A TOOL TO VALUE REDUCTIONS IN COMMUNITY SEVERANCE CAUSED BY ROADS

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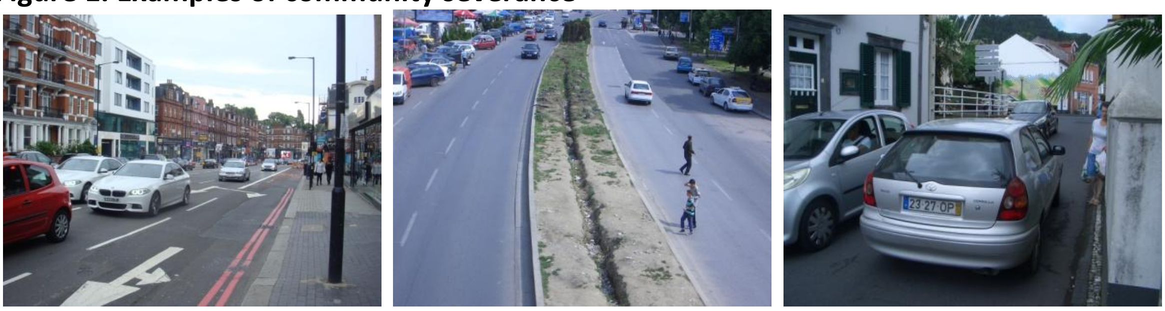
1. INTRODUCTION

Community severance happens when large transport infrastructure such as busy roads act as a barrier to the movement of pedestrians, with potential negative impacts on levels of physical exercise, accessibility to local facilities, and social cohesion (Appleyard and Lintell 1972, James *et al.* 2005, Sauter and Huettenmoser 2008, Scholes *et al.* 2015).

Figure 1 illustrates three different types of community severance. The road in photo (a) is a wide, multi-lane road without any crossing facilities. Although there are no physical barriers preventing pedestrians from crossing (such as guard railings, fences, or walls), crossing is risky and unpleasant due to the exposure of pedestrians to moving traffic. In general, the presence of a central reservation aids pedestrians crossing the road, by splitting the crossing into two stages. However, in many cases, central reservations can become an additional barrier, if they have steps or uneven surfaces, making them inaccessible to people with mobility restrictions (photo b). Even narrow roads can become barriers to the movement of pedestrians, if they have high traffic densities or speeds, reducing the ability of pedestrians to cross and walk along the road (photo c).

Figure 1. Examples of community severance



(a) (b) (c)

While the three cases shown in Figure 1 clearly represent different levels community severance, there are currently no established methods to measure those levels and value the benefits of reducing them. In absence of objective indicators to quantify the extent to which roads limit the mobility of pedestrians, or to identify the city neighbourhoods that are most affected by the problem, governments and transport authorities rely on subjective qualitative scales. For example, WebTAG suggests using a 3-point scale ("slight", "moderate", and "severe" severance) based on information about motorised traffic levels and likely impact on walking trips.

The academic literature provides several methods to measure community severance but few of these methods have been integrated into routine practice by transport professionals (Anciaes *et al.* 2016). Recently, some studies have started to use stated preference surveys to analyze issues related to community severance. In these surveys, participants are asked to choose among hypothetical alternatives, characterized by several attributes, each with different potential levels. These method have been used to estimate willingness to pay for policy interventions that reduce severance, such as building road tunnels (Grisolía *et al.* 2015), implementing traffic calming measures (Garrod *et al.* 2002), or adding or modifying pedestrian crossing facilities (Hensher *et al.* 2013).

The present study builds on these approaches by using a stated preference model to assess people's preferences regarding a comprehensive set of road features that cause severance, including the number of lanes for motorised traffic, the presence of a central reservation, traffic density, traffic speeds, and the type of crossing facilities.

2. STATED PREFERENCE SURVEY

The survey is a part of the UCL Street Mobility project and was conducted in March 2017 in the areas surrounding two busy roads in London:

- A 3-mile section of the A4 in Hounslow (200 interviews)
- A 0.5-mile section of the A23 in Streatham (150 interviews)

These roads where chosen among other possible roads in London because they are characterised by an insufficient number of pedestrian crossing facilities, the presence of features preventing crossing (such as guard railings) along some of its length, and high traffic density and speeds. The samples contained a balanced number of males and females and of individuals aged below and over 50 years old. The questionnaire was designed in order to minimise non-trading behaviour (participants choosing the same option in all questions).

The main component of the survey questionnaire consisted in three exercises, as follows.

Exercise 1

The objective of the first exercise was to quantify the participants' preferences regarding crossing the road in a place without designated crossing facilities. Three options were presented in each question:

- Option A: Cross the road (with specified characteristics) in a place without crossing facilities
- Option B: Walk a given distance (given in minutes) and cross in a place where the road is covered over
- Option C: Don't make the trip

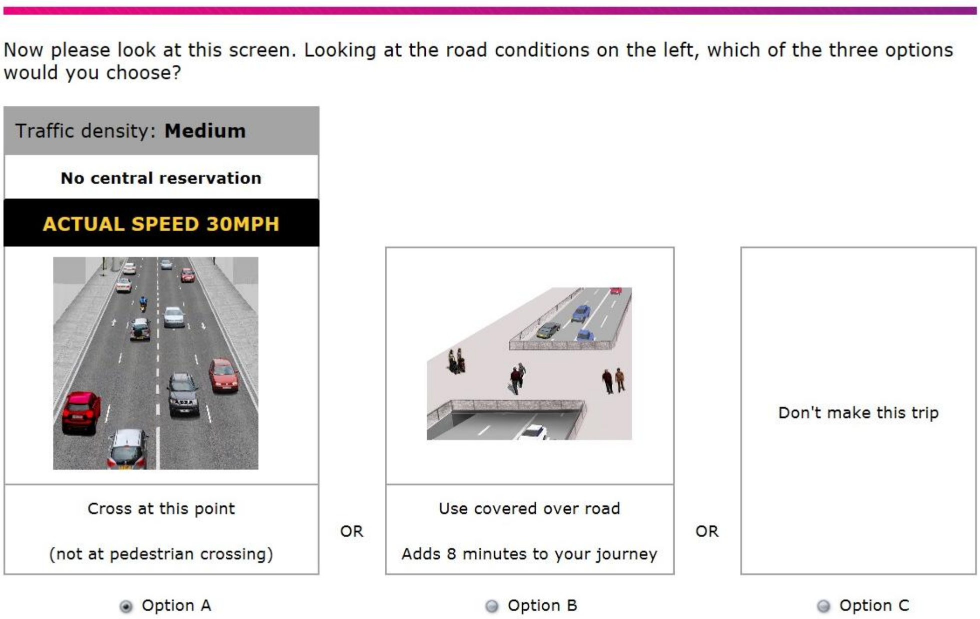
Table 1 presents the attributes and levels of the problem, that is, the characteristics of the road in Option A and the walking time in Option B. The design was constrained so that high traffic density is never associated with 30mh or 40mph speeds, in order to account for road congestion.

Table 1. Attributes and levels of Exercise 1

Attributes	Levels
Number of lanes in each direction	1 2 3
Central reservation	Not Present Present (with no guard railings)
Traffic density	Low Medium High
Traffic speed	10mph (Streatham only) 20mph 30mph 40mph (Osterley only)
Time added to journey	from 2 to 20 minutes, in 2 minute increments

The exercise consisted of eight questions, each one presenting different levels of the road attributes in Option A and walking time in Option B. Figure 2 shows an example of the questions, where the road in Option A has two lanes in each direction, no central reservation, medium traffic density, and 30mph speed, and the walking time in Option B is 8 minutes.

Figure 2. Example of question in Exercise 1



Exercise 2

The objective of the second exercise was to quantify the participants' preferences regarding crossing the road using different types of crossing facilities. Four options were presented in each question:

- Options A and B: Walk a given distance (in minutes) and cross the road using a certain type of crossing facility
- Option C: Walk a given distance (given in minutes) and cross the road in a place where the road is covered over
- Option D: Don’t make the trip

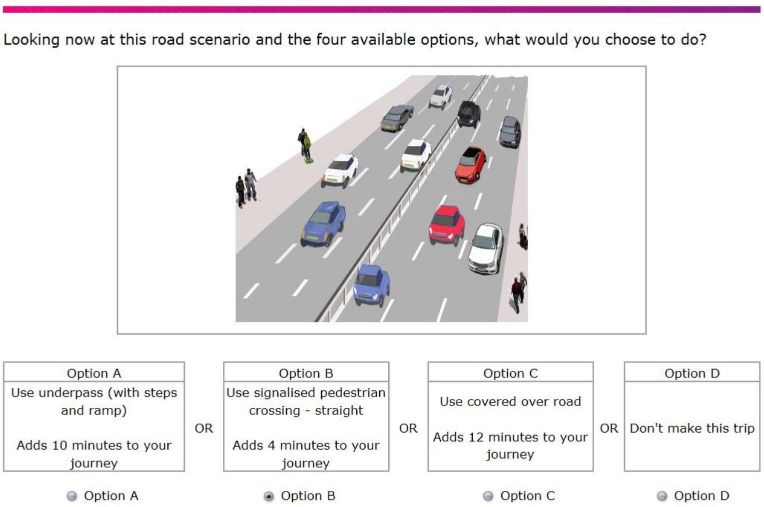
Table 2 presents the attributes and levels of the problem, that is, the types of crossing facilities in Options A and B and the walking times in Options A, B, and C. The design was constrained so that the walking times in Option C are always longer than the walking times in Options A and B.

Table 2. Attributes and levels of Exercise 2

Attributes	Levels
Types of crossing facilities	Straight pelican Staggered pelican Footbridge Underpass
Time added to journey	from 2 to 20 minutes, in 2 minute increments

The exercise consisted of eight questions, each one presenting different types of crossing facilities in Options A and B and walking times in Options A, B, and C. Figure 3 shows an example of the questions, where the crossing facilities in Option A and B are an underpass and a straight pelican, and the walking times in Options A, B, and C, are respectively 10, 4, and 12 minutes.

Figure 3. Example of question in Exercise 2



Exercise 3

The objective of the third exercise was to quantify the participants' willingness to pay to cross the road in a place without designated crossing facilities. The scenario involves the participant having the opportunity of paying a lower shopping bill or public transport fare by crossing the road. Participants who stated they crossed the road to access public transport less often than once every 2-3 months or who are aged 60 or older were shown the shopping bill alternative. The other participants were shown the public transport alternative.

Three options were presented in each question:

▪ Option A: Cross the road (with specified characteristics) in a place without crossing facilities and pay a cheaper public transport fare or shopping bill on the other side
▪ Option B: Do not cross the road and pay the higher public transport fare or shopping bill on this side of the road

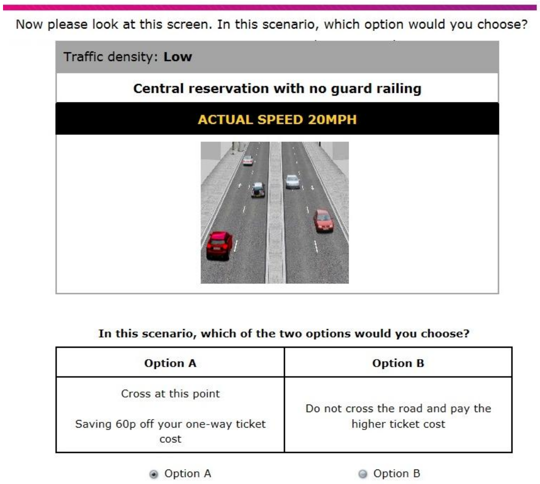
Table 3 presents the attributes and levels of the problem, that is, the characteristics of the road and the value of the saving in Option A. As in Exercise 1, the design was constrained so that high traffic density is never associated with 30mh or 40mph speeds, in order to account for road congestion. The cost savings presented to participants in the shopping bill segment are double of those presented to participants in the public transport segment, as the former have to cross the road twice.

Table 3. Attributes and levels of Exercise 3

Attributes	Levels
Number of lanes in each direction	As in Exercise 1
Central reservation	
Traffic density	
Traffic speed	
Saving	▪ Public transport segment: from 20p to £2, in 20p increments ▪ Shopping bill segment: from 40p to £4, in 40p increments

The exercise consisted of eight questions, each one presenting different levels of the road attributes and the saving value in Option A. Figure 4 shows an example of the questions, where the road in Option A has two lanes in each direction, a central reservation, low traffic density, and 20mph speed, and the participant can save 60p by crossing the road to use a bus stop on the other side.

Figure 4. Example of question in Exercise 3



3. RESULTS

The choices were analyzed using econometric models. Indicators of severance were then calculated from the estimated coefficients.

Exercise 1

Table 4 shows the results of the models of the answers to Exercise 1. The model was estimated on a dataset with one observation for each of the three options in all the eight questions answered by all participants in the two case study areas. The dependent variable is the probability that option was chosen. The explanatory variables are dummy variables representing Options A and Option C, dummy variables representing specific road conditions in Option A, and the number of minutes in Option B. The most benign road conditions (one lane, central reservation, low traffic density, and 10mph speed) were omitted from the model as separate variables, as they are implicit in the general coefficient of Option A.

The first column shows the estimated model coefficients. The coefficients of all the road attributes have the expected sign (negative). This suggests that participants prefer to avoid crossing roads with two or three lanes, no central reservation, medium or high traffic density, and 20, 30, or 40 mph speed, comparing with roads with one lane, a central reservation, low traffic density, and 10mph speed. The relative magnitude of the 2 vs. 3 lane roads, medium vs. high, and 20 vs. 30 vs. 40 mph speed are also consistent with prior expectations. The time and "don't cross" coefficients are negative, which means that participants prefer shorter walking times and to cross the road, rather than avoid making the trip.

The second column shows the ratios between the coefficients of the different road characteristics and the coefficient of walking time. These ratios can be understood as the willingness to walk to avoid crossing a road with those characteristics in a place without crossing facilities. For example, participants are willing to walk 4.3 minutes to a place where the road is covered over in order to avoid crossing a road with two lanes in a place without crossing facilities. They are also willing to walk 22.7 minutes in order to be able to make the trip (that is, to avoid Option C).

The third column shows the ratios between the coefficients the different road characteristics and the coefficient of Option C. These ratios can be understood as the (dis)utility of Option A comparing with the (dis)utility of Option C (not making the trip). For example, crossing a road with two lanes in a place without crossing facilities has a disutility which is perceived to be 19% of the disutility of not making the trip. A minute walking has a disutility which is perceived to be 4% of the disutility of not making the trip.

Table 4. Model results (Exercise 1)

	coefficient	willingness to walk (minutes)	utility relative to Option C
time	-0.42***		0.04
option A (cross)	0.53		
lanes=2	-1.80***	4.3	0.19
lanes=3	-3.83***	9.1	0.40
no reservation	-2.77***	6.6	0.29
density=medium	-1.33***	3.1	0.14
density=high	-4.05***	9.6	0.42
speed=20	-1.40***	3.3	0.15
speed=30	-2.21***	5.2	0.23
speed=40	-3.61***	8.5	0.38
option C (Don't make the trip)	-9.58***	22.7	

Notes: n=262. Significance levels: ***1%, **5%, *10%

Exercise 2

Table 5 shows the results of the models of the answers to Exercise 2. The model was estimated on a dataset with one observation for each of the four options in all the eight questions answered by all participants in the two case study areas. The dependent variable is the probability that option was chosen. The explanatory variables are a dummy variable representing Option D, dummy variables representing the four possible types of crossing facilities presented in Options A or B, and the number of minutes in Option A, B, or C. The type of crossing scenario in Option C (a place where the road is covered over) was omitted from the model to avoid redundancy.

The first column shows the estimated model coefficients. The coefficients of the crossing types have the expected sign (negative). This suggests that participants prefer to avoid using crossing facilities, comparing with the omitted alternative (a place where the road is covered over). The relative magnitude of the coefficients is also consistent with prior expectations: straight pelicans are the most preferred type of facility, followed by staggered pelicans, footbridges, and underpasses. As expected, the time coefficient is negative, which means that participants prefer shorter walking times.

The second column shows the ratios between the coefficients of the different crossing facilities and the coefficient of walking time, i.e. the willingness to walk to avoid using those facilities and cross in a place where the road is covered over. For example, participants are willing to walk 1.9 minutes to a place where the road is covered over in order to avoid crossing a road using a straight pelican. They are also willing to walk 21.9 minutes in order to be able to make the trip (that is, to avoid Option D). This last value is very similar to the one obtained in the previous exercise for the same option (22.7 minutes), showing that participants have consistent preferences.

The third column shows the ratios between the coefficients of the different types of facility and the coefficient of Option D. These ratios can be understood as the (dis)utility of Option A comparing with the (dis)utility of Option D (not making the trip). For example, crossing a road using a straight pelican has a disutility which is perceived to be 9% of the disutility of not making the trip. A minute walking has a disutility which is perceived to be 4% of the disutility of not making the trip, which is equal to the value obtained in the previous exercise, again confirming that participants show consistent preferences across exercises.

Table 5. Model results (Exercise 2)

	coefficient	**willingness to walk (minutes)**	**utility relative to Option D**
time	-0.56^{***}		0.04
straight pelican	-1.07^{***}	1.9	0.09
staggered pelican	-1.14^{***}	2.0	0.09
footbridge	-3.20^{***}	5.7	0.26
underpass	-3.80^{***}	6.8	0.31
option D (Don't make the trip)	-12.26^{***}	21.9	

Notes: n=350. Significance levels: ***1%, **5%, *10%

Exercise 3

Table 6 shows the results of the models of the answers to Exercise 3. The model was estimated on a dataset with one observation representing Option A in all the eight questions answered by all participants in the two case study areas. The dependent variable is the probability that Option A was chosen. The explanatory variables are dummy variables representing specific road conditions and the value of the saving in Option A. The most benign road conditions (one lane, central reservation, low traffic density, and 10mph speed) were omitted from the model to avoid redundancy.

The first column shows the model coefficients. Once again, all the coefficients of road attributes have the expected sign and magnitude. The savings coefficient is positive, which means that participants prefer higher savings, as expected.

The second column shows the ratios between the coefficients of the different crossing facilities and the coefficient of the savings value. These ratios can be understood as the willingness to pay (or more precisely, to forego a cost saving) to avoid crossing the road in a place without crossing facilities. For example, participants are willing to pay 80p in order to avoid crossing a road with two lanes in a place without crossing facilities.

Table 6. Model results (Exercise 3)

	coefficient	willingness to pay (£)
saving	1.57***	
lanes=2	-1.33***	0.8
lanes=3	-2.70***	1.7
no reservation	-2.22***	1.4
density=medium	-0.90**	0.6
density=high	-2.87***	1.8
speed=20	-0.75*	0.5
speed=30	-1.48**	0.9
speed=40	-2.48***	1.6
constant	1.68***	

Notes. n=275. Significance levels: ***1%, **5%, *10%

Indicators of severance for different types of road and crossing facilities

The results of Exercise 1 can be used to estimate a "severance index" of roads with different combinations of the values of the attributes included in the exercise (number of lanes, presence of a central reservation, traffic density, and traffic speed). The index represents the (dis)utility participants derive from crossing the road as a percentage of the (dis)utility of not making the trip. This index can be estimated by adding the coefficients representing the specified road conditions and dividing that sum by the coefficient of Option C.

The minimum value of the indicator is 0, in the case where participants do not attach any (dis)utility to crossing the road in a place without facilities, that is, when all coefficients related to Option A are equal to zero. Values above 1 represent the case where participants attach less utility to crossing the road in a place without facilities than to not making the trip. This means that the road is perceived as an absolute barrier, not worth crossing.

The willingness to walk and willingness to pay to avoid crossing roads with different characteristics can be calculated in a similar fashion, by adding the coefficients of representing the specified road conditions and dividing that sum by the coefficient of walking time (in Exercise 1) and the coefficient of the saving (in Exercise 3).

Table 7 gives the results of the severance index and of the willingness to walk and to pay for all possible combinations of road attributes presented in the exercises.

Table 7. Severance indices, willingness to walk, and willingness to pay, by type of road

			Roads with 1 lane			Roads with 2 lanes			Roads with 3 lanes		
Central Reservation	Traffic density	Traffic speed (mph)	Severance index	Willingness to walk (minutes)	Willingness to pay (£)	Severance index	Willingness to walk (minutes)	Willingness to pay (£)	Severance index	Willingness to walk (minutes)	Willingness to pay (£)
Yes	low	10	0%	0.0	0.00	19%	4.3	0.85	40%	9.1	1.72
		20	15%	3.3	0.48	33%	7.6	1.33	55%	12.4	2.20
		30	23%	5.2	0.95	42%	9.5	1.79	63%	14.3	2.67
		40	38%	8.5	1.58	56%	12.8	2.43	78%	17.6	3.31
	medium	10	14%	3.1	0.57	33%	7.4	1.42	54%	12.2	2.30
		20	28%	6.5	1.05	47%	10.7	1.90	68%	15.5	2.78
		30	37%	8.4	1.52	56%	12.6	2.37	77%	17.4	3.24
		40	52%	11.7	2.16	70%	16.0	3.01	91%	20.8	3.88
	high	10	42%	9.6	1.83	61%	13.9	2.68	82%	18.7	3.56
		20	42%	9.6	2.31	76%	17.2	3.16	97%	22.0	4.04
No	low	10	29%	6.6	1.42	48%	10.8	2.26	69%	15.6	3.14
		20	44%	9.9	1.89	62%	14.1	2.74	83%	18.9	3.62
		30	52%	11.8	2.36	71%	16.1	3.21	92%	20.9	4.08
		40	67%	15.1	3.00	85%	19.4	3.85	107%	24.2	4.72
	medium	10	43%	9.7	1.99	62%	14.0	2.84	83%	18.8	3.71
		20	57%	13.0	2.47	76%	17.3	3.32	97%	22.1	4.19
		30	66%	14.9	2.93	85%	19.2	3.78	106%	24.0	4.66
		40	80%	18.3	3.57	99%	22.5	4.42	120%	27.3	5.30
	high	10	71%	16.2	3.25	90%	20.4	4.10	111%	25.2	4.97
		20	86%	19.5	3.73	105%	23.7	4.58	111%	25.2	5.45

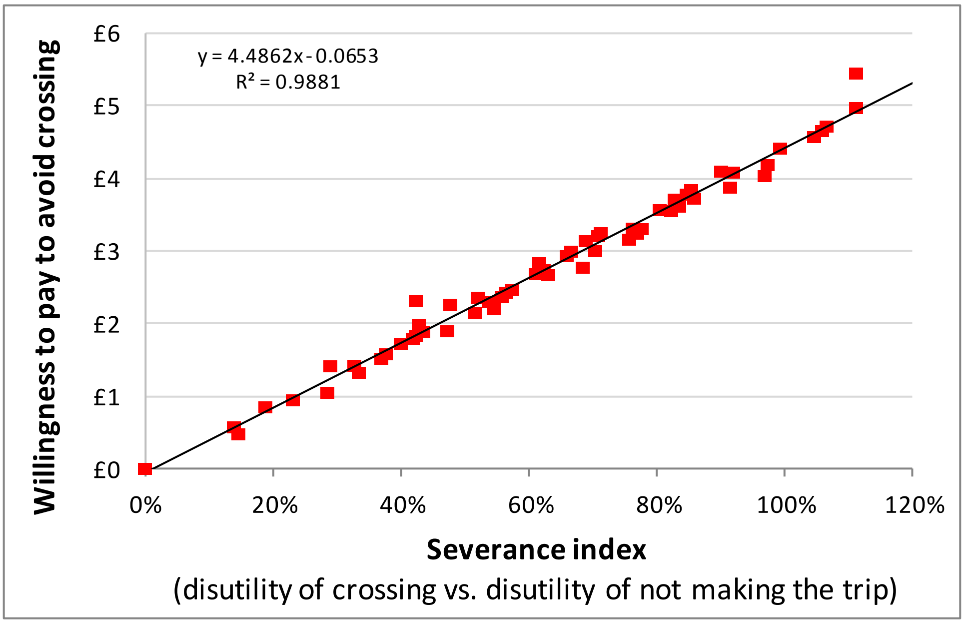
The value of the severance index is between 0 and 100% in almost all cases. The index for the roads with the best possible characteristics (one lane, central reservation, low traffic density, and 10mph speed) is 0%, which means that participants attach the same utility to crossing that type of road in a place without facilities and to crossing in a place where the road is covered over. It should be noted that the value is not 0% by definition, but because the estimated coefficient of Option A (which represents roads with the most benign conditions for pedestrians) is not statistically different from 0 (see Table 4). In six cases, the estimated index is above 100% which means that participants attach less utility to crossing the road with the presented characteristics than to avoid making the trip.

The values of the willingness to walk vary between 0 and 27.3 minutes and the values of the willingness to pay vary between 0 and £5.45.

Figure 5 shows the relationship between the estimated severance indices of different types of roads and the willingness to pay to avoid crossing those roads in places without crossing facilities. The relationship is almost linear, which once more confirms that participants have consistent preferences across exercises.

Plotting willingness to walk against willingness to pay (not shown) produces an identical chart, with a slope equal to 0.1978, which corresponds to an implicit value of walking time of 19.78p per minute. This value is broadly consistent with WebTAG's recommended values of travel time savings (10.1-11.4p per minute for non-work trips by any mode and 20.2-22.8p per minute when walking is used as a means of inter-change between modes of transport).

Figure 5. Relationship between estimated severance indices and willingness to pay



The results of Exercise 2 can be used to estimate severance indices for specific types of crossing facilities. The index is expressed in the same scale as the one defined above, since the values are relative to the same base best and worst scenarios (which are, respectively, crossing the road in a place where the road is covered over, and not making the trip). As such, it is possible to compare severance caused by roads with specific types of crossing facilities and by roads with no facilities and specific design and traffic characteristics. The results are shown in the first column of Table 8. As expected, the indices are lower than most of the indices for roads with no facilities, shown in Table 7. However, footbridges and underpasses have a higher index than some of the 1-lane road scenarios.

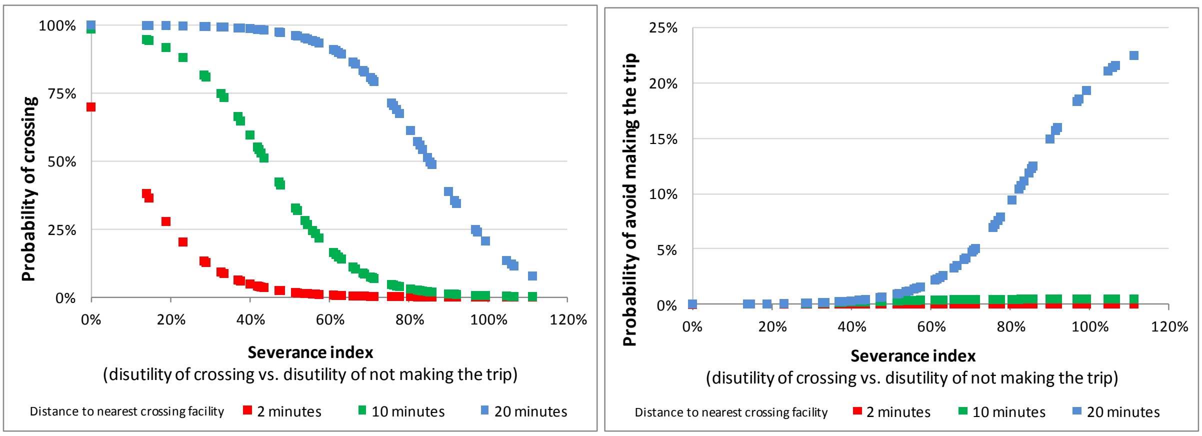
The relationship shown in Figure 5 can then be used to estimate the willingness to pay to avoid using specific types of crossing from the values of the severance index associated with those facilities. The results are shown in the second column of Table 8, and vary between 33p (for straight pelicans) and £1.32 (for underpasses).

Table 8. Severance index and estimated willingness to pay by type of crossing

	Severance index	Estimated willingness to pay (£)
straight pelican	9%	£0.33
staggered pelican	9%	£0.35
footbridge	26%	£1.10
underpass	31%	£1.32

Finally, it is also possible to use the results of Exercise 1 to derive the relationships between the severance index and pedestrian behaviour (that is, the probabilities that someone will cross the road, will walk to the nearest crossing facility, or will avoid the trip) for different road characteristics and distances to the nearest crossing. Figure 6 shows these relationships.

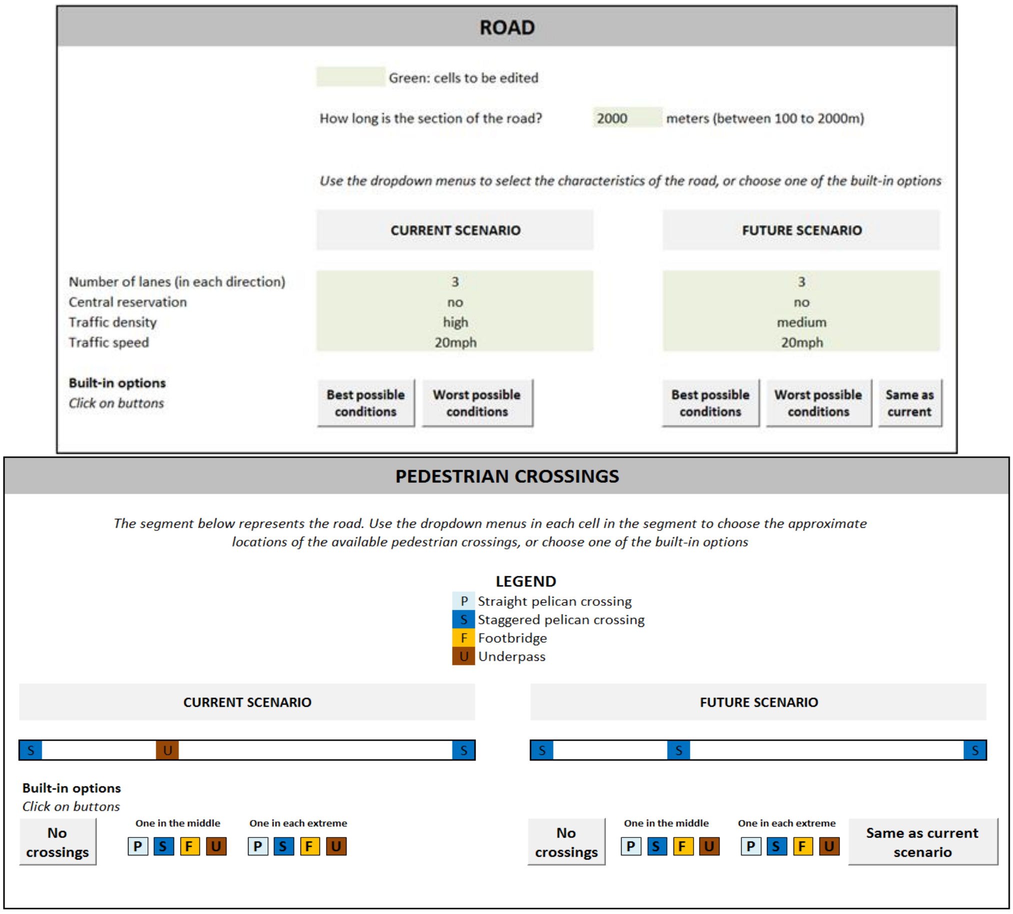
Figure 6. Relationship between estimated severance indices and pedestrian behaviour



4. APPLICATION

These results will be included in an interactive tool under development at UCL Centre for Transport Studies (Figure 7). This tool estimates the reduction in the severance index and the economic value (expressed as reduction in willingness to pay) per trip associated with interventions such as reducing the number of lanes, adding a central reservation, reducing traffic volume or speed, adding new crossing facilities, modifying the type of existing facilities, or burying the road.

Figure 7. Examples of input pages of severance tool (under development)



The simplest version of this tool requires as inputs the characteristics of the road and crossing location and type facilities in the pre- and post- policy scenario. However, the tool can also generate indicators disaggregated by population group, and overall indicators weighted by the proportion of each group in the population, as the results shown in this paper can be disaggregated according to the characteristics of the participants.

The tool can also provide estimates of the total benefit of interventions. This is calculated taking into account the per-trip values and the impact on the total number of trips. This impact can be derived using information from the stated preference model described in this paper, by multiplying the change in the probability that participants choose the "Don’t make the trip" option with an indicator of the "need for crossing" based on the catchment areas of nearby trip attractors (such as schools, supermarkets, parks, or railway stations).

The effects on interventions on the number of walking trips can also be linked with wider impacts on health, social inclusion, and vitality of local retail. These impacts can be monetized linking the tool with other existing tools (such as the Health Economic Assessment Tool) and results of previous studies.

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