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Pedestrian Gap Acceptance for Mid-block Street Crossing

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Background

- Pedestrian crossing behaviour is largely governed by the gap acceptance theory
  - Each pedestrian has a critical gap to cross the street
  - These gaps are often described by means of probability distributions or are estimated by means of linear regression models
  - They may depend on traffic density, vehicle headspaces, characteristics of the road environment, the incoming vehicles or the pedestrians

- Pedestrian crossing decisions (to cross the road or not)
  - These are modelled by means of discrete choice models
  - They may depend on vehicle speeds and headspaces, waiting times, characteristics of the road environment, the vehicles or the pedestrians

- Several studies were carried out in Northern and Western Europe or in the United States, where transport systems and infrastructure correspond to improved levels of service of pedestrians, resulting in a generally compliant behaviour from the part of the pedestrians as well.

- Their results can not be transferred to a national setting like the one of Greece, where the road infrastructure and traffic control are often inadequate for pedestrians, and also the behaviour of pedestrians is particularly non-compliant and often risk-taking.

Objectives

The objective of this paper is to investigate pedestrians' traffic gap acceptance and crossing decisions, for mid-block street crossing in urban areas.

- The effect of several factors, on the traffic gap acceptance of pedestrians and their decision to cross or not, is analyzed.
  - pedestrians waiting time
  - the presence of illegal parked vehicles
  - vehicles' characteristics (speed, size)
  - pedestrians' characteristics (gender, age)

Methods

- A field survey was carried out at an uncontrolled mid-block location in the center of Athens.

- A lognormal regression model was developed in order to examine the effect of various parameters on pedestrian gap acceptance, defined as the size of traffic gaps accepted by pedestrians

- A binary logistic regression model was developed, so that the effect of the traffic gaps available and of other parameters on the decision of pedestrians to cross the street or not is examined.

Data collection

- A field survey was carried out in the center of Athens, in Solonos street, where pedestrians crossing decisions were videotaped in real traffic conditions.
  - Considerable pedestrian volumes and systematic illegal parking were observed
  - No significant variations in traffic and no congestion were encountered

- Only pedestrians who actually crossed the street, either immediately or after several attempts were captured; pedestrians who abandoned the crossing task after some attempts were not included in the sample.

- The traffic gap accepted was calculated as the difference between 2 time points:
  - Point 1: the pedestrian is just ready to set foot on the street.
  - Point 2: the head of the vehicle has just passed through the vertical virtual line indicating the pedestrian's crossing path

- The speed of incoming vehicles was measured by means of speed laser guns at point 1

Descriptive statistics (1/2)

- Continuous variables

Variables	N	Minimum	Maximum	Mean	Standard Deviation
Waiting time (sec)	243	0	37,32	6,21	6,12
Speed (km/h)	243	4	48	25,21	7,82
Distance (m)	243	2,97	64,98	30,07	12,08
Traffic gap(sec)	243	0,50	11,11	3,29	1,76

Descriptive statistics (2/2)

- Discrete (binary) variables

Variables	Value '0'	Value '1'	% of value '1' in the sample
gender	woman	man	56.80%
size	small vehicle	large vehicle	47.00%
crossing	did not cross	crossed	54.0%*
Illegal parking	no	yes	82.30%
Accompanied	pedestrian alone	pedestrian accompanied	11.50%
Lane	Vehicle in nearside lane	Vehicle in farside lane	25.00%
Vehicle type: Motorcycle	no	yes	34.60%
Vehicle type: Car	no	yes	26.30%
Vehicle type: Taxi	no	yes	23.00%
Vehicle type: Truck	no	yes	2.50%
Vehicle type: Bus	no	yes	8.20%
Age group: Young	no	Aged 18-35 years	39.50%
Age group: Middle	no	Aged 35-60 years	36.70%
Age group: Old	no	Aged >60 years	16.50%

Gap acceptance model (1/4)

- **Parameter estimates and fit**

- Log-Gap = 0.262 + 0.009 * distance + 0.05 * size + 0.043 * accompanied + 0.048 * parking + 0.025 * gender

Where:

- Distance: the space between the vehicle and the pedestrian
- Size: the size of the vehicle that is small or big
- Accompanied: the pedestrian is accompanied by another pedestrian or not
- Parking: presence of illegally parked cars
- Gender: gender of the pedestrian

- The goodness of fit measure R^2 is equal to 0.455 for this model whereas all the above variables were statistically significant at 95%.

Gap acceptance model (2/4)

- **Variable elasticities**

- The point elasticity (e_i) for each pedestrian (i) in the sample is calculated according to the following formula, whereas the overall elasticity (e) is calculated as the average of (e_i) in the sample:

  $e_i = (\Delta Y_i \ / \ \Delta X_i) \ (X_i / Y_i) = \beta_i \ (X_i / Y_i)$

Independent variables	Log(gap)			
			Elasticities	
	β_i	p-value	e	e^*
Distance	0.009	0	0.423	51.62
Size of the vehicle	0.05	0.002	0.039	4.79
Accompanied	0.043	0.082	0.008	1
Illegal parking	0.048	0.019	0.065	7.92
Gender	0.025	0.116	0.023	2.86

- The relative effect (e*) is a normalization of the estimated elasticities in relation to the lowest elasticity

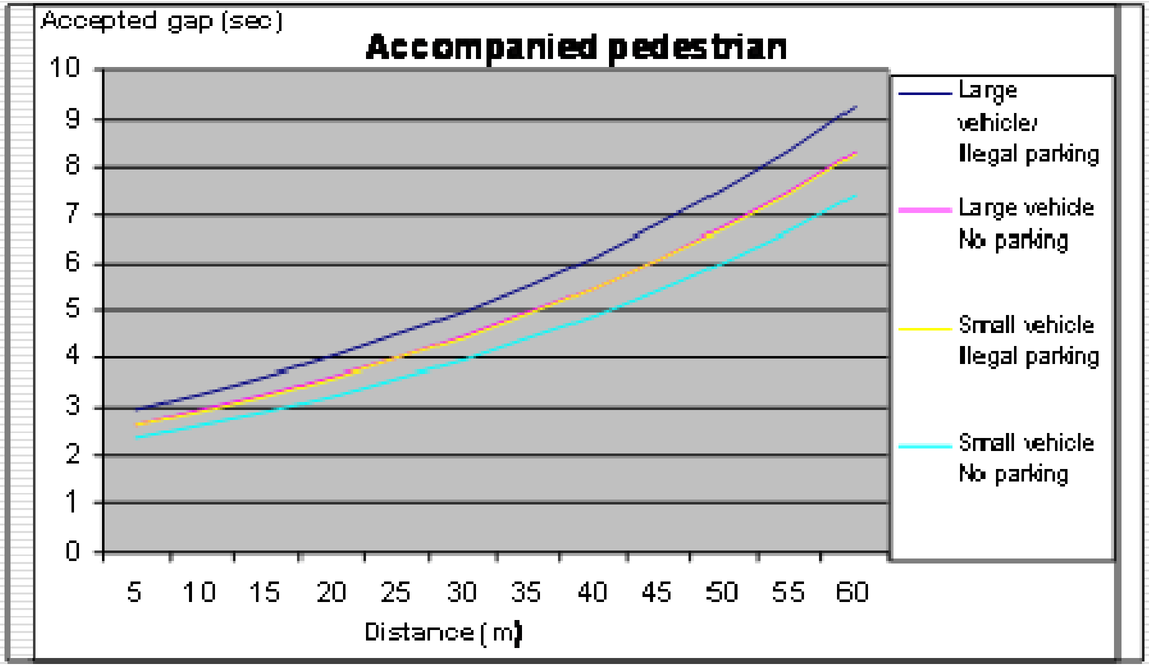
Gap acceptance model (3/4)

- **Summary of results**

- The distance between the vehicle and the pedestrian has the greatest effect on pedestrian log-gap acceptance. This appeared to be intuitive, because it was shown in the videotapes that those pedestrians who crossed the road when the vehicle was close to them had accepted smaller gaps than those who chose to cross the road when the vehicle was far away.
- The presence of illegal parking has the second larger effect on log-gap acceptance. Illegal parking made pedestrians more careful and acceptant of larger gaps.
- Vehicle size follows with the third higher elasticity. It appears that pedestrians accept larger gaps when facing larger vehicles.
- Men appear to take fewer risks than women, as they generally accept larger gaps.
- The parameter that has the lowest effect on log-gap acceptance is the one indicating that accompanied pedestrians seem to accept relatively larger gaps.

Gap acceptance model (4/4)

- **Sensitivity analysis**



- The sensitivity of the gaps accepted to the distance from the incoming vehicle increased with the size of the vehicle and with the presence of illegal parking.

Crossing choice model (1/4)

- **Parameter estimates and fit**

- U = - 5.241 - 0.25 * wait + 2.161 * gap +1.078 * car + 0.969 * parking

Where:

- U: the utility function for crossing
- Wait: waiting time
- Gap: the gap from the vehicle
- Car: if the type of vehicle is passenger car
- Parking: presence of illegal parking

- The crossing probability is estimated as: $P=e^u/(e^u+1)$

- The goodness of fit measure ρ^2 is equal to 0.474 for this model whereas all the above variables were statistically significant at 95%.

Crossing choice model (2/4)

- **Variable elasticities**

	Crossing or not			
			Elasticities	
Independent variables	**βi**	**p-value**	**e**	**e***
Waiting time	-0.25	0	0.202	12.75
Traffic gap	2.161	0	0.764	48.26
Type of vehicle: car	1.078	0.013	0.015	1
Illegal parking	0.969	0.08	0.123	7.77

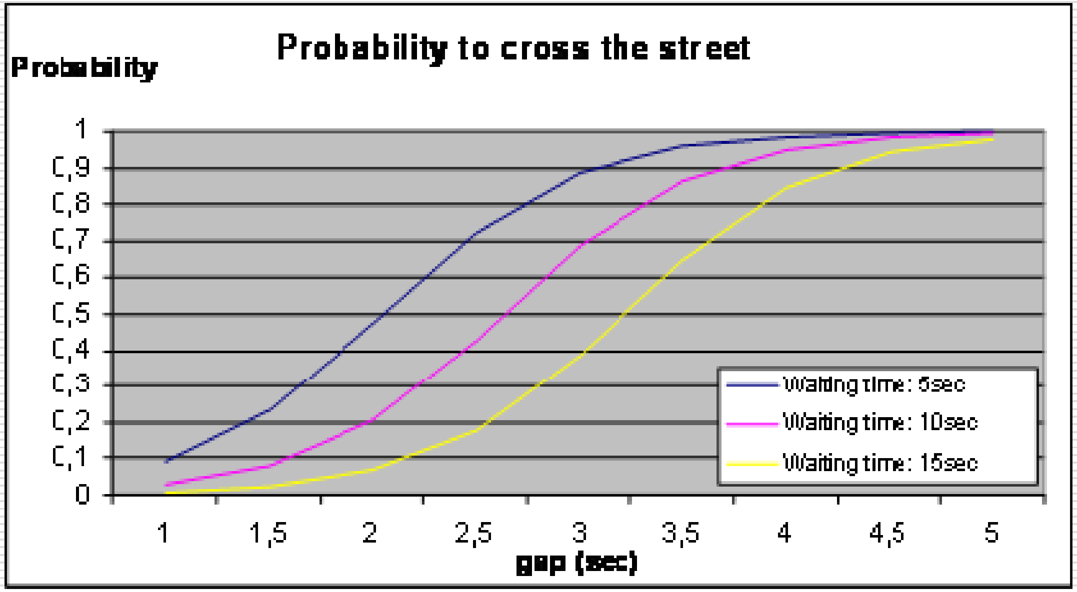
Crossing choice model (3/4)

- **Summary of results**

- The traffic gap has the greatest effect on pedestrians' decision to cross the street or not. The higher the available gaps, the easier the crossing.
- The variable with the second greater effect is the waiting time. As pedestrians keep waiting to cross the road, the probability to cross is decreasing. That can be explained as follows: those pedestrians who intend to wait for a long time to cross the street are most careful and they will not take risks.
- The presence of illegal parked vehicles leads pedestrians to cross the road. This may be attributed to the fact that a crossing seems safer when part of the crossing distance is taken by parked vehicles. However, illegal parking seems to have two different effects on pedestrians gap acceptance and their decisions to cross or not. This is something which needs further investigation.
- When the incoming vehicle is a passenger car, the crossing probability increases; however, this variable has the lowest effect.

Crossing choice model (4/4)

- **Sensitivity analysis**



- In favourable conditions (i.e. passenger car incoming and presence of illegal parking) the probability to cross decreases with waiting time.
- The majority of pedestrians would accept a 6 seconds gap. The crossing probability when a gap is larger than 6 seconds is almost 100%. Moreover, waiting time increases the probability that a pedestrian crosses the street

Conclusions (1/2)

- A lognormal regression analysis was implemented for modeling pedestrians' traffic gap acceptance.

- It was found that the accepted gaps depend on the distance from the incoming vehicle, the size of the vehicle, the presence of illegal parking, the gender of the pedestrians and whether he is accompanied by another pedestrian.

- It seems that men select the highest and the safest gaps, especially when they are accompanied, when the incoming vehicle is large and when there is illegal parking.

- A statistical analysis of the decision to cross the street or not was carried out by using binary logistic regression.

- The results suggest that pedestrians’ decision to cross the street depends on the traffic gap, the waiting time, the type the incoming vehicle and the presence of illegally parked vehicles.

Conclusions (2/2)

- The results of this research confirm previous findings as regards the effects of basic roadway and traffic parameters on pedestrians crossing decisions.

- It was found that pedestrians crossing decisions are strongly associated with the distance from the incoming vehicle, rather than its speed, possibly because vehicle distance can be more easily assessed by pedestrians.

- Pedestrians' individual characteristics were not found to be significant in this research; only pedestrian's gender was found to affect gap acceptance. On the contrary, traffic conditions were found to be the most important determinants of crossing behaviour.

- This may be attributed to the fact that all survey participants can be considered to have a strong familiarity with the survey site, as this is located in a very central area, resulting in less uncertainty in the decisions of those groups of pedestrians that are often associated with particular behaviours (e.g. children, elderly).