Store performance, pedestrian movement, and parking facilities

STORE PERFORMANCE, PEDESTRIAN MOVEMENT, AND PARKING FACILITIES

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1. Introduction

A central theme of this conference concerns the issue of whether city centre attractiveness in general and store performance in particular is influenced by pedestrian movement and city parking policy. In examining this issue, one is inclined to conclude that parking facilities and pedestrian movement indeed are highly important factors influencing city centre attractiveness and the viability of individual shopping streets. For example, it is not very difficult to think of cases in which merchant associations have objected against transportation plans developed by planning authorities, especially when such plans implied a reduction of traffic volume. In Roermond, the Netherlands, a break in the street pattern caused the bankruptcy of most retailers in a particular shopping street because pedestrians changed their route choice behaviour. Likewise, DAVIES/ BENNISON (1978a, 1978b) reported dramatic shifts in pedestrian movement and turnover levels in shopping streets of Newcastle-upon-Tyne as a direct result of a major restructuring of the city centre involving both dramatic changes in the locational patterns of shops and changes in the transportation network and facilities.

However, counterexamples can also be given. As part of its structure plan, the city of Maastricht restricted access by car in a major shopping street. Still, the viability of this street improved considerably once the plan was implemented. Hence, it seems the issue of the relationship between attractiveness, pedestrian movement, and traffic regulation is very complicated; the nature of this relationship seems to depend upon the types of retail establishments that comprise the shopping streets, their position within the city centre, the kind of consumers who patronize the shopping streets, and its location vis-a-vis parking facilities and other points of entry. Unfortunately, much of our knowledge about this complicated issue remains speculative in that most is still based on experience, and thus lacks empirical verification. Very little research has been conducted on the interplay between attractiveness, pedestrian movement, and traffic regulation.

The purpose of the present paper is to briefly summarize the work that has been completed by the Eindhoven Urban Planning Group on this topic over the last five years. Timmermans and his associates have conducted a series of studies seeking answers to such questions as 'What is the influence of parking facilities on pedestrian movement?'; 'Is there any regularity in pedestrian destination and route choice behaviour?'; 'What kind of decision heuristics do shoppers apply when choosing a set of stores to buy a series of items'? The ultimate goal of their research endeavour was to develop an advanced model of pedestrian destination choice, spatio-temporal sequencing and route-choice behaviour. However, building blocks of their approach and experiences with applications to problems of retail planning in various cities can be used to present some evidence on the complicated issue of the interplay between store performance, pedestrian movement, and transport policy.

To accomplish this goal, this paper is organized as follows: First, we will summarize empirical research that describes the relationship between entry points, attractiveness of shopping streets, and pedestrian movement. Next, we will highlight the major theoretical underpinnings of models of pedestrian movement. Then, we will present some empirical evidence on the effects of parking choice on store patronage and vice versa. Finally, we will draw some main conclusions and discuss issues that deserve more attention in future research endeavours.

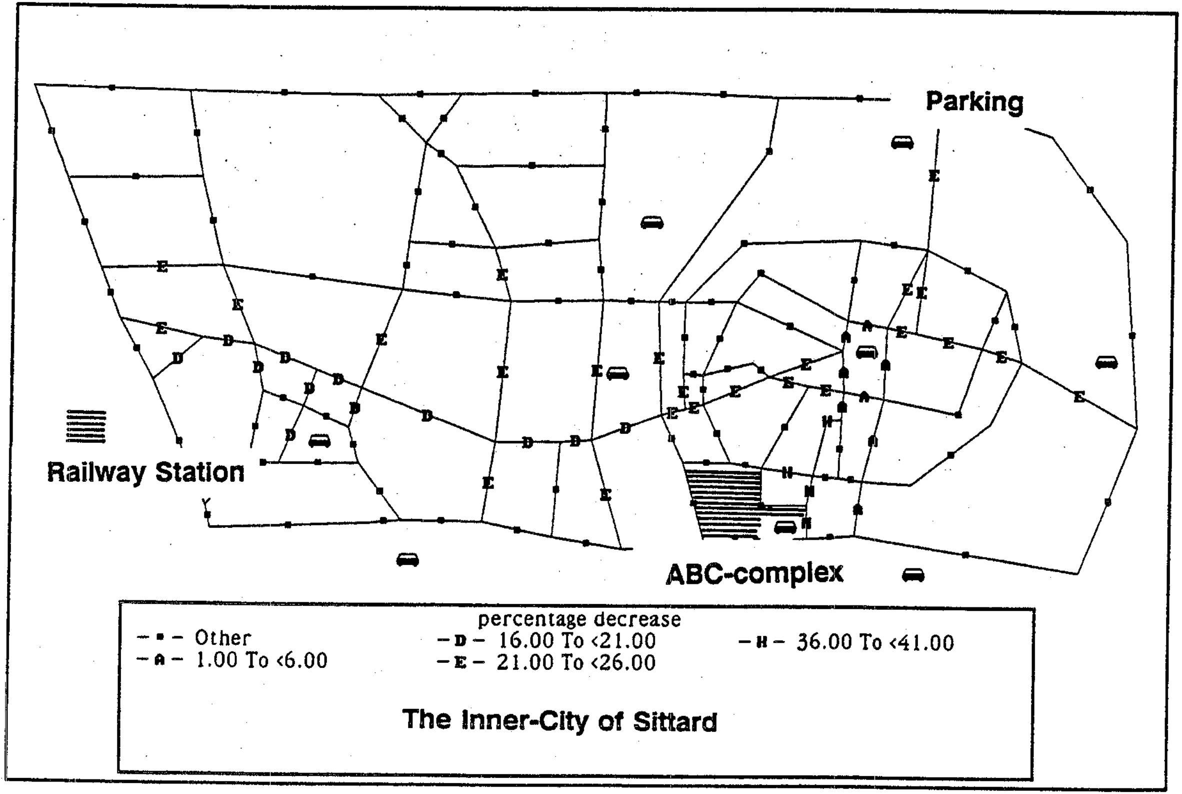
2. Empirical Research

The problem of the relationship between entry points, pedestrian movement, and the viability of shopping streets has found only limited interest in the geographical and urban planning literature. Traditionally, the description and analysis of the retailing structure of city centres has been a main focus of interest in retailing geography (e.g. PARKER, 1962; GETIS, 1967; GETIS/GETIS, 1968; DAVIES, 1973; SHEPARD/ROWLY, 1978; LEE, 1979; SCHMIDT/LEE, 1979), but the analysis was restricted to locational arrangement per se; the relationship to pedestrian flows was not addressed explicitly.

One of the first studies actually examining pedestrian movement within city centres was conducted by JOHNSTON/KISSLING (1971) in Christchurch and Melbourne. They concluded that pedestrian movement has a strong distance bias. Pedestrians tend to patronize retail establishments within close proximity. They also found that major traffic arterials may act as a barrier to movement: pedestrians are less inclined to cross such streets. Consequently, different networks can be distinguished in data on pedestrian movement. In their case, the following networks were identified: (i) the eastern versus the western part of the shopping centre, (ii) the eastern versus the central part of the shopping centre, and (iii) a network of some interconnected higher order establishments in the western part. All these groups were related to points of entry. In addition, the authors found that pedestrians tend to patronize those shops closest to their homes.

A similar study was conducted by BENNISON/DAVIES (1978a) in Newcastle-upon-Tyne. An interesting element of their study was an analysis of complementary relationships in destination choices. They found that on the average consumers visited 2.17 shops; department stores accounted for 74% of the total number of visits. They also analysed the relationship between point of entry and patronage. Streets in close proximity to nodes in the transportation network, such as bus stations and parking garages, are visited significantly more often than more distant shopping streets. An analysis of comparative

Fig. 1: Changes in pedestrian flows caused by a new network node in the city centre of Sittard, the Netherlands



versus complementary linkages indicated that comparative linkages are associated primarily with product classes such as clothing, shoes, furniture, records, and books, while complementary linkages are more typical for food, personal services, and refreshments.

In a subsequent follow-up study, BENNISON/DAVIES (1978b) examined the impact of the new Eldon Square Centre on the existing retail structure and consumer behaviour. They concluded that the new shopping centre attracted consumers primarily from shopping streets within close proximity. The new centre did not seem to significantly affect pedestrian flows in more distant streets, especially not in those streets with strong linkages to bus stations and parking garages. They also found that the new major shopping centre acted as a new node in the network of pedestrian flows. PACIONE (1980) and TIMMERMANS (1981) reached highly similar conclusions in Clydebank and Maastricht respectively.

A research project in Sittard (BORGERS/TIMMERMANS/Van der WAERDEN, 1988), the Netherlands, also illustrated that a new shopping complex (ABC-complex) with a supermarket, an appliance store, and a clothing store became a new node in the network of pedestrian flows which attracted most pedestrians from shopping streets in close proximity.

An example illustrating the effect of changes in the transportation network on retailing is presented by BUIT (1979), WALEN/BUIT (1979a and 1979b) who demonstrated that especially retail establishments were affected by such planning policies. These empirical studies of pedestrian movements thus seem to suggest that pedestrians are engaged in a complex sequential behaviour in which they attempt to satisfy their shopping needs. Major retail establishments such as department stores and central elements of the transportation network such as parking places/garages, and bus and railway stations, tend to be the determinants of their behaviour. Depending upon the kind of products required, pedestrians shop in a comparative or complementary fashion. In addition, impulse buying plays a certain role. Consequently, the centrality of a particular shopping street in this network is of major importance to its viability. Likewise, those stores or shopping streets that rely on proximity to major stores or transportation nodes will be affected most by (planned) changes in the retailing structure and/or transportation network. The ultimate effect of any planning decision is therefore dependent upon the net effect of all these factors.

Previous research may have been too simplistic to address this complex issue in any reliable manner. In the next section, we will summarize some of the research efforts of the Eindhoven Urban Planning Group to develop more sophisticated models of pedestrian movement and gain a better understanding of pedestrian decision-making and choice processes.

3. Towards a Better Understanding

3.1 Spatio-Temporal Sequencing Processes

The strong distance bias in pedestrian destination choice has led most researchers to assume distance-minimizing behaviour in developing mathematical models of pedestrian movement. This is to say that pedestrian movement has been conceptualized as a form of sequential behaviour in which pedestrians minimize distances between successive destinations. Distance minimizing is thus assumed to regulate their route choice behaviour, which in turn dictates predictions of impulse buying and aspects of complementary and comparative behaviour. The assumption of distance-minimizing behaviour was confirmed in a laboratory setting by HAYES-ROTH/HAYES-ROTH (1979). In contrast, SÄISÄ/GÄRLING (1987) found that individuals tend to use global distance-minimizing behaviour, although the use of these strategies seems to depend on the strength of the cognitive representation of the retail environment (GÄRLING et al., 1986; GÄRLING, 1987; GÄRLING/GÄRLING, 1988).

Given these contrasting partial results, the Eindhoven Urban Planning Group decided to study spatio-temporal sequencing processes of pedestrians more carefully (Van der HAGEN/BORGERS/TIMMERMANS, 1989; van der HAGEN /TIMMERMANS/BORGERS, 1989). More specifically, a more extensive conceptual model of sequencing heuristics was developed and tested in the cities of Eindhoven and Maastricht, (the Netherlands). Pedestrian destination and route-choice behaviour was conceptualized as a problem of multistop-multipurpose behaviour that can be viewed as a problem of choosing and sequencing several destinations to conduct different activities or buy different goods. There are several different decision heuristics that an individual might adopt to deal with this problem. An individual engaged in sequential decision-making may attempt to minimize distance between all successive pairs of destinations that make up the entire journey. This was called a **local-distance-minimizing (L-D-M) heuristic.** Alternatively, the traveller could choose destinations in such an order that the total distance travelled on the entire journey is minimized. This is an example of a simultaneous decision-making process in the sense that an individual attempts to minimize the total distance travelled. This was called a **total-distance-minimizing (T-D-M) heuristic.**

A third heuristic describes the case where individuals patronize the destinations in an optimal order, without minimizing distance in all segments of their trip. This was called a **global-distance-minimizing (G-D-M) heuristic** (see fig. 2).

These heuristics concern the temporal sequencing of destinations in a multistop-multipurpose trip. However, temporally-based heuristics sometimes generate sequences of destinations that are equivalent on the objective function. This is especially true for symmetrical tours. The total distance travelled in the sequence H-A-B-C-D-H is exactly the same as the total distance travelled in the sequence H-D-C-B-A-H, where H is home or the entry/departure point of some area. Hence, in addition to the above temporal heuristics, some spatial heuristics were identified. Individuals may visit the destinations in order of proximity to home or entry point. This was called a **nearest-destination-oriented (N-D-O) heuristic.** It implies that an individual will generally have to carry the

Fig. 2: Types of Temporal Heuristics

DISTANCES	SEQUENCE OF DESTINATION	
	NON-OPTIMAL	OPTIMAL
Distances of all segments minimized	Local Distance Minimizing heuristic	Total Distance Minimizing heuristic
Distances of all segments NOT minimized	Mixed Heuristic	Global Distance Minimizing heuristic

things he or she bought along the route across longer distances. Alternatively, an individual may decide to first visit the destination farthest from home or the entry point. This was called **a farthest-destination-oriented (F-D-O) heuristic.**

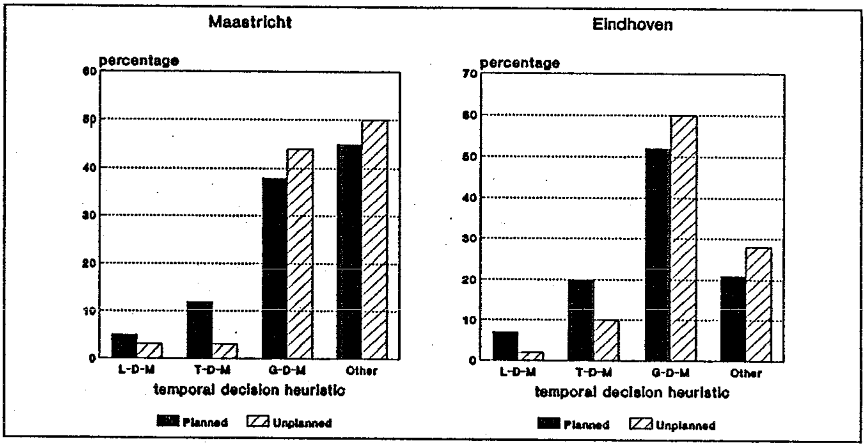
The aim of the empirical analysis was to find out (1) to what degree each of these heuristics was used by the sample pedestrians, (2) whether the choice of some heuristics depends upon whether or not the shopping trip was planned and (3) if there is any association between the temporal and spatial heuristics, and if so, what is the nature of this relationship.

The results of the study provided evidence on the prevalence of decision heuristics underlying multistop-multipurpose travel (fig. 3). The results indicated that the global distance-minimizing heuristic was used most frequently (40% in Maastricht and 55% in Eindhoven). This percentage was higher for Eindhoven probably because of its less complex structure. Only approximately 4% of the respondents in both cities revealed a local-distance-minimizing heuristic. This implies that the decision-making process of a substantial number of pedestrians was not uncovered by the assumption of shortest route behaviour underlying almost all existing models of pedestrian movement. The percentages of respondents revealing local or total-distance-minimizing behaviour were significantly lower for unplanned trips than for planned trips. Thus, it appears that pedestrians who go to downtown retailing environments with a list of shops to visit were engaged in a rational decision-making process in the sense that their sequencing of shop visits and/or route choice behaviour between successive stops is more optimal.

The farthest-distance-oriented heuristic was used most in Maastricht (fig. 4). This finding suggests that a majority of the pedestrians in Maastricht first visits shops located farthest from the point where they entered the city centre and then proceed back to their point of departure. Although this was not tested explicitly, such behaviour might be explained by the fact that pedestrians would have to carry their heavy purchased items for shorter distances.

The pedestrians in Eindhoven most often applied the nearest-destination-oriented heuristic. The percentage of respondents applying a nearest-distance-oriented heuristic was higher for unplanned trips than for planned trips in both cities, a finding consistent

Fig. 3: Number of shopping pedestrians applying different temporal decision heuristics



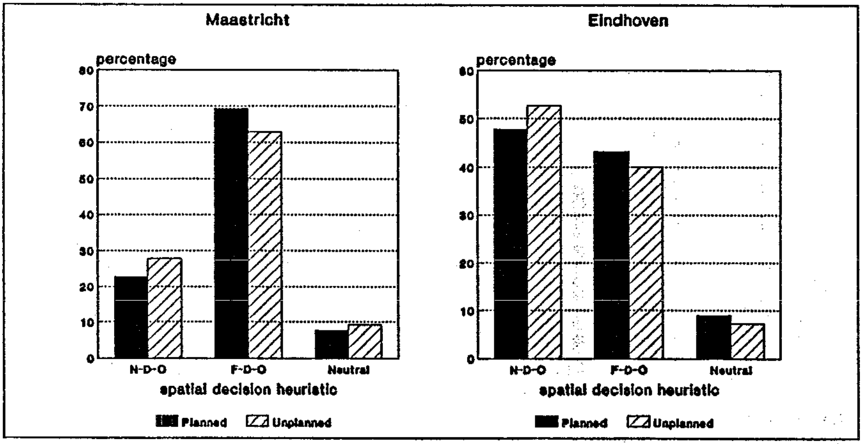
with a priori theoretical expectations. Pedestrians who plan their visits have a higher probability of revealing optimal behaviour in terms of the sequence in which these shops are visited. Likewise, sequencing behaviour of pedestrians who do not plan their trips is more likely a function of routing considerations.

In the case of planned trips in Maastricht, the F-D-O heuristic was associated more with either a L-D-M or T-D-M heuristic than with a G-D-M heuristic. This association disappeared for unplanned trips. These findings were, however, not substantiated by the results obtained for Eindhoven. In the case of planned trips, the spatial heuristics were largely independent of the temporal heuristics. A possible explanation for these results might be that the complexity of the retail environment affects pedestrian propensity to plan a shopping trip. Pedestrians in Maastricht who plan a trip a priori are more likely to reveal optimal behaviour as exemplified by a higher probability of applying both T-D-M and F-D-O heuristics.

One might expect that the use of temporal heuristics is influenced by the complexity of the journey, as indicated by the number of stops made during the journey. The more stops to be made, the more difficult it will be to reveal rational, optimizing behaviour. To test this hypothesis, the use of the various temporal heuristics was checked against the number of stops made during the shopping trip. Again, the results were disaggregated according to whether the trip was planned or not, and the analysis was performed for each of the two cities separately.

The propensity to adopt a local-distance-minimizing heuristic increased with an increasing number of stops made during the journey for planned trips in Maastricht. The same tendency was observed for Eindhoven, although it seemed that in this case

Fig. 4: Number of shopping pedestrians applying different spatial decision heuristics



saturation already occurred after four stops. As expected, the use of the total-distance-minimizing heuristic decreased monotonically with an increasing number of stops in both cities. It suggests that the tendency to adopt a T-D-M heuristic drops dramatically for more than four stops. In the case of Maastricht, the use of a G-D-M heuristic also dropped with an increasing number of stops made during the trip; this result was, however, not obtained for Eindhoven: the percentage of respondents applying a G-D-M heuristic was more or less independent of the number of stops. Again, this result might be due to the less complicated layout of the shopping environment in Eindhoven, which could result in pedestrians having a more reliable cognitive image of the structure of the downtown shopping area.

For the unplanned trips, few regularities were found. The use of global-distance-minimizing heuristics seemed to drop more dramatically with an increasing number of stops as compared to planned trips. Perhaps even more significant was the relatively high number of respondents that applied some "other" heuristic, and this number increased with an increasing number of stops made during the journey, especially in Maastricht.

Similar analyses were performed with respect to the use of the spatial heuristics. The results of these analyses were that in the case of planned trips in the city of Maastricht, the use of the N-D-O heuristic tended to decrease slightly as the number of stops increased. This was compensated first by an increasing percentage of pedestrians applying the F-D-O heuristic in case of four stops, and second by relatively more pedestrians using a 'neutral' heuristic in case of five stops. Eindhoven displayed reverse results. The percentage of respondents applying a nearest-destination-oriented heuristic slightly increased with an increasing number of stops. As a result, the percentage for the F-D-O heuristic monotonically decreased with an increasing number of stops. It is difficult to think of reasons that might explain these observed differences between the two cities. In case of unplanned trips, the percentage of pedestrians applying the F-D-O heuristic decreased with an increasing number of stops in both cities, while the percentage of pedestrians applying the N-D-O heuristic tended to increase with an increasing number of stops made during the journey. This finding is consistent with theorical expectations in that one would expect pedestrians to patronize shops relatively more in order of appearance with an increasing complexity of the trip since the trip was not planned a priori.

3.2 The Influence of Parking Facilities

The results reported in the previous section stem from studies that focus on pedestrian destination and route choice behaviour given a choice of entry point. A natural extension would be to include the choice of parking into this framework. This constitutes an interesting theoretical issue in that it is not evident if the choice of parking is influenced by the shops a consumer intends to visit or not. It is also an important research question from an applied planning perspective because the distribution of pedestrians among entry points cannot be assumed to remain constant, since it is likely to change as a result of housing construction programs and changes in the transportation network.

In order to gain some insight into this issue, we have conducted a series of small-scale research projects. Van der WAERDEN/BORGERS (1989) developed a model of parking-choice behaviour. The model included (i) attributes of the parking places, (ii) proximity measurements to shopping opportunities, and (iii) distance to home.

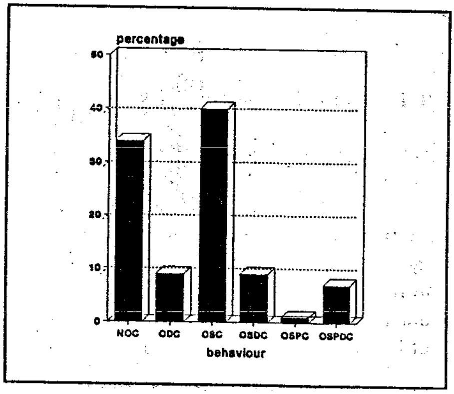
First, a multinomial logit model was estimated from evaluation data. The evaluations for the 'expected number of free parking spaces', 'distance to the shopping area', 'parking comfort' and 'minimum walking distance for visiting the planned shops, had a significant influence on the choice of a parking place. Next, a model with physical attributes was estimated. The attributes 'crossing a supply route', 'entrance supermarket' and 'minimum walking distance for visiting all planned shops, play a significant role in the parking choice. Therefore, both approaches show the importance of the location of the shops with regard to the location of the parking places.

In a second study (Van der WAERDEN/TIMMERMANS, 1990), we examined actual strategies along the lines of the study by Van der HAGEN/TIMMERMANS/BORGERS discussed in the previous section. In this study, the relationship between parking and route-choice behaviour was considered. More than 50% of the motorists optimized the sequence of the shops they planned to visit. When we looked at the optimized shopping behaviour in relation to the chosen parking place, we found that motorists who visit one or two shops don't optimize the place where they park their car. Of the motorists who wanted to visit three or more shops, 19% optimized their choice of parking place. This means that the distance from the parking place to the shopping area plays a minor role in the total distance when the motorists plan to visit more than two shops (fig. 5). When we looked at the distance from the parking place to the first and the last shop visited, we found that motorists who optimize their sequence in shops and chosen parking place also optimize the distance to the first or last shop.

Fig. 5: Parking and route choice behaviour of motorists who planned to visit three or more shops

In Figure 5 the following codes are used:

NOC: None Optimal Choice
ODC: Optimal Destination choice
OSC: Optimal Sequence Choice
OSDC: Optimal Sequence and Destination Choice
OSPC: Optimal Sequence and Parking Choice
OSPDC: Optimal Sequence, Parking and Destination Choice



Finally, an examination of pedestrian destination and route-choice behaviour showed a significant difference as a function of mode choice (Van der WAERDEN/TIMMERMANS, 1991). We found that there are little differences between users of cars and users of public transport regarding the number of visits and the number of goods purchased. The distribution across the branches, however, differed significantly. Motorists visited mostly appliance stores and clothing stores. Shoppers using public transport visited especially clothing stores. The patterns of cyclists and pedestrians differed from the users of other modes. Both the number of visits and number of purchased items were lower. In addition, pedestrians visited mostly service establishments and bought goods in food stores and service establishments. Cyclists had no specific behaviour in this respect.

An analysis of route-choice behaviour did not reveal substantial differences between the users of different transport modes. The analysis of the 'distance to walk in the shopping area' showed that visitors who came by bike to the shopping centre walked the shortest distance.

3.3 Modelling Attempts

In order to predict the impact of urban planning decisions on pedestrian movement, a model of pedestrian destination and route-choice behaviour is required. Conventional models are unable to capture most of the empirical regularities discussed in the preceding sections (TIMMERMANS/Van der HAGEN /BORGERS, 1991). Therefore, we have developed and tested two new modelling approaches: a time-varying Markov model (BORGERS/TIMMERMANS, 1986a; BORGERS/TIMMERMANS/Van der WAERDEN, 1988) that elaborates O'Kelly model of trip-chaining (O'KELLY, 1981), and a simulation model (BORGERS/TIMMERMANS, 1986b).

More specifically, both models of pedestrian movement are based on the assumption that pedestrian movement can be represented as a multi-purpose trip that consists of both intended and impulse stops. The intended stops are assumed to be the result of a multi-step decision-making process of destination choice in which utilities are sequentially maximized. The impulse stops are assumed to be a function of pedestrian route-choice behaviour which, in turn, is conditional upon pedestrian destination choice. Thus, the model consists of separate submodels of destination choice, route choice, and impulse stops.

Pedestrian destination-choice behaviour is assumed to be a nonlinear multiplicative function of the total amount of floor space in a specific product class and a shopping street, and the distance separation between the streets. Note that this specification is similar to those typically used in shopping models.

Given the predicted probability that a particular destination will be chosen at successive stops, the model then predicts the probability that a specific route will be chosen. In particular, it is assumed that route-choice behaviour can be described by a multinomial logit model. Route length is used as the independent variable of this model. The route-choice model is then used to calculate the number of pedestrians who pass through the various links of the network. Finally, the distribution of impulse stops across the network is predicted as a function of floorspace and number of pedestrians that pass through the link.

The simulation model is very similar in underlying theoretical assumptions. It differs in that it is not based on a Markovian transition matrix, but rather on Monte Carlo simulations. The model works as follows: First, the number of goods purchased by a random pedestrian is determined by drawing at random from a distribution that corresponds to the observed relative frequencies of purchases of goods. The same procedure is used to identify the types of goods that are bought using the relative purchase frequencies, conditional upon the number of goods bought, as a reference distribution. The second step in the modelling process involves predicting the links where the selected goods are bought. It is assumed that the probability of buying the first goods in the simulated sequence in a particular shopping street is a function of the total amount of floorspace in a product class in a specific street and the distance associated with the shortest route from an entry point to a shopping street.

The model proceeds by simulating the choice of links of the remaining goods, if required. Otherwise, the model assumes that the consumer returns to the entry point from where he or she departed. This choice process is based on the same principles, however, in this case using the minimum distance between shopping streets.

In the third step, the model simulates the route-choice behaviour of a pedestrian given information on the location of the entry point and the link where goods will be bought, using dynamic programming techniques.

Both the time-varying Markov model (BORGERS/TIMMERMANS, 1986a) and the simulation model (BORGERS/TIMMERMANS, 1986b) were calibrated from the data of two Dutch cities, Maastricht and Sittard. Table 1 presents the correlation coefficients between observed and predicted arrivals at the destinations for both models and both cities. It shows that the destination-choice models for Maastricht perform satisfactorily as indicated by correlation coefficients well above 0.90 for many types of shops. Evidently, the category 'other' forms an exception in this respect, but this is probably due to the heterogeneous nature of this category. Table 1 also shows that both models perform almost equally well. However, this should not be surprising because the assumptions underlying these models are very similar and the models use the same data. The correlation coefficients for Sittard are less appealing than those obtained for Maastricht, but they are still satisfactory.

Tab. 1: Correlation Coefficients of the Destination Choice Submodel for Maastricht and Sittard

	MAASTRICHT			SITTARD		
TYPE OF SHOP	Markov model	Sim. model	N	Markov model	Sim. model	N
Groceries	0.909	0.903	121	0.842	0.802	896
Clothing	0.939	0.942	124	0.894	0.895	428
Department stores	0.999	0.999	143	0.964	0.945	688
Markets	0.999	0.999	77	0.739	0.786	198
Other	0.781	0.639	96	0.852	0.940	311

The correlation coefficients which express the appropriateness of the route-choice submodel were 0.839 for Maastricht and approximately 0.700 for Sittard (0.749 for Tuesday, and 0.680 for Saturday). The results for the submodel of impulse stops were also good: the correlation coefficients ranged from 0.797 to 1.000 (Maastricht) and from 0.677 to 0.987 (Sittard).

4. Conclusions and Discussion

The purpose of this paper has been to summarize the main research findings of the Eindhoven Urban Planning Group on the relationship between store performance, pedestrian movement, and parking policy. The main point of interest concerns the issue of whether city centre attractiveness and store performance is influenced by pedestrian movement and parking policy.

The scattered pieces of empirical evidence reported in this paper suggest that this is a rather complicated issue. Shopper parking choices seem at least to some degree to be influenced by the locational pattern of shops in the city centre. There is some tendency that individuals seek a parking lot that minimizes the distance to the shops they want to visit, although this is clearly not the only influential variable. Once pedestrians have entered the city centre, they demonstrate a choice behaviour that reflects primarily a trade-off between attractiveness and distance decay. Pedestrians reveal a strong distance bias. Especially department stores constitute the main foci in the sequential choice process of pedestrian destination choice. It implies that some shopping streets and stores have an attractiveness strong enough to attract pedestrians, while other streets and stores depend to a large degree on complementary relationships. The viability of these streets is largely dependent upon the number of pedestrians who pass through them.

Thus, some store performance seems to a large extent to be a function of pedestrian route-choice behaviour. The empirical evidence illustrated thus far suggests that pedestrians may implement different decision heuristics in this respect. Simple distance-minimizing heuristics underlying most models of pedestrian movement are applied by only a small proportion of pedestrians. Spatio-temporal sequencing processes tend to become much more complex as the length of the trip and the number of stops increase.

The ultimate performance of stores and shopping streets is the net result of these factors. Consequently, it is difficult if not impossible to draw general conclusions regarding the relationship between store performance, pedestrian movement, and parking policy. It is evident that these three factors are interrelated, but their relationship is complex and difficult to generalize.

The implication of these complex interactions is that urban planning schemes should not be based upon simplistic assumptions about city centre attractiveness and pedestrian movement. It is also difficult to assess the quality of planning proposals regarding city centres a priori on these dimensions. It is important, therefore, to build models of pedestrian movement that incorporate the mechanisms underlying pedestrian sequencing, destination and route-choice behaviour described in this paper. Unfortunately, existing models of pedestrian movement fail in this regard. They lack a structure that emphasizes the spatial and functional linkages implied by shopping-trip chains. Moreover, most models are typically based on the assumption of distance-minimizing behaviour proven to be false or at least of limited empirical value in the studies that we have conducted over the past five years.

Future research endeavours should concentrate on developing more sophisticated models. Especially simulation models that incorporate concepts of artificial intelligence and neural networks seem promising in this regard because these models allow one to incorporate decision heuristics that are difficult to represent by conventional mathematical equations. It is also important to compare the predictions of such models against the actual impacts of changing retail structures and new parking policies on pedestrian destination and route-choice behaviour. The authors hope to report on such developments in the near future.

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