Chapter 13
Prospects of the Activity-Based Modelling Approach: A Review of Sweden's Transport Model-SAMPERS

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Abstract The rapid changes in global development scenarios, such as technological advancements, lifestyle decisions and climate change, call for updated transport models to test micro-level policy decisions. This paper explores the advances in activity-based transport modelling in simulating travel demand in urban scenarios, focusing on Sweden's National Transport model. Sampers is used for impact analysis, investment calculations for traffic simulations, transport policy implementation evaluations, and accessibility and impact analysis of extensive changes in land use and transport systems in cities and regions of Sweden. This research systematically compares individual components, sub-models, and algorithms and discusses integrations with cutting-edge agent-based models. Furthermore, recent research and projects for Sampers are investigated, highlighting its advantages over current models, potential gaps and limitations, and long-term development prospects. The study concludes by cross-referencing Sampers' global developments and regional needs to assess its long-term development prospects.

13.1 Introduction

The advancements in behavioural research have highlighted the strengths of an Activity-based modelling approach, such as the integrity of its sub-models, reduced interdependence between the four stages, and has resulted in a paradigm shift in travel behaviour analysis. Despite these advantages, the inability of Activity Based Model's (ABM's) to reflect such realism foreshadows the obvious need to improve

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upon the present transportation models. Moreover, researchers and transport planners are increasingly relying on ABM, the third-generation models for simulating transport demands based on the simulated behaviour for activities.

This research aims to identify recent advances in ABM for its individual components and integrated approaches, particularly agent-based models. The advantages and limitations of these advancements are analysed systematically to determine their potential applications in urban scenarios.

The recent advances [1] over various integrated approaches in ABM for the utility maximization based econometric models and the rule-based computational process models, are discussed here. We seek to note integrations of major advancements in ABM's for their potential advantages and limitations over apt applications in a systematic manner.

Overall, this paper aims to contribute to the ongoing debate on the prospects of the activity-based modelling approach by providing a comprehensive analysis of recent advancements in ABMs, their potential advantages and limitations, and their integration with cutting-edge agent-based models. The specific contribution of this research is the development recommendations for the evolved [2] Sampers.

13.2 Theoretical Background

Activity-based models focus on individual activity schedules, which include activity choice, sequence, mode and route choice as well as time dynamics, in sync with the transport network and its attributes. The model's output being simulation of scenarios and forecasting variations in trip chains for activities, modes of transportation, routes, and other constraints.

13.2.1 ABM Components and Applications

Activity-based models (ABMs) are travel demand models that simulate the entire process of individual decision-making regarding their daily activities and travel choices. ABMs typically consist of three components: activity generation, activity scheduling, and mobility assignment. The activity generation component determines an individual's desire to participate in different activities and is often modelled using heuristic, hazard-based, or micro-behavioural models. The Agent-based Dynamic Activity Planning and Travel Scheduling (ADAPTS) model, an American computational process model for the Chicago region, uses concurrent competing hazard models to determine whether to generate a new out-of-home activity of a specific type.

The activity scheduling component determines each activity's start time, duration, and location while considering all constraints. This component is the most researched of the three and often uses probability-based models to determine these factors.

The Canadian model for the Greater Toronto region, Travel Activity Scheduler for Household Agents (TASHA), generates activity agendas and their attributes based on empirical distributions. While the complex rule-based ABMs, A Learning-Based Transportation Oriented Simulation System (ALBATROSS) of the Netherlands uses decision heuristics. The DaySim ABM model, which uses a disaggregate dynamic network traffic assignment tool TRANSIMS router developed for Sacramento and Jacksonville, USA, is an application of the micro-behavioural model.

The mobility assignment component determines the mode choice and vehicle allocation based on the previously determined activity and scheduling choices. This component often uses heuristic, hazard-based, or micro-behavioural models. Agent-based models (ABMs) are also commonly used to represent human behaviour in ABMs, as they can produce complex travel behaviours using simple heuristics. Recent research on the integration of activity-based and agent-based models has shown that these models can forecast traffic in greater detail. For example, the MATSim (Multi-Agent Transport Simulation) model has been enhanced [3] to include network, zone, traffic counts, road pricing, trip length distribution, route assignment algorithms, and behaviour modification programs (flexible scheduling, ridesharing), and so on. MATSim, the stand-alone agent-based modelling framework, has also been shown to produce traffic flows that are more accurate than other models, such as Canadian EMME (multimodal equilibrium model).

Aside from MATSim and ALBATROSS, other notable integrations include FEATHERS, developed initially as a computational process model for Flanders, Belgium. The FEATHERS model has also been successfully applied in new contexts. Also included is TRANSIMS, a disaggregate dynamic network assignment tool integrated with multiple ABMs such as DaySim, ADAPTS, and others via sequential integration. SimMobility is another recent multiscale integrated agent-based simulation platform that includes a learning day-by-day module. POLARIS, which integrates dynamic simulation of travel demand, network supply, and network operations to solve the difficulty of integrating dynamic traffic assignment and disaggregate demand models, is also available. Gains in computational efficiency and performance enable previously distinct aspects of the urban system to be included in planning models.

While ABMs offer many benefits, including a more comprehensive understanding of travel behaviour and the ability to forecast traffic in greater detail, they also have limitations. For example, agent-based models have high computational complexity and require well-defined conditions and constraints. Additionally, there needs to be a streamlined process for calibrating and imputing model parameters, which can result in non-reproducibility and difficulties in understanding agent interactions with other agents and environmental parameters.

13.2.2 Overview of Sweden's National Transport Model

Sampers, the national transport model system developed by the Swedish Trans- port Administration (Trafikverket [4]), is a powerful tool for cross-modal passenger transport analysis. It forecasts future traffic volumes for different scenarios, simulations by varying infrastructure availability, and parameters such as GDP, fuel price, employment, population growth, to be contrasted in a socio-economic constraint. Sampers model is integrated with its socio-economic model (Samkalk) for comparison and investigative analysis, using its calculation module divided into matrix program, route analysis, effect models, and financial program.

The model comprises several travel forecasting modules, including the frequency choice model, destination choice model, mode of transportation choice model, and route choice model, linked in a nested logit model estimated using data from national travel habit surveys (RIKS-RVU/RES). A generic overview of the recently proposed Sampers in comparison to the model systems can be acquired from Fig. 13.1 below. The logit models compute probability distributions for how an individual or group of individuals chooses between diverse alternatives. Furthermore, the logit model computes log sums, which measure the combined benefit generated by the model's selectable options. The log of the denominator of this logit choice probability, the activity-based accessibility measure (logsum), gives the expected utility from a set of alternatives and links different choices, as in nested logit models. This metric is ideal for project evaluation because it expresses the consumer's benefits from all travel alternatives.

The route choice model comprises modules built into the EMME software toolkit and accounts for congestion as a factor that controls route choice in the algorithm

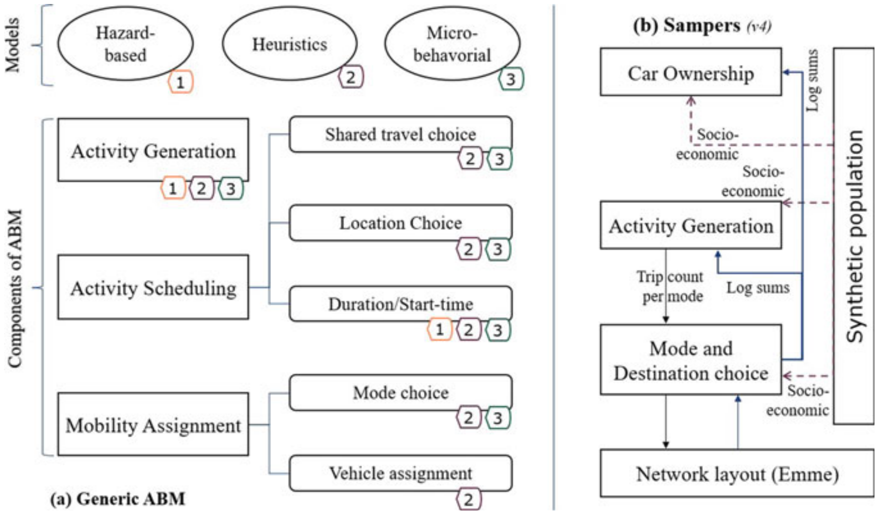

Fig. 13.1 Overview structure of model and sampers

for car traffic and is vital for the travel times obtained in route choice simulations. To achieve equilibrium between supply (travel times and costs) and demand, the car route choice model must iterate between the first three steps of the Sampers model (frequency, destination, and mode choice) and the route choice model.

The socio-economic module determines the socio-economic benefit of one investigation alternative over another, using data on travel by various modes of transportation, travel times, traffic volumes, and traffic revenue on various public transportation routes as input. The model used travel times, travel costs, greenhouse gas emissions, and accident values to calculate benefits.

Sampers is used primarily for impact analysis and investment calculations for traffic simulations, transport policy implementation evaluations, as well as accessibility and impact analysis of extensive changes in land use and transport systems in cities and regions [5]. It can also be used for micro-modelling scenarios that investigate intersections for minor variations in traffic control and travel times, meso-modelling constraints that investigate the effects of institutional conditions on traffic counts, interactions between transport systems and land use, and impact studies of IT-based or relevant scenarios on travel demand.

While the model has several sub-models, including a module for connecting journeys, it is used sparingly due to high uncertainty and limitations in handling travel between Sweden and abroad. Several methods for managing trips need to be calculated in the demand model, including static arrays and quota adjustments for existing travellers. Overall, Sampers is a valuable tool for transportation planning and analysis in Sweden, but certain innovations in the model are worth exploring to realise the limitations and further recommendations.

13.3 Sampers Innovation Projects

Transportation systems are continuously evolving with technological innovations such as electric vehicles, connected and collaborative intelligent transport systems, and autonomous vehicle technology, along with lifestyle-altering events such as the recent pandemic and sustainability issues related to climate change. As a response to these changes, several recent industries and university-led research projects analyse scenarios and work towards introducing relevant changes in the existing Sampers model. In this section, we will discuss some ongoing and completed projects that focus on improving Sampers for planning prospects in Sweden.

13.3.1 IHOP Project: Building Dynamic Network Models for Next-Generation Activity-Based Models

IHOP aimed to create a dynamic and disaggregate person/network simulation system. This project framework aims to develop a model for car traffic, to handle queues with back-blocking, the interaction between vehicles at junctions, weaving stretches, and other scenarios to make socioeconomic calculations more comparable and consistent. With the vision of a traffic system with connected and collaborative autonomous vehicles, the project evolved to develop an overall control model to optimize the behaviour of the traffic system. A natural choice for network deployment of demand matrices constructed from activity-based models was to integrate dynamic network deployment methods in Sampers.

IHOP2 [6] connected the Regent travel demand model and the TransModeler network assignment package via a new agent-based interface layer based on the MATSim transport simulation toolkit. The main goal of this effort was to demonstrate that such a coupling, with frequent status updates in the system between all vehicles and immediate updates of the route options, is possible. The interface layer could link the mesoscopic network model (TransModeler) to the activity-based demand model (Regent) by defining agents routed through the network. The agents could also communicate with each other in real-time, providing the ability to perform various collaborative maneuvers such as lane changing and car following. The results showed that the coupled models could accurately represent travel behaviour, with its interface between the demand model and mesoscopic, dynamic network layout, a shift from estimation to implementation in its forecasting system.

IHOP3 focused on ensuring an economically consistent analysis of the simulated travel behaviour in such a system. To achieve this, IHOP3 developed a simulation method for economically consistent integration of Sampers and MATSim. This resulted in the specification of a joint, fully dynamic, and person- centric utility function in both Sampers and MATSim. Given the different time and travel demand resolutions of the two models, different utility functions were used in Sampers and MATSim, resulting in different models of travel experience and different cost–benefit analysis results. However, the integrated model developed in IHOP3 was able to overcome these discrepancies and provide a more accurate and consistent estimation of travel behaviour in the network.

The IHOP project successfully improved the Sampers model by creating a more dynamic and disaggregate person/network simulation system. With the development of a simulation method for economically consistent integration of Sampers and MATSim, the project achieved a shift from estimation to implementation in forecasting systems.

13.3.2 Simulations for Long-Distance Trips: Vehicle Fleet Electrification

This research [7], initiated in 2018, aimed at reducing the carbon footprint based on technological advances in electric drivetrain and battery technology that allow them to travel long distances independent of public charging infrastructure during most suburban and commuting trips. This effort was part of a larger project to electrify the vehicle fleet in Sweden. The impact of large-scale vehicle electrification on long-distance trips was assessed by combining a Swedish agent-based long-distance transport model with a detailed energy consumption and battery charging model. This new approach developed a microscopic transport model using agent-based simulations to assess different system parameters' impact on total energy consumption.

The goal was to derive the charging infrastructure needs or the overall system cost for all electromobility-related technologies. By simulating different scenarios, the impact of different system configurations on energy consumption and charging infrastructure requirements were assessed, providing valuable insights into the potential benefits of vehicle electrification for long-distance travel.

13.3.3 Modelling and Analysis Module for EVs, ITS and Autonomous Vehicles

Significant research is being conducted on the future scenarios and impacts of self-driving vehicles in academic institutions and industry projects. Swedish research institutes are developing AV-induced transport system simulations [8] to better understand the impacts of autonomous vehicles on the country's transportation system. Meanwhile, other studies are focused on identifying research gaps and performing cost analysis modelling for AV freight operations, as well as introducing comprehensive impact assessment tools [9] to assess the overall impact of AVs on the transportation system.

One key aspect of this research is its connection to the Swedish transport model, Sampers, which is used to review AVs in relation to system assessment. This project conducts analyses to identify uncertainties and gaps in current modelling tools and the freight transport module and derive socioeconomic calculation results by identifying research needs for effective relationships. The project evaluates the calculation system's future development needs concerning behavioural, cost and emission changes to function in a future with a high proportion of connected, self-driving vehicle systems in the Swedish transport system. Time values, travel costs for passenger traffic, and transport costs for goods transport must all be estimated and updated.

Another vital consideration in this research is the need to develop appropriate algorithms for the possibility of using the exact automated vehicle for multiple modes of transport by members of the same family without the need for a driver or for the vehicle to park itself where parking costs are reasonable. These efforts aim to identify the charging infrastructure needs and overall system costs for all electromobility-related technologies, as well as assess the impact of large-scale vehicle electrification on long-distance trips. Overall, this research aimed to understand better self-driving vehicles' impacts on Sweden's transportation system and develop effective resource allocation strategies to support the growth of this technology.

13.3.4 Synthetic Sweden Mobility (SySMo): Agent-Based Models

The Synthetic Sweden Mobility (SySMo) project at Chalmers is an ongoing research effort to address the shortfalls in the Swedish Transport model- Sampers. This comprehensive effort to create a new agent-based integrated model of Sampers envisioned a decision support system framework based on a combination of several computing tools and techniques in synthetic information systems and large-scale agent-based simulations.

The SySMo model employs a stochastic approach combined with Neural Networks, a machine learning technique to generate a synthetic population and behaviourally realistic daily activity-travel schedules for each agent. This new approach allows for creating a synthetic population representative of the actual population and can be used to generate activity-travel schedules for each agent. The current model provides a valuable planning and visualization tool for illustrating Swedish population mobility patterns [10].

Using SySMo, we can better evaluate mobility and transport scenarios in Sweden, which can help identify areas for improvement and inform policy decisions. The model can also be used to simulate different future scenarios, such as the adoption of AVs, and assess their potential impacts on the transportation system.

13.4 Limitations and Recommendations for Sampers

In this era of the IT revolution, new data resources for travel demand analysis must be analysed and validated for real-time transport modelling. The challenge remains in extracting accurate activity detail from big data and integrating them for travel demand models. Various algorithms- genetic, evolutionary, fuzzy, and techniques such as advanced text and data mining, natural language processing, and machine learning/neural networks- must be tested to evolve the models further.

Sampers has its limitations; for example, the impact of new infrastructure on buildings and housing is not modelled. Where people live and work is included as a given condition in the forecast, produced by Statistics Norway. Sampers cannot model travel chains in which individuals select modes of transportation based on the activities to be performed during the day. If you drive to work, shopping trips are separate from work trips; instead, each trip is modelled separately.

Changed preferences and values cannot yet be modelled over Sampers. If, for example, people's attitudes towards driving change or cycling are perceived as more attractive due to increased health and environmental awareness in the future, this is not captured in the model. The model also does not capture remote working scenarios, which would reduce the need for work or business trips.

13.4.1 Long-Term Development Recommendations

Integration with emerging technologies: As emerging technologies such as connected and automated vehicles continue to evolve, it is essential to integrate them into Sampers to predict travel behaviour and demand accurately. This integration could involve developing agent-based models that simulate the behaviour of these vehicles and their interactions with other vehicles and the transportation system. Sampers can aim to integrate Land Use Transport Interaction (LUTI) models for policy implementation, such as the 'Transport Infrastructure Land-use Interaction Simulation model' (TIGRIS XL) developed since the 1990s, to better address the impact of new infrastructure on buildings and housing.

Incorporating spatial and temporal constraints: Investigating evolved spatiotemporal concepts like the Time–space prism modelling can capture the spatial and temporal constraints that people use to construct the patterns of their trips and activities. Integrating such modelling techniques into Sampers could improve the model's accuracy in predicting travel behaviour by capturing the constraints that affect travel choices.

Addressing equity concerns: Sampers could be further developed to address equity concerns in transportation planning. This could involve analyzing the model's outputs for fairness and ensuring that the model is inclusive of all demographic groups.

Improved data collection: Sampers could be updated to incorporate more detailed, accurate, and real-time data sources as technologies evolve. Research projects concerning integrating real-time mobile, GPS tracking, crowd-sourced, and social media data sources to understand travel behaviour better are ongoing.

Enhancing policy analysis capabilities: Sampers could be further developed to provide policymakers with a more detailed analysis of the potential impacts of policy decisions. This could involve adding a more detailed analysis of policy decisions' environmental, social, and economic impacts.

13.5 Conclusions

Sampers remains a critical tool for transportation planning and decision-making in Sweden. Its mechanisms are based on observable behaviour. Measures examined today for advancements in self-driving vehicles, information systems, and electric vehicles might have a lengthy development time, so the advantages of the measures are frequently computed over forty years. However, technological advancements have resulted in significant changes that might render present estimates exceedingly questionable, if not meaningless.

The Swedish Transport Administration must develop an approach for how evaluation methodology and forecasting tools should be developed to reasonably consider technological development in the transport planning process, considering both the opportunities and problems that development may entail. Furthermore, addressing its limitations and incorporating emerging technologies and modelling techniques can provide valuable insights for policymakers and ultimately lead to more sustainable and equitable transportation systems.

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