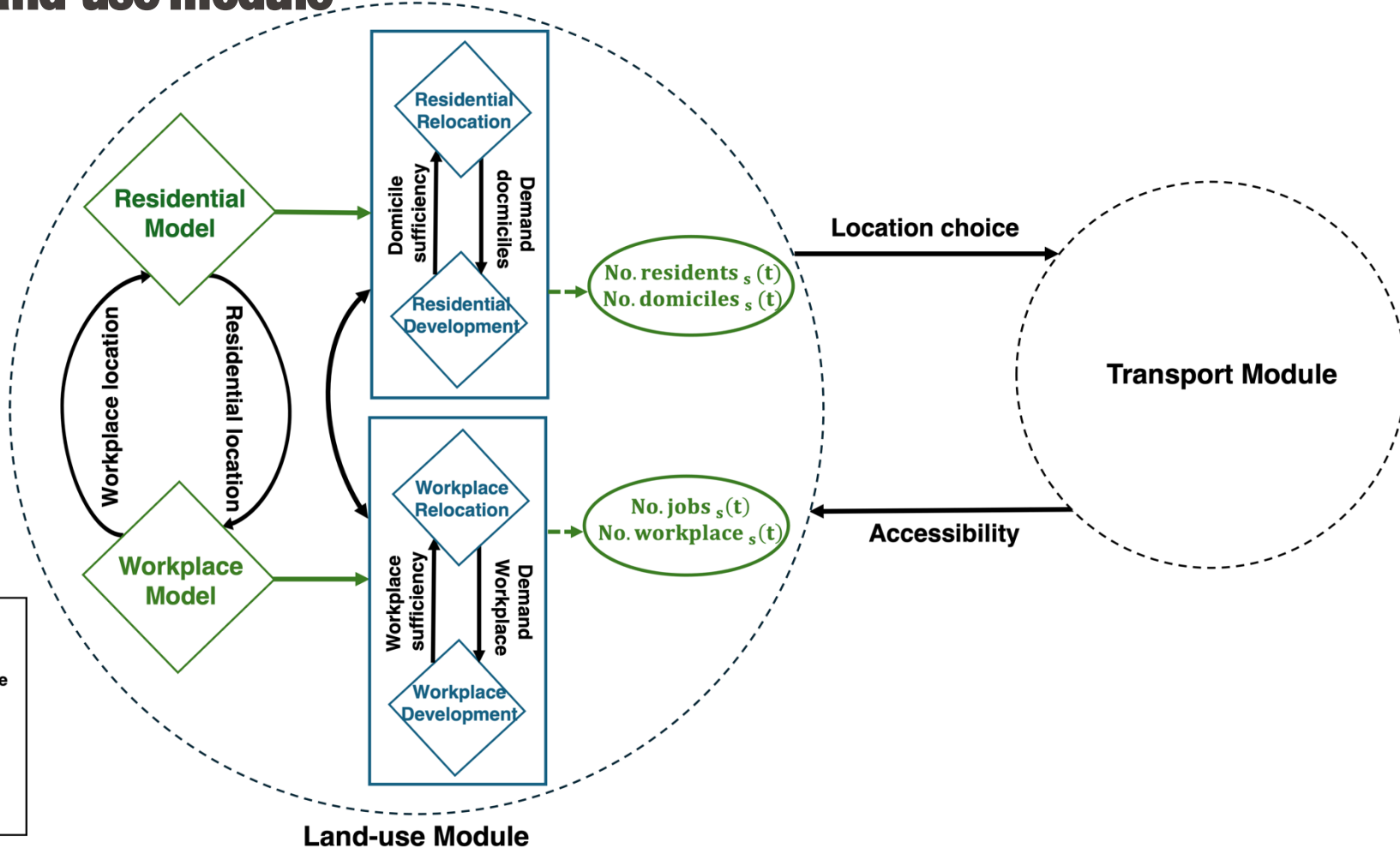
- Can we have a framework that:
 - **Integrates** transport and land-use models.
 - Model both transport and land-use **endogenously** within the **same framework**.
 - Capture **interaction** and feedback mechanisms **explicitly**.
 - **Dynamic** modelling, development path over time.
 - Take into account **time lags** between entities.
 - Elicit the **structure** that drives the system behaviour.
 - Computationally **quick**.
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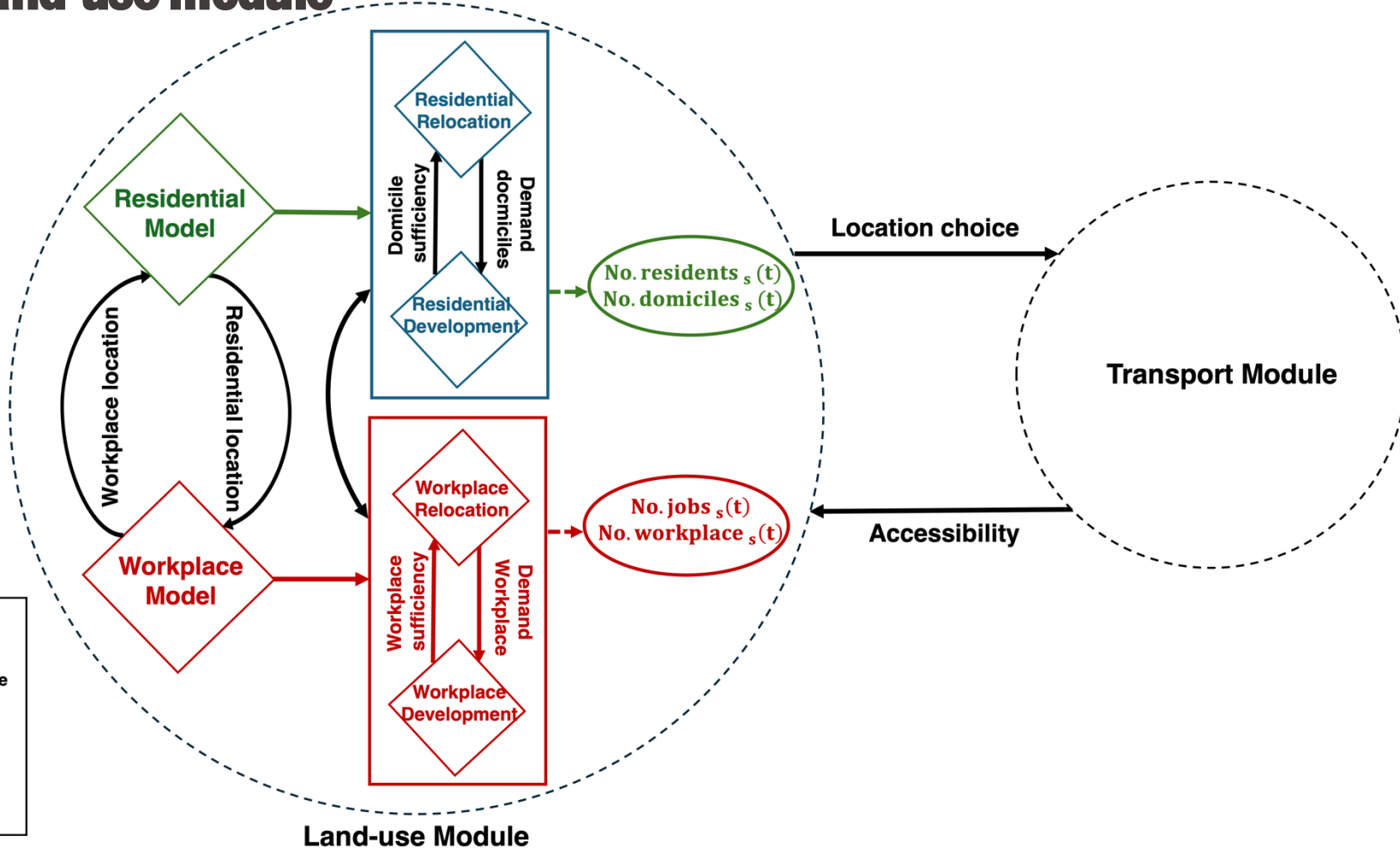


- The output of the transport module in each simulation step is the **number of trips at an origin-destination basis by each mode, travel times and cost between each origin-destination pair**, which links the transport module back to the land-use module through **accessibility**.





Land-use Module



Guide

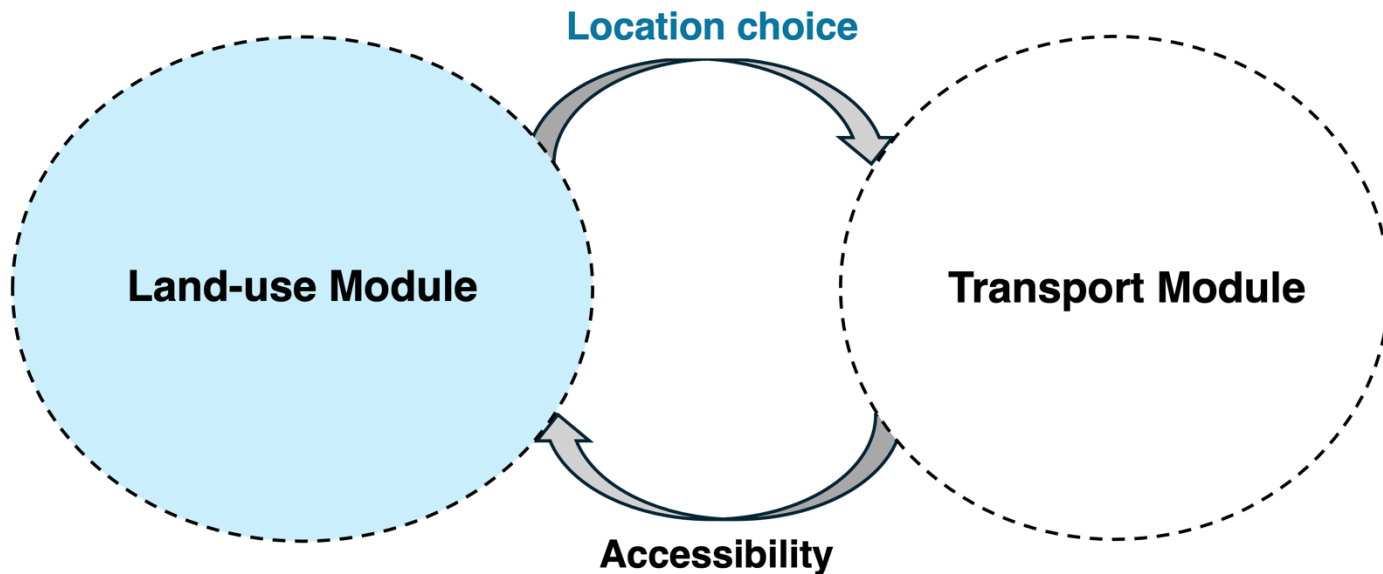
- Model output
- Exogenous variable
- ◇ Model
- ◇ Sub-model
- Set of sub-models
- Relations

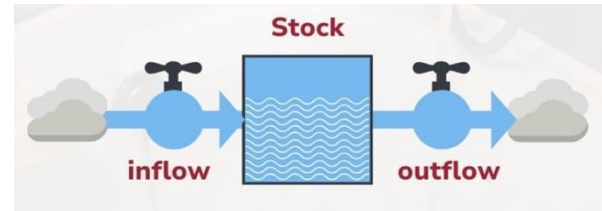
Land-use Module

- The residential relocation sub-model simulates the relocation of residents within the zones in the area through 3 steps:
 - The **out-migration of residents** is estimated for each zone.
 - The out-migration residents are **pooled** over all the zones.
 - The movers are **distributed** within residential zones based on a **logit model** based on the characteristics of the destination such as rent prices, and accessibility to workplace.
 - **Check sufficiency of housing in the area for the movers.**
 - **Sufficiency of available domiciles** in each zone is checked when distributing the residents. In case of insufficient housing in a zone, the unsatisfied demand is **redistributed** within other zones.



- The output of the land-use module in each simulation step is the **spatial distribution**, which links the land-use module back to the transport module.

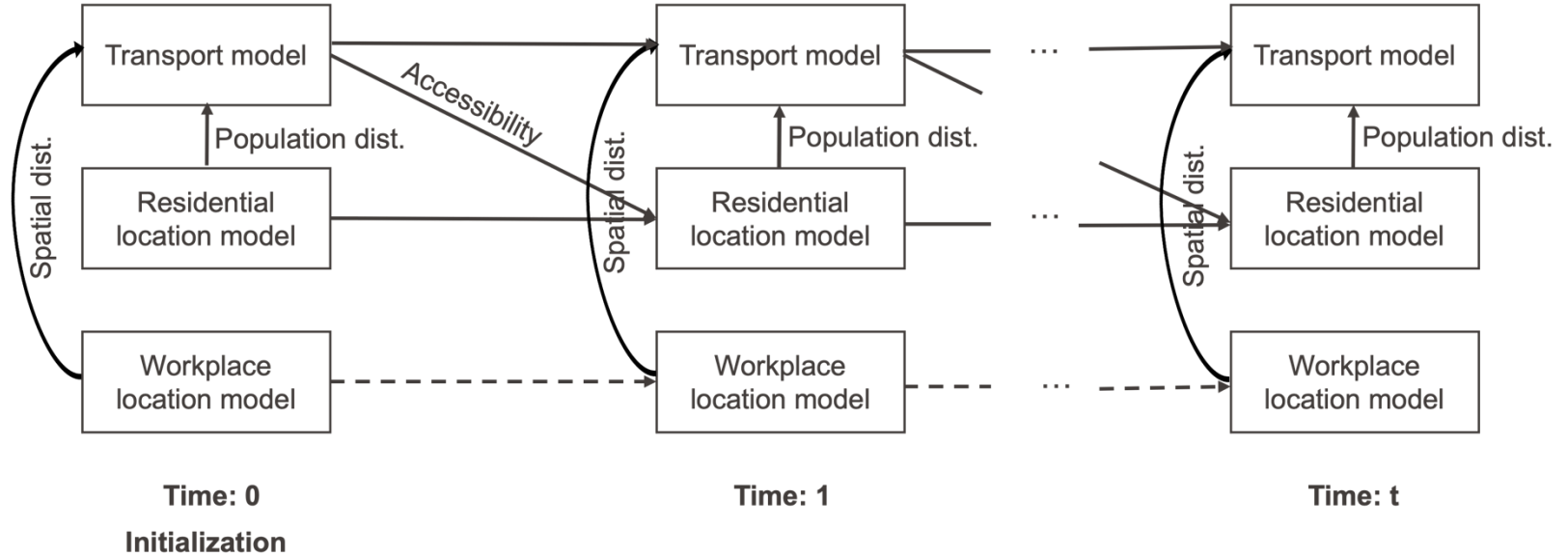


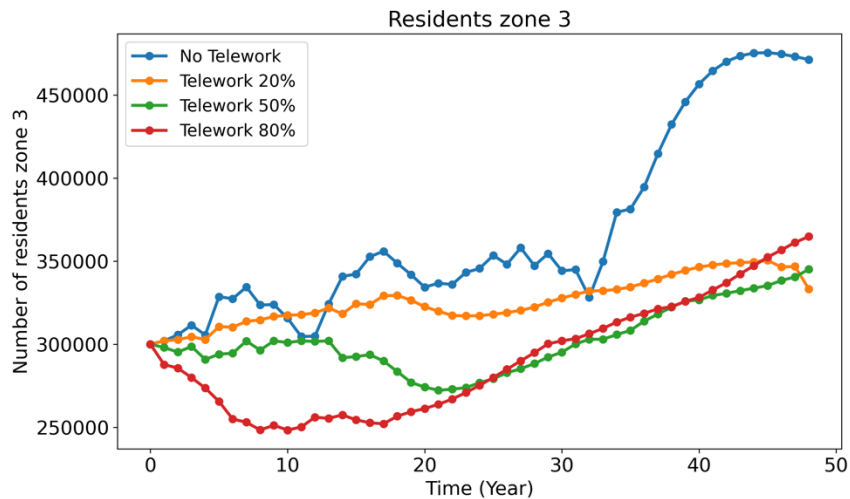
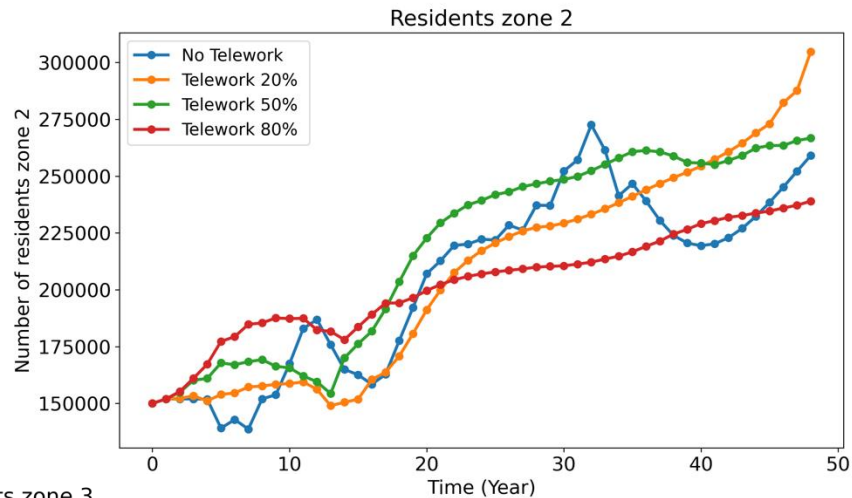
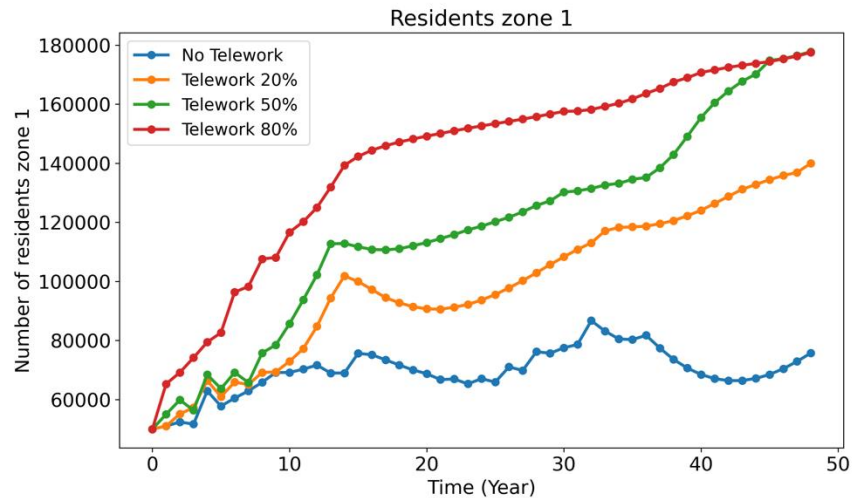


$$S(t) = S(t_0) + \sum_{\tau=t_0}^t (F_{in}(\tau) - F_{out}(\tau)) \Delta\tau$$

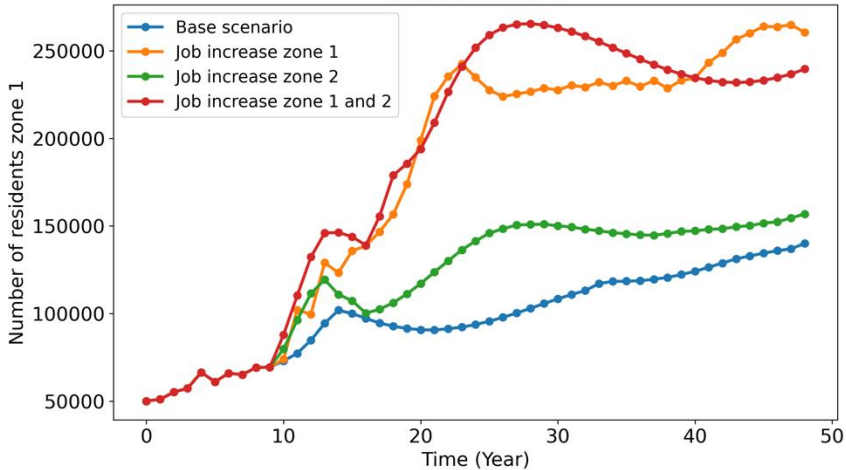
- **Transport section:**
 - *Stock variables:* transport infrastructure.
 - *Flow variables:* transport infrastructure construction processes, transport infrastructure depreciation.
 - *Auxiliary variables:* travel cost, travel time, speed, modal split, ...
- **Land-use section:**
 - *Stock variables:* Population, housing units, available land to construct, rent price, land price.
 - *Flow variables:* Population growth/decline, migration, construction/demolition of housing units, change in available land.
 - *Auxiliary variables:* average household size, distance.
- **Intersection of land-use and transport:**
 - *Auxiliary variables:* accessibility measure, spatial distribution.

- Dynamic model.
- Spatial: Discrete urban zonal level.
- Time-step: Years, Months, Days.
- The state of the urban system is directly derived through dynamic modelling.

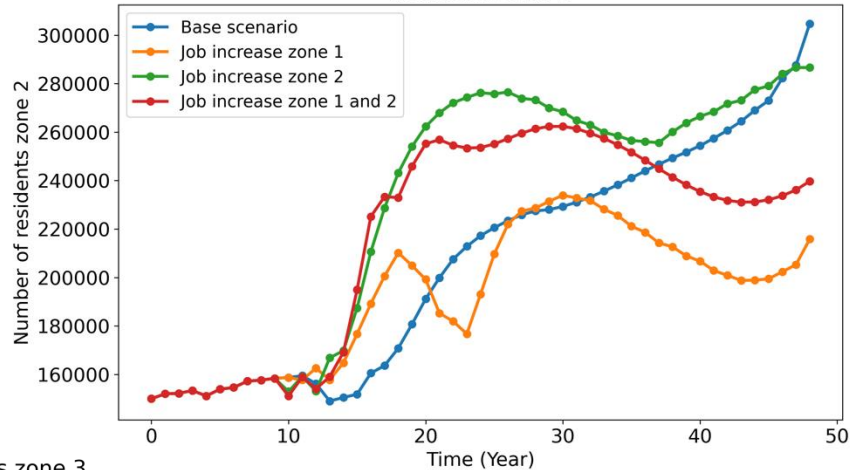




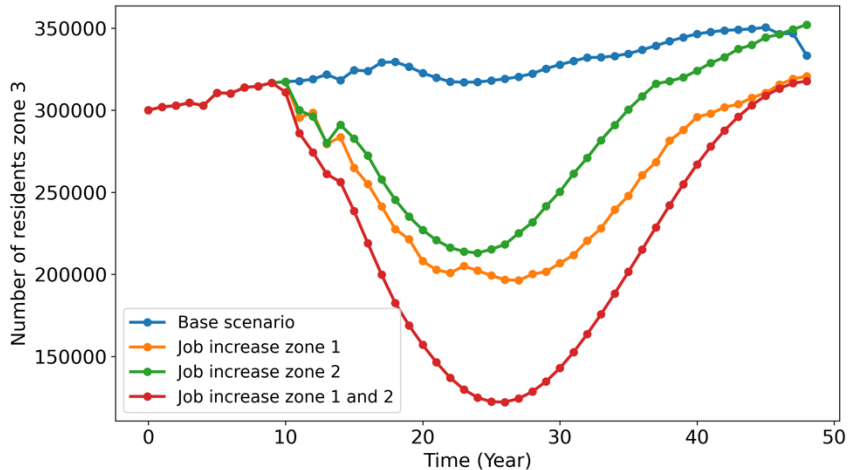
Residents zone 1









Residents zone 2



Residents zone 3



- Motivation: computationally efficient dynamic integrated transport and land-use.
- Combine land-use and transport models.
- Use system thinking and dynamic modelling.
- Main advantages of the framework:
 -  Integrated design,
 -  Computationally efficient decision-support tool,
 -  Dynamic,
 -  Reproducible,
 -  Flexibility, and
 -  Easy to understand.

Future work:

- Empirical application to Luxembourg; calibration.
- Testing: behaviour reproduction, model robustness and sensitivities.
- Other choice complexities; e.g., buying or renting for satisfying residential demand
- Probabilistic simulation.
- Economic aspects; time value of money and inflation.



Thank you!