# Parking in the City: The Model as a Tool for Policy Evaluation

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## 1. The Goal

Parking policies have a strong impact on the functioning of cities. The introduction of a new or changes in the existing parking policy requires a careful analysis and evaluation of these impacts in light of policy goals. To do that we need a model of parking in the city which could serve as a *tool* for systematic analysis of the impacts of various policy scenarios.

Surprisingly, quantitative data about parking in the city are rare and models play a limited role in the analysis of urban parking policies, with few exceptions (e.g. Shiftan 2001). Much of the modelling literature regarding parking is theoretical in nature and has not been applied to real-world situations (e.g. Voith 1998; Petiot 2004; Lam 2006). Most policy-oriented work, in turn, hardly makes use of the potential offered by state-of-the-art modelling techniques (e.g. Ferguson 2003; Marsden 2006). Against this background, we propose using an agent-based model (Benenson and Torrens, 2004) to simulate urban parking policy scenarios and analyze their impacts from user and public policy perspective.

In practical cases, policy-makers may have many reasons to introduce new parking policies, such as the wish to reduce parking search times, to improve parking availability for visitors, or to guarantee parking for local residents. Whatever the policy goals, in all cases in which the ratio between demand and supply for parking approaches or exceeds one, it will be extremely difficult to forecast the impacts of new policies, without testing these policies at the spatial and temporal resolution at which they will be implemented. Classical models based on averages will not do under such circumstances. In other words, we need a spatially explicit agent-based dynamic model of parking in order to analyze, and ultimately tackle, parking problems in current highly motorized societies.

## 2. A Model of Parking in the City

The proposed model aims helping planners and decision-makers to formulate and compare parking policies. The model has been built using a Geosimulation approach (Benenson and Torrens, 2004). In this approach, real-world entities are directly represented as inanimate and animate model objects, which "behave", that is, change their properties and location in space. The inanimate objects directly represent the features belonging to the layers of a high-resolution GIS of urban infrastructure. The only animated objects in our case are car drivers, and their behavioural rules describe all stages of driving: driving towards the area in which parking search starts, parking search, and leaving the study area after parking. However, the model focuses on parking search. The model enables the formulation of parking constraints and enforcement levels and its outcomes can be aggregated over ensembles of individual drivers delineated by areas and time periods, according to the interests of the policy-maker.

## 2.1. Static model objects

To adequately represent the parking process, we build on the following components of an urban GIS, which are available or can be constructed for most Israeli cities: (1) Road network with data on number of lanes, traffic directions and on-street parking permissions; (2) Houses (Destinations); (3) Off-street parking places; and (4) On-street parking places (Figure 1). The attributes of on-street parking places are parking permission, fees and, when available, the probability of a fine for illegal parking.

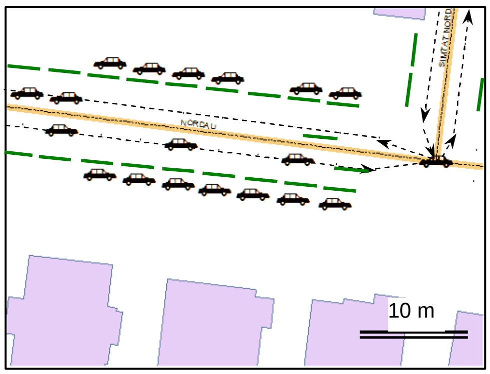


Figure 1: To represent a two-way traffic street, the centreline is duplicated, and each copy is employed for representing one direction. Parking places are built by dividing the segments into 4m fragments.

## 2.2. Animated driver agents

The essence of the agents' representation in a Geosimulation model is their behaviour. In case of drivers, the complete description of the behaviour should include behaviour during: (1) driving towards the destination, (2) parking search, (3) parking, and (4) driving out. The model is thus built in two versions. The "full" one accounts for the entire driving process, starting from the moment the car enters the system till the moment it leaves through one of the exit points. In this paper we focus on the second stage, and consider the "parking only" version, in which drivers "land" at the outer boundary of the parking search area, immediately start their parking search, and disappear from the system just after leaving the parking place.

## 2.3. Performance indicators

The object-based nature of the model makes it possible to follow every driver and, thus, enables direct estimation of the performance of the parking policy from the driver's and the policy-maker's point of view.

***Drivers' view:*** Given the set of targets, time interval, and group of drivers we estimate distributions of:

- Parking search time;

- Distance between parking place and destination;
- Overall/hourly payment.

***Policy-maker's view*:** The policy-maker observes (but not necessarily accounts for) drivers' indicators. In addition, the policy maker accounts for the following collective characteristics of the parking situation:

- Fraction of occupied parking places, and its changes over time;
- Number of cars searching for parking place, and its changes over time;
- Parking turnover (number of cars using a parking place during a time interval);
- Revenues from on-street and off-street parking.

### 2.4. Technical characteristics of the model

The model is implemented as a VBA ArcGIS application and can work with a practically unlimited number of simultaneously parking drivers. Model parameters and results at resolution of cars and parking places are managed with the SQL Server and, thus, policy performance indicators can be constructed for various groups of drivers, sets of destinations and time intervals without re-running the simulation.

## 3. Application of the model

Within the framework of the project, various policy scenarios will be tested to improve the existing parking situation in the centre of Tel Aviv. As a first try-out, the model has been applied to analyze the consequences of a local scenario, the construction of a multi-level underground garage in a neighbourhood, where all places will be for sale to local residents. The consequences of this local scenario have been studied for the Basel neighbourhood, a densely built, mixed-use, neighbourhood, located in the old centre of Tel Aviv. According to the GIS-based estimates, the demand for parking in this neighbourhood amounts to about 1.10 cars per parking place. The municipality is considering allowing the construction of an underground parking garage in the area of up to 200 places, to reduce parking problems for local residents, who complain on a regular basis about the lack of parking.

The model demonstrates that the main effect of local improvements in parking supply lies in the reduction of the fraction of drivers who search for parking for a long period of time. This finding suggests that, assuming no positive feedback loop in terms of increases in car ownership, the additional supply could substantially reduce overall parking search time, at least in the short run. Following the modelling results, if about 250 additional parking places were to be added in the centre of each urban block of 500 by 500 meter in the dense Tel-Aviv centre (about 1,000 parking places every 1 $km^2$), the share of residents searching for more than 10 minutes for a parking space would drop from 25% to less than 10%, with evident consequences regarding air pollution, traffic congestion, and public opinion. At the same time, even with such an additional supply, residents will continue experiencing a lack of parking in Tel Aviv's central area, i.e. they will still face substantial *average* search time and walking distance between parking place and place of residence. This, in turn, suggests that if the developer will be able to offer the parking places in the new garage at a price attractive enough for local residents, they will be eager to buy them. The decision about the size of the parking garage has thus been reduced to an economic rather than a transport issue.

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