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Agent-based simulation of consumer behavior in grocery shopping on a regional level

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Abstract

In the field of multi agent systems, spatial modeling is gaining new momentum. Spatial modeling offers the possibility of simulating human actions on a micro scale level in a way that blends in with the existing network of theoretical approaches in the social sciences. The present research project examines the applicability of techniques that simulate spatial choice in shopping behavior on a regional level. This paper presents the particulars of an agent-based micro model for grocery shopping, based on an individual population and store data gathered in northern Sweden. The high quality of the data, gathered exclusively for this project, allows a fine validation of the simulation results. Future applications include the prognosis of consumer behavior and turnover forecasts on the basis of which alterations could be made on the supply side, particularly regarding the competition among stores in the center and those on the edges of cities.

Keywords: Consumer behavior; Spatial decision-making; Agent-based simulation; Sweden

1. Introduction

1.1. Spatial analysis of consumer behavior

With regard to the role of geography in the retail trade, consumer choice behavior reflects the important but often ignored demand side of the economic process of shopping. Spatial consumer behavior and the spatial structure of retailing are dynamically interrelated. Although the consumers, by their choice of a particular shopping location, form the economic base of the retailer, the latter may influence the consumers by adopting different business strategies. Agergård et al. (1970) were the first to analyze these phenomena, describing the development of retail locations in urban centers as a spiral movement. A current stage in this development is the growing competition between retail locations in the center and those on the edges of the cities, which is increasingly perceived as a threat to the urban business environment itself. Planning is therefore concerned with finding more effective research methods to judge the potential impacts of such developments. At the same time consumer attitudes and behavior are changing rapidly toward more individuality and more diversity. Agent-based simulations are currently the most promising tool to address these challenges on the level of modeling.

1.2. Previous applications

Applications of agent-based simulations in the spatial sciences and planning are diverse and range from the simulation of urban housing markets (Benenson, 1998; Bura et al., 1996) to map generalization (Galanda and Weibel, 2003), traffic flows under different land use conditions (Miller et al., 2004), and land use transformations (Parker et al., 2003). In retail geography, Arentze and Timmermans (2005) present a multi agent model of consumer behavior which, besides the structural attributes of and the distance to the shop, also includes opening hours as part of the institutional context of the shopping destination choice. Furthermore, Arentze and Timmermans call for the incorporation of combining shopping with other activities in such models. Zhang et al. (2005) make use of the specific characteristics of the multi agent approach to design a

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model that depicts shopping as a form of cooperation among household members. Even if only one person is performing the shopping activity, a joint decision is required when resources have to be shared (e.g. a car) or when the household members experience particular constraints, such as the mother having to watch the children in the absence of her partner.

Koch (2000) presents such a model for a German study area. Based on the results of a household survey, Koch simulated the supply behavior with respect to daily and convenience goods of 11 consumers modeled as agents. The shopping trips started and ended at the agents' residences, but could involve multiple destinations. With every purchase, a share (10%) of the store inventory was transferred to the agent and could subsequently be consumed. When they became short of supplies, the agents independently generated a new need for a shopping trip. They would then base their decision upon evaluating the surrounding stores fitting their personal preferences.

Rauh and Hesse (2002) use an agent-based simulation to optimize the locations of stores inside shopping centers. Again based on a consumer survey providing information on the general affinity of consumer types to certain stores, they passed on these preferences to the agents as a memory that led their activities. Additionally, the agents had the possibility to perceive other stores on their shopping trip, being allowed to react spontaneously on stimuli and make purchases. Such actions could alter the state of the agents' preferences as well as the agents' further activities. Having his/her own simulation tool enables the user to follow the simulation results on the screen, which provides a clear picture of the interactions between the location of the stores and the consumer activities in the center.

In this project, the authors model and simulate the shopping activities of the population of an entire region. The authors have designed two models, one for the retail sector of groceries, representing daily goods, and one for the fashion sector, referring to convenience goods. The consumer decision patterns of these product groups are fundamentally different. With groceries, rational decision processes tend to prevail, whereas shopping for fashion is much more dependent on hedonistic influences, such as styles, recreational activities, social pressures and opportunities. Also, the two models focus on different study areas, each with their characteristic situational data. To simplify matters, the authors implemented a model for grocery shopping for the region of Umeå (Sweden), whereas the region of Regensburg (Germany) forms the stage for a model aimed at fashion shopping. The remainder of this paper will deal with the first of these two models.

1.3. Study area

The functional region of Umeå, northern Sweden (Fig. 1), includes the municipalities of Bjurholm, Nordmaling, Robertsfors, Umeå, Vindeln, and Vännäs, adding up to a population of 136,000 and covering a total area of 13,500 km^2 (roughly 5300 sq. mi.). About 70,000 people live in the university town of Umeå. The surrounding communities consist of a main town

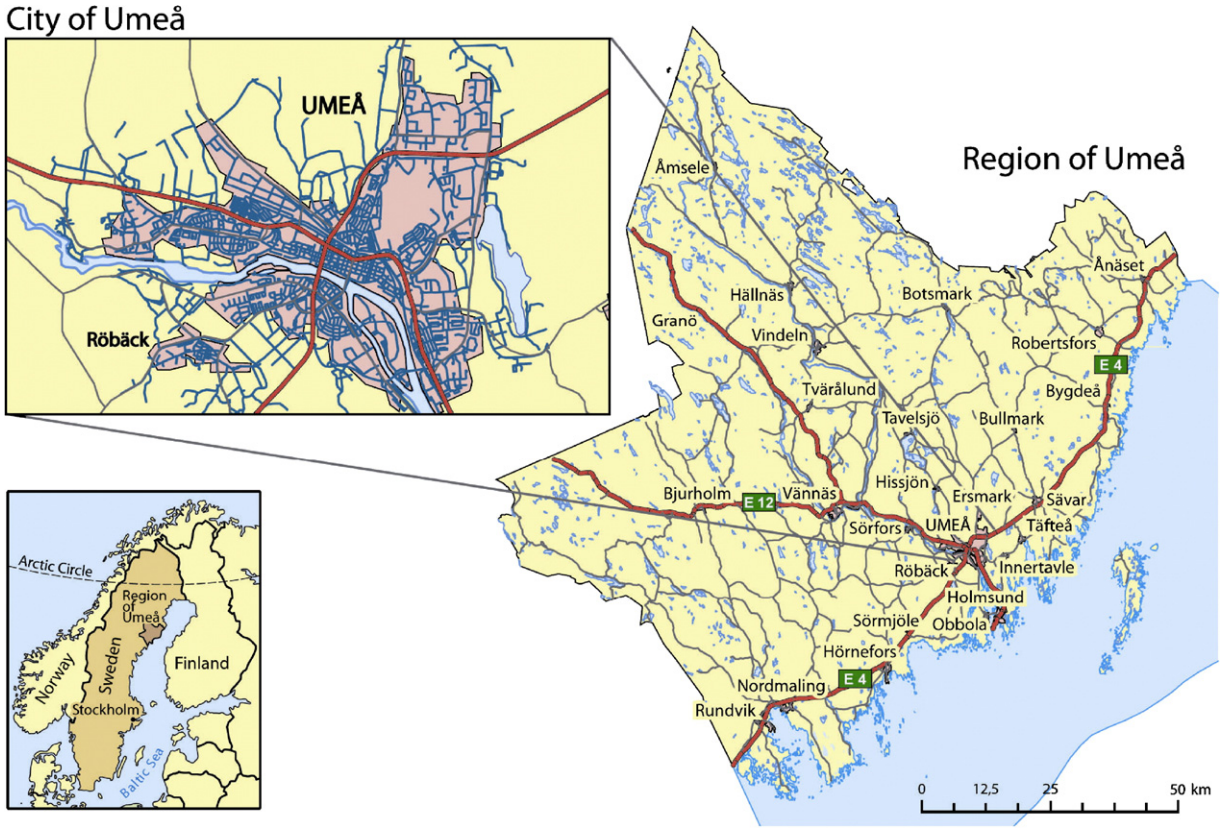

Fig. 1. The study area.