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A stated preference model to value reductions in community severance caused by roads

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ABSTRACT

This paper uses a stated preference survey to estimate the value of reductions in community severance (the "barrier effect" of transport infrastructure on pedestrians). The survey was conducted in four urban areas in England. Participants were asked whether they would cross a road without designated crossing facilities in order to access a cheaper shop or a bus stop on the other side of the road, instead of a more expensive one on their side of the road. This method provides information for the inclusion of severance effects in the appraisal of interventions to change road design and to control motorised traffic. The estimated value per walking trip of reducing the number of vehicle lanes from 3 to 2 and from 2 to 1 is £1.28 and £1.00 respectively. The value of adding a central reservation (median strip) is £1.08. The value of reducing traffic levels from medium to low and from high to medium is £0.76 and £1.08 respectively The value of reducing speed limits below 30mph is £0.45. These values depend on age, gender, disability, health condition, mobility restrictions, qualifications, location, and walking behaviour.

1. Introduction

Transport systems have a number of negative effects that are not priced in the market. The economic value of these impacts is relevant for decisions about pricing policies and investment in the transport system. Over the years, economists have developed sophisticated methods for assigning monetary values to some of those effects, including congestion, accident risk, noise, air pollution, water pollution, and climate change (Mayeres et al., 1996; Maibach et al., 2007; CE Delft et al., 2011). In comparison, community severance has been relatively neglected by economists and transport planners. Community severance, an issue also known as barrier effect, arises when transport infrastructure (such as roads and railways) or high volumes of motorised road traffic cut through communities, disrupting the walking mobility and accessibility of local residents (Tate, 1997; Read and Cramphorn, 2001; James et al., 2005; Bradbury et al., 2007; Anciaes, 2015; Anciaes et al., 2016a, 2016b; Mindell et al., 2017). This impact can have major negative consequences for public health, well-being, and social inclusion (Mindell and Karlsen, 2012), but is not well captured in existing transport appraisal methods as it is poorly understood and lacks a basis for economic valuation.

In most cases, the assessment of severance relies on ad-hoc procedures or on subjective qualitative scales (Anciaes et al., 2016b). The valuation of severance is difficult because in general it is also difficult to assign values to the benefits and costs of walking. The task is especially problematic when severance leads to trip suppression, as it requires the understanding of the complex set of psychological and social aspects that shape travel behaviour (Anciaes et al., 2016a). In the United Kingdom, severance is classified as an impact that is currently not feasible to monetise (UK DfT, 2017, p.2). In the past, official guidance documents for transport appraisal in some countries have proposed methods for the calculation of the value of severance. For example, in Denmark, the effect was set at 50% of the value of roadside noise (Vejdirektoratet, 1992) and in Sweden, the values depended on the age groups affected (Vägverket, 1989). However, these methods were seldom used in practice and were not included in more recent documents for transport appraisal in those countries.

This paper develops a method to estimate the value of road schemes that improve conditions for pedestrians crossing busy roads, including changes in road design (number of traffic lanes and existence of central reservation/median strip) and traffic characteristics (density and speed). The method is based on a survey carried out in the areas surrounding four major roads in England. The survey included a stated preference exercise in which participants chose between crossing the road informally with no special provision (under varying scenarios for the road design and traffic

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characteristics) in order to access a cheaper shop or a bus stop in a cheaper travel zone on the other side of the road. Mixed logit models were used to derive the value of the willingness to accept the saving in order to cross the road.

The rest of the paper proceeds as follows. Section 2 reviews the use of stated preference methods to value community severance. Sections 3 and 4 describe the study areas and the study design. Section 5 analyses the participants' trading behaviour. Section 6 reports the results of the modelling of the choices. Section 7 analyses the reasons given by participants for their choices. Section 8 concludes the paper.

2. Literature review

Community severance is a non-marketed 'bad', so methods of economic valuation are usually needed to determine its value. A growing number of studies have started to assess severance using methods similar to those used to assess other negative effects of transport (such as noise and air pollution). In particular, stated preference methods have been used to assess preferences regarding different aspects of severance or different mitigation measures. These methods consist of surveys where participants choose among hypothetical alternatives. Preferences can be estimated in terms of willingness to pay/accept or to trade-off marginal changes in the attributes of the problem.

Contingent valuation is a stated preference method in which participants are asked directly about their willingness to pay for or accept a certain change (Mitchell and Carson, 1989). Soguel (1995) used this method to assess the cost of severance in a city in Switzerland, assuming that effect could be removed through the construction of a tunnel. The participants' maximum willingness to pay was determined by an open-ended question, followed by a bidding game. Grudemo et al. (2002) also used contingent valuation with binary choices to derive the willingness to pay to bury roads and railways that restrict access to recreational spaces, and Maddison and Mourato (2001) used payment cards to elicit values for changes in the layout of a road that restricts access to a site with cultural value.

Advances in statistics and computing have contributed to the development of more sophisticated stated preference methods such as choice modelling (Hanley et al., 2011). This technique is based on surveys where participants choose from alternatives defined by several attributes. The choices are then modelled as functions of the attribute levels and the characteristics of the participants. If one of the attributes defines the payment or compensation associated with each alternative, then it is possible to calculate the willingness to pay or to accept compensation for changes in the other attributes.

This technique has been widely used to value other negative impacts of transport such as noise (Bristow et al., 2015) and in recent years has started to be applied to the valuation of community severance and related issues. For example, Grisolía et al. (2015) estimated the willingness to pay for burying a road in Spain, considering the types of land use and amenities on the surface and the cost of the project, as reflected in an increase in local taxes. The study found that people who currently walk in the area around the road are willing to pay €149 per year to finance the construction of a road tunnel and those who do not currently walk in that area are willing to pay €73. ITS and Atkins (2011) also estimated the value of policies that give different levels of priority to pedestrians, finding that participants were willing to pay £64 per year for a road pedestrianisation project.

Stated preference methods can also be used to model perceptions and behavioural responses to different types and levels of severance, even when not including a cost attribute in the experiment. This approach assumes that severance can be mitigated by policies that are less radical than building a road tunnel or pedestrianisation, such as traffic control, road redesign, and provision of crossing facilities. Preferences are captured as trade-off values between road and traffic attributes and walking time or distance. A proposal was made by (Read and Cramphorn (2001), Ch.4) for including this type of approach in official guidance for transport appraisal in New Zealand, but this proposal was never implemented. A decade later, Meltofte and Nørby (2012) used a similar method in a study in Denmark to derive trade-off values between number of lanes, traffic variables (density, composition, and speed), and distance to crossing facilities. Cantillo et al. (2015) also considered different options for the provision of crossing facilities, and modelled the choices between crossing the road informally and using signalised crossings and footbridges, taking into account pedestrian delay, traffic density, and walking distance to crossing facilities.

A few studies of pedestrian safety have also used stated preference surveys. For example, Hensher et al. (2011) estimated preferences for different types of crossing facilities, total walking time, delay at the crossings, number of traffic lanes, traffic speeds, safety outcomes (measured as predicted numbers of deaths and injuries), and increases in local taxes. The study assessed people's willingness to pay for the reduction of collision risk, but did not calculate trade-offs between the different methods to achieve this reduction.

The negative impact of major roads on the ability to cross the road can also be assessed alongside broader impacts of the road on walking. For example, Kelly et al. (2011) developed a model that considered attributes related to crossing the road (traffic density, speed, pedestrian delay and detours, and number of crossings) and to walking along the road (street lighting and characteristics of pavements). Garrod et al. (2002) also estimated preferences for the reduction of several impacts of motorised traffic, including traffic speed, noise, visual impacts, and waiting time to cross the road. The mitigation of the impacts was to be achieved by traffic calming measures, but these measures were not specified.

The present study builds on these previous efforts, by assuming thatthe disutility of crossing the road depends on the characteristics of the road (number of traffic lanes and presence of a central reservation) and traffic (density and speed). The modelling of the choices for crossing the road under different cost saving scenarios allows for the estimation of trade-off values, expressed in monetary terms, between crossing roads with more and less adverse conditions. These trade-off values can be used as indicators of the benefits of reducing severance.

3. Study areas

The survey was conducted in the areas surrounding four major roads, in London (Seven Sisters Road and Finchley Road), Southend-on-Sea (Queensway), and Birmingham (Stratford Road) (Fig. 1). Research using participatory mapping, video surveys, street audits, space syntax, and a health and mobility survey revealed that these roads are a barrier to the movement of pedestrians, especially for older people, with negative effects on the frequency of walking trips and on levels of accessibility to local facilities. There is a high incidence of irregular crossing behaviour (away from designated crossing facilities) but many local residents have also developed strategies for avoiding crossing the road in dangerous locations, such as choosing alternative destinations or routes, or using buses.

The two roads in London have three lanes for motorised traffic in each direction and high traffic levels (annual average daily flows of 35,420 vehicles in Seven Sisters Road and 46,617 vehicles in Finchley Road, according to 2015 data from the UK Department for Transport). The 800 m section of Seven Sisters Road selected as case study crosses through the neighbourhood of Woodberry Down, a residential area with few workplaces, shops, or facilities. There are no pedestrian crossings near bus stops, leading to a high incidence of dangerous crossing behaviour (Fig. 1a). The selected 1.7 km section of Finchley Road is a major destination for pedestrians accessing underground stations, shopping centres, and other facilities. The large majority of these places are located on the west side of the road. There are walls and guard railings preventing pedestrians from crossing in many locations (Fig. 1b).

The two roads outside London have two lanes in each direction and lower traffic levels comparing with the roads in London (daily flows of 11,669 to 19,893 in Southend, depending on the section, and 15,608 in

Fig. 1. Case studies.

Birmingham). The Southend case study includes two sections of Queensway, a road separating the city centre from residential areas. The road itself has few destinations for pedestrians. There are walls and guard railings along almost the whole length of the two road sections (1.8 km). Informal crossing behaviours are prevalent: the video survey revealed that almost half of pedestrians choose to cross a complex road junction at the surface instead of using an underpass (Fig. 1c). The Stratford Road case study in Birmingham is a 2 km high street which is a major local shopping area serving the neighbourhood of Sparkhill. There are regularly spaced crossings and in some parts, the road narrows to one lane per direction. However, crossing the road is difficult because of a constant flow of traffic and the presence of parked cars (Fig. 1d).

Table 1 shows the characteristics of the sample. The survey consisted of around 100 interviews in the London and Southend case studies and 121 interviews in Birmingham. The objective of the sampling process was to obtain a balanced number of men and women and of individuals aged below and over 50 years old, given the aim of the research project of understanding the links between ageing and barriers to walking. However, the achieved sample in London Seven Sisters Road and in Birmingham is slightly imbalanced due to problems in recruiting older participants. Other differences between the four samples reflect population differences. The main purpose of the most recent walking trip of participants in all four areas was shopping, but the proportion of shopping trips is lower in the two London case studies. The Southend sample also has a lower proportion of people who cross the road most days.

4. Survey design

The objective of the stated preference exercise was to derive the value of reductions in community severance in terms of changes in participants' willingness to accept a saving in order to cross a road in a place without 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 (and as such, entitled to a free bus pass) were shown the shopping bill alternative. The other participants were shown the public transport alternative. The shopping bill segment represents 36% of the sample (24% in Seven Sisters Road, 30% in Finchley Road, 42% in Southend, and 47% in Birmingham).

Two options were presented in each question:

Option A: Cross the road in a place without crossing facilities and pay a cheaper public transport fare (shopping bill) on the other side
Option B: Avoid crossing

The exercise consisted of seven questions in the London Finchley Road survey and eight questions in the other three surveys. Table 2 shows the attributes and levels of the problem, that is, the characteristics of the road and traffic in Option A (number of lanes for motorised traffic, presence of a central reservation, traffic density, and traffic speed) and the value of the saving in Option B. These attributes were chosen after a preliminary study using focus groups and in-depth interviews. That study also found that traffic composition (the proportion of heavy goods vehicle) was not very relevant in shaping people's perceptions about the road and their choices for crossing the road, comparing with traffic density and speed. Traffic composition was therefore not included as a separate attribute.

It was assumed that trips to bus stops only require crossing the road once, as bus stops for services running in opposite directions usually stop on opposite sides of the road. The savings presented in the shopping bill segment were therefore set to double of those in the public transport segment.

The attribute values shown in each question were systematically varied. An efficient design was used, which generates data that allows for the minimization of the standard errors of the parameter estimates (Rose and Bliemer, 2009). The design was obtained using the Ngene software. The design was constrained so that high traffic density was always associated with low speeds (0 or 10 mph), to account for the effects of road congestion. The number of traffic lanes shown was always equal or

Table 1
Sample characteristics.

		All (n = 423)	London (S.S.Rd) (n = 102)	London (F.Rd) (n = 100)	Southend (n = 100)	Birm. (n = 121)
Gender	Male	45	41	45	54	40
	Female	55	59	55	46	60
Age	18–34	31	33	34	24	33
	35–49	29	36	20	29	31
	50–64	25	23	22	25	28
	65+	15	7	24	22	8
Disability affecting walking		13	17	7	15	12
Bad health condition		10	18	2	11	9
Qualifications	Degree or higher	32	38	47	23	22
	Technical qualification	40	42	36	41	43
	No qualifications	27	21	16	36	35
Employment status	Full-time employment	34	36	40	36	26
	Part-time employment	11	12	12	14	6
	Unemployed	10	13	7	11	10
	Retired	20	17	28	25	13
	Student	7	6	8	4	8
	Looking after someone/home	15	11	4	7	34
Car ownership	No car	48	64	53	53	26
Frequency of crossing the main road in local area	Most days	47	42	53	28	61
	2-3 times a week	29	32	29	30	24
	About once a week	15	19	14	23	7
	Less than once a week	9	7	4	19	7
Last walking trip	Purpose: Work	15	16	22	16	7
	Purpose: Shopping	61	49	45	71	76
	Purpose: Visit/leisure	6	20	25	7	7
	Alone	69	69	73	72	62
	With children	17	24	10	12	23
	Mobility restrictions	24	28	14	24	28
	Dark	3	4	5	3	1
Location	Near road (<100 m)	41	76	30	40	21
	Near crossing (<200 m)	56	70	52	66	39
	Affected by problems on own road	25	43	18	15	28

Note: Mobility restriction: using a walking aid, pushing a pram, or carrying heavy luggage.

Table 2
Attributes and levels.

Attribute	Segment	Levels
Number of lanes	London	2; 3 (each direction)
	Not London	1; 2 (each direction)
Central reservation (median strip)		Not Present; Present (with no guard railings)
Traffic density		Low; Medium; High
Traffic speed		0; 10; 20; 30; 40 miles per hour
Saving	Public transport fare	from 20p to £2, in 20p increments
	Shopping bill	from 40p to £4, in 40p increments

below the existing number of lanes in each road (3 in the London case studies and 2 in the non-London case studies). Options with more lanes than the existing ones were not shown as this could raise concerns not related with crossing the road, such as loss of kerb space and demolitions.

The scenarios were described with images, designed based on the feedback from the participants in the preliminary qualitative study. Fig. 2 shows an example of one of the questions, where the road in Option A has two lanes for motorised traffic in each direction, a central reservation, low traffic density, and 20mph speed, and participants can save 80 pence if they cross the road to use a bus stop on the other side.

The survey also included a series of background questions:

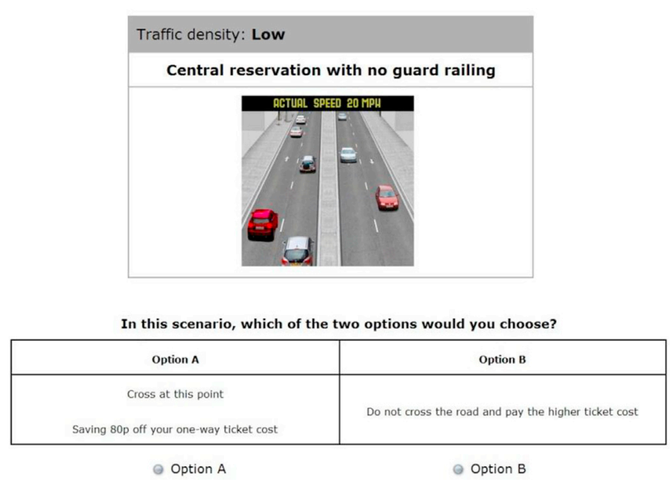

Fig. 2. Example of question.

- Characteristics of participants: gender, age, household composition, housing tenure, length of residency in the same address and area, number of cars in the household, employment status, qualifications, and income.
- Frequency of crossing the main road in the local area and characteristics of the most recent walking trip: trip purpose, time of day, mobility restrictions (using a wheelchair or a walking aid, pushing a

pram or buggy, or carrying large luggage) and whether the participant was accompanied with children or other adults.

Spatial variables were calculated using a geographic information system to measure characteristics of the residence location such as walking distance to the road and to the nearest crossing facility (signalised crossing, footbridge, or underpass). Variables were also imported from a separate questionnaire answered by the same participants focusing on health, disabilities, and perceptions about local traffic other neighbourhood characteristics.

5. Trading behaviour

5.1. Extent of non-trading behaviour and strategies to address the issue

Non-trading behaviour is an issue affecting the validity of stated preference surveys, as many studies find that participants consistently chose the same options, regardless of the levels of the attributes presented. Non-trading may reflect extreme preferences, but it can also be explained by strategic behaviour (participants hiding their true preferences), misunderstanding of the exercise, or fatigue (Hess et al., 2008).

Analysis of the choices in the first three case studies revealed a high incidence of non-trading behaviour (Table 3). 45% of participants in Seven Sisters Road, 28% in Finchley Road, and 48% in Southend never chose to cross in any question. This issue was particularly prevalent in the shopping bill segment. On the other hand, 4% of participants in Seven Sisters Road, 18% in Finchley Road, and 17% in Southend chose to cross the road in all questions.

This issue was initially addressed by increasing the range of values of the savings after the first survey in London Seven Sisters Road, from a maximum of £1.6 to a maximum of £2 (and £4 for the shopping bill segment). The experimental design was also changed so that all participants were presented with the scenario with the most benign road and traffic conditions: 1 or 2 lanes (depending on the site), central reservation, low traffic density, and speed lower than 30mph. These two approaches had little effect in terms of the proportion of participants who never cross the road in the London Finchley Road and Southend surveys.

A third approach was adopted in the Birmingham survey, by including two filter questions before the stated preference exercise, in order to identify two groups of non-traders.

- **First filter question**: Worst road and traffic conditions (2 traffic lanes in each direction, no central reservation, high traffic density and 20mph speed) and minimum saving (20p for the public transport segment and 40p for the shopping segment). Participants choosing to cross were then identified as those who always cross the road regardless of the value of saving and the characteristics of road and traffic.
- **Second filter question**: Best road and traffic conditions (1 traffic lane, with central reservation, low traffic density, and 10mph speed) and maximum saving (£2 for the public transport segment and £4 for the shopping segment). Participants choosing not to cross were identified as those who never cross the road.

As shown in Table 3, 20% of participants in the Birmingham survey chose not to cross the road in the best scenario (and so were classified in the group who never cross) and 15% chose to cross the road in the worst scenario (and were classified in the group who always cross). These proportions were again higher in the shopping bill segment. The two groups of non-traders then answered a contingent valuation exercise (see Section 6.4), instead of the stated preference exercise. The answers of traders to the two filter questions were added to the Birmingham dataset in the stated preference exercise.

Table 3
Non-trading behaviour (%).

	All		Shopping bill segment		Public transport segment	
	Never cross	Always cross	Never cross	Always cross	Never cross	Always cross
All	35	13	38	14	33	13
Identified in the exercise						
London (Seven Sisters Road)	45	4	71	0	37	5
London (Finchley Road)	28	18	40	13	23	20
Southend	48	17	51	17	41	17
Identified in filter questions						
Birmingham	20	15	23	18	10	3

5.2. Explaining trading behaviour

Table 4 shows the results of logit models explaining the probabilities of never and always choosing to cross the road. The explanatory variables are the characteristics of the participants, their most recent walking trips, and their residence location. The classifications of the age variable and the distance thresholds defining proximity to roads and crossings are the ones that yielded most significant coefficients, among the different alternatives tested. Interactions between explanatory variables (for example, age and gender) were also tested but were not statistically significant.

Table 4
Model of the probability of being a non-trader.

	Never cross		Always cross	
	coefficient	std. error	coefficient	std. error
Constant	−2.52	0.43***	−2.22	0.46***
Characteristics of participants				
Female	0.94	0.27***	−0.55	0.33*
Age>65	0.71	0.35**	−1.09	0.53**
Disability affecting walking	1.08	0.37***	–	–
No-car household	−0.79	0.27***	–	–
Qualification: degree or higher	–	–	−1.26	0.42***
Characteristics of walking trips				
Cross own main road most days	–	–	0.74	0.36**
Cross own main road less than once a week	–	–	1.04	0.56*
Last walking trip: alone	−0.58	0.33*	1.11	0.41***
Last walking trip: restricted mobility	0.96	0.35***	–	–
Last walking trip: dark	–	–	1.54	0.74**
Location				
London Seven Sisters Road	1.38	0.41***	−1.43	0.66**
London Finchley Road: west of road	1.24	0.39***	–	–
London Finchley Road: east of road	–	–	0.84	0.50*
Southend: west of road	2.49	0.59***	–	–
Southend: east of road	1.72	0.37***	–	–
Near road (<100 m)	−0.64	0.36*	–	–
Near pedestrian crossing (<200 m)	0.85	0.33**	–	–
Affected by problems on own main road	0.69	0.29**	−1.15	0.51**
N	395		383	
No-coefficients log-likelihood	−250		−152	
Log-likelihood	−199		−128	
Pseudo R^2	0.20		0.16	

Notes: Logit model. Significance levels: ***1%, **5%, *10%.

As expected, the probability of **never choosing to cross** the road is higher for participants aged above 65 and individuals with a disability affecting walking or who had a mobility restriction in their last walking trip. The probability is also higher for women, individuals in households with private vehicles, participants who reported being affected by problems in their own road, those not living very close to the main road, those living near a pedestrian crossing facility, and those who were not alone in their most recent walking trip. The need to cross the road is also relevant, as the probability of never choosing to cross is higher in the Seven Sisters Road and Southend case study areas and in the west side of the Finchley Road area. As mentioned in Section 3, the Seven Sisters Road and Queensway in Southend are mostly residential, with few destinations for pedestrians and the large majority of destinations in Finchley Road are located on the west side of the road. The higher coefficient for residents in the west side of the Southend area, comparing with the east side, reflects the fact that the city centre is located on the west side of the road. However, the positive coefficient obtained for both sides of the road in Southend may also be related to the presence of physical barriers preventing informal crossing along most of Queensway.

The probability of **always choosing to cross** is higher for men, participants younger than 65, and those without university degrees. The probability is also higher both for participants who cross their own main road most days and those who cross rarely (less than once a week), and for those who walked alone or after dark in their most recent trip. The results are consistent with those obtained in the preliminary qualitative study, as participants consistently mentioned that they are more likely to cross the roads in places without crossing facilities if they were alone. The higher probability of crossing after dark might also be explained by the lower traffic flows at that time. Only three variables related to residence location were significant. The probability of always choosing to cross is higher for participants not affected by problems in their own road and who live in the east side of the Finchley Road case study and not in the Seven Sisters Road case study. As in the previous model, this last result might reflect different levels of need to cross the road.

Overall, the significance of spatial variables in both models suggests that many participants tend to approach the survey not as an abstract exercise but in relation to the conditions in their immediate vicinity. In addition, employment status and purpose of last walking trip were not significant in any of the two models. This is probably because the impact of these variables is captured by the dummy variables representing the different case study areas.

Non-trading behaviour could also be related to the degree to which participants understood the survey. All but one participant stated they were able to make comparisons and 97% thought the scenarios presented were realistic (not shown in the table). Interviewers' feedback also revealed that 95% of participants understood the questions, 91% gave the questions consideration, and 92% maintained concentration throughout the survey. The proportion of non-traders in the group of participants who did not understand or gave consideration to questions, or did not maintain concentration is higher (57%) than in the whole sample (48%). However, a dummy variable identifying that group was not significant in the models explaining the probabilities of never and always choosing to cross the road.

6. Choice modelling and trade-off values

6.1. Model specification

The choices were analysed using discrete choice models. The data was reshaped so that each record captured the choice regarding each of the two options presented in each of the questions answered by each participant. This procedure generated a dataset with 6212 records. The dependent variable is a dummy variable where 1 represents the case where the participant chose that option. The explanatory variables are the value of the saving, dummy variables for attribute levels (equal to 1 when an option included those levels), a dummy for the option of not crossing the road, and interaction terms between the variables above and dummy variables for the characteristics of participants and their walking trips. The omitted attribute levels are the ones representing the most benign conditions for pedestrians: one lane in each direction, central reservation, low traffic density, and traffic speed lower than 30 mph. The expectation is that the saving amount has a positive coefficient and that variables representing conditions other than the most benign ones have a negative coefficient.

A mixed logit specification was used (Revelt and Train, 1998). In this model, the coefficients of the variables representing the attributes were assumed to be random, with the utility of an option depending on the attribute levels. The cost saving variable and the interactions were assumed to be fixed. The model can be specified as

$$Y_{i,j} = \begin{cases} 1 & if \quad U_{i,j} \geq U_{i,k}, \quad \forall k \neq i \\ 0 & \qquad otherwise \end{cases} \tag{2}$$

$$U_{i,j} = \beta_i x_{i,j} + \varepsilon_{i,j} \tag{3}$$

where $Y_{i,j}$ is the observed choice made by individual i regarding alternative j, $U_{i,j}$ is the utility of that alternative, k are the other alternatives, $x_{i,j}$ is a vector measuring the attributes of alternative j, β_i is a vector of random parameters, and $\varepsilon_{i,j}$ is an error term that follows the Extreme Value Type I distribution. The probability that individual i chooses alternative j is

$$P_{i,j} = \int L_{i,j}(\beta) f(\beta) d\beta \tag{4}$$

where $L_{i,j}$ is the probability of choice for a value of β, defined as

$$L_{i,j}(\beta) = \frac{\exp(\beta_i x_{i,j})}{\sum_k \exp(\beta_i x_{i,k})} \tag{5}$$

Alternative variable specifications were tested using different combinations of traffic speed values, and using traffic speed as a numerical variable, but they produced poorer models in terms of goodness of fit and variable significance. Non-linearities in the saving variable and interactions between attributes (for example, high traffic densities or speeds in roads with 3 lanes) were also tested but were insignificant.

Four models were estimated. Models 1 and 2 (unsegmented analysis) do not include the interaction terms. Models 3 and 4 (segmented analysis) include all variables. Models 1 and 3 use the whole sample, excluding the participants in the Birmingham survey who were identified as non-traders in the filter questions and did not answer the stated preference exercise. Models 2 and 4 include only traders, that is, exclude participants who chose the same option in all questions in the London and Southend surveys and the non-traders identified in the filter questions in the Birmingham survey.

6.2. Model results

Table 5 shows the estimated models. As expected, the coefficient of the saving variable is significant and positive in all models, which means that participants prefer higher, rather than lower, savings. The coefficients of the road and traffic conditions are significant and also have the expected sign (negative). This shows that participants prefer to avoid crossing roads with more than one lane, no central reservation, medium or high traffic density, and speed equal or above 30mph, comparing with roads with one lane, with central reservation, low traffic density, and speed lower than 30 mph. The coefficient of the “don't cross” variable is positive in the models with all participants and negative in the models with only the traders. This reflects the fact that the majority of non-traders are those who always choose not to cross, so removing them from the model decreases the propensity for the “don't cross” option to be chosen in any given question by any participant. Most of the coefficients of the standard deviations of the coefficients are significant, confirming that there are relevant variations in preferences within the sample.

Table 5
Model of choices.

	Not segmented				Segmented			
	Model 1 (All)		Model 2 (Traders)		Model 3 (All)		Model 4 (Traders)	
	coeff.	s.e.	coeff.	s.e.	coeff.	s.e.	coeff.	s.e.
MEAN								
Attributes								
Saving	1.53	0.15***	1.39	0.15***	1.61	0.18***	1.34	0.16***
2 lanes (not London)	−1.53	0.22***	−1.67	0.26***	−1.12	0.42***	−0.91	0.32***
3 lanes (London)	−1.95	0.22***	−2.05	0.28***	−2.67	0.35***	−2.16	0.28***
No reservation	−1.65	0.18***	−1.80	0.20***	−1.97	0.22***	−1.90	0.20***
Density = medium	−1.17	0.19***	−1.08	0.20***	−1.28	0.22***	−1.17	0.20***
Density = high	−2.81	0.31***	−2.75	0.33***	−2.16	0.42***	−2.50	0.33***
Speed ≥ 30	−0.69	0.19***	−0.67	0.20***	−0.46	0.23**	−0.47	0.20**
Don't cross (Option B)	0.69	0.31**	−0.98	0.26***	0.20	0.65	−0.67	0.30**
Interactions								
Saving								
Age<25					0.77	0.37**	1.15	0.31***
Cross own main road less than once/week					−0.62	0.35*	−0.91	0.33***
2 lanes (not London)								
Female					−1.46	0.53***	−1.45	0.44***
High traffic density								
Age:50-65					−1.03	0.56*		
Age>65					−1.77	0.76**	−2.01	0.76***
Cross most days					−1.02	0.49**		
Speed>=30								
Restricted mobility					−1.96	0.60***	−2.10	0.52***
Poor health					−1.86	1.05*	−1.56	0.86*
Don't cross (Option B)								
Age>65					1.27	0.59**	−0.80	0.41**
Male aged<35					−1.69	0.61***		
Qualifications: degree					1.01	0.47**		
Cross own main road most days					−0.94	0.42**	−0.48	0.26*
Restricted mobility					2.59	0.67***		
Walk with children					2.46	0.62***		
Purpose: shopping					−0.91	0.47*		
Southend (West)					2.61	0.84***		
STD. DEVIATION								
2 lanes (not London)	0.40	0.34	1.29	0.34***	0.89	0.39**	1.10	0.36***
3 lanes (London)	0.18	0.68	1.13	0.39***	2.09	0.43***	1.01	0.43**
No reservation	1.06	0.28***	1.24	0.27***	1.35	0.31***	1.09	0.27***
Density = medium	0.31	0.30	0.51	0.37	0.41	0.30	0.40	0.38
Density = high	1.89	0.33***	2.14	0.36***	2.22	0.31***	1.97	0.33***
Speed ≥ 30	0.83	0.28***	0.98	0.31***	1.11	0.39***	0.44	0.39
Don't cross (Option B)	4.07	0.31***	1.27	0.16***	4.04	0.33***	1.35	0.15***
N	6212		3728		5584		3566	
Groups	381		220		342		210	
No coefficients Log-Lik.	−2153		−1292		−2153		−1292	
Log likelihood	−1233		−923		−1082		−845	
Pseudo R^2	0.43		0.29		0.50		0.35	

Notes: Mixed logit model. Significance levels: ***1%, **5%, *10%.

The relative magnitude of the coefficients of the attributes is also consistent with prior expectations. The coefficients of high traffic density are larger in absolute value than the medium traffic density ones and the coefficients of 3-lane roads in the London case studies are larger in absolute value than the coefficients of 2-lane roads in the non-London case studies.

The full segmented models (model 3) show that women have a lower probability than men of choosing to cross roads with two lanes. The probability of crossing roads with high traffic density is lower for people who cross the main road in their local area most days, and decreases with age, as the coefficients for participants aged above 50 are negative and the one for participants over 65 is also negative and larger in absolute value than the ones for those aged 50 to 65. Participants who reported a poor health condition or who had mobility restrictions in their last walking trip have a lower probability of choosing to cross roads with high traffic speeds. Participants aged below 25 and who cross the road more often than once a week are more sensitive to the saving variable. There were no significant interactions with the central reservation, 3-lane, and medium traffic density attributes. Interactions with employment status, car ownership, trip purpose, and time of day of the last walking trip were also insignificant. The interaction of the saving with a dummy variable representing participants who answered questions with the shop scenarios (rather than the public transport scenarios) was also insignificant, suggesting that participants in both segments have the same sensitivity to the saving attribute.

As expected from the analysis of non-trading behaviour, the probability of choosing Option B (not crossing the road) is higher for: older people, individuals with a university degree, participants who had a mobility restriction or were with children in their last walking trip, and those in the west side of the Southend case study area (where there is a lower need to cross the road). The probability is lower for men below 35, people who cross the main road in their local area every day, and those who walked for shopping. In Model 4, the only significant interactions with the "don't cross" variable were those representing participants aged over 65 and those who cross the main road every day.

6.3. Value of interventions to reduce community severance

Table 6 shows the values of alternative interventions to reduce community severance, by changing road design and traffic characteristics. The values for the whole sample were obtained from Model 1, the values for traders were obtained from Model 2 and the values segmented by age and gender were obtained from Model 3. These values were calculated by taking the ratio between the coefficients of the dummy variable representing the characteristics of the road and traffic and the coefficient of the saving variable. The value of reducing traffic density from high to medium is the difference of the ratios between the high and medium traffic density coefficients and the saving coefficient. In the case of the age and gender segments, the coefficients of the relevant interactions were added to the main coefficients.

These values are valid for individuals with did not report a poor health condition, and who have qualifications lower than a university degree, cross the road 1-3 times a week, were not on a shopping trip, did not have mobility restrictions, and were not accompanied by children on their last walking trip, and do not live in the west side of the Southend case study area. Values for other participants can easily be derived from the model coefficients.

The intervention with the highest overall value is reducing the number of vehicle lanes from 3 to 2 (£1.28), followed by adding a central reservation or reducing traffic density from high to medium (£1.08), reducing the number of lanes from 2 to 1 (£1.00), reducing traffic density from medium to low (£0.76), and reducing traffic speed below 30mph (£0.45). The values for the group of traders are slightly higher than those for the whole sample.

The values vary with age and in the case of the reduction from 2 to 1 lane, also with gender. The values for the reduction from high to medium traffic density attribute are the most variable, ranging from £0.37 (in the case of males aged below 25) to £1.65 (in the case of males and females aged over 65).

6.4. Using contingent valuation to estimate willingness to pay of non-traders

A possible solution to the problems created by non-trading behaviour is to add a contingent valuation question to the survey. The participants identified as those who never cross the road in the Birmingham survey (after answering the filter question showing the best possible conditions) were asked to imagine that the local council had a scheme to remove the traffic from the road (by re-routing it or putting it underground), which would need to be partly funded by an increase in the local Council Tax.

Table 6
Values of interventions to reduce community severance (£ per person per trip).

	2 to 1 lane	3 to 2 lanes	Central reservation	Medium to low density	High to medium density	Speed below 30 mph
All						
Low	0.69	0.94	0.79	0.51	0.90	0.20
Central	1.00	1.28	1.08	0.76	1.08	0.45
High	1.31	1.62	1.37	1.02	1.26	0.70
Traders	1.21	1.48	1.30	0.78	1.20	0.48
Male						
<25	0.47	1.12	0.83	0.54	0.37	0.19
25–50	0.70	1.66	1.22	0.79	0.55	0.28
50–65	0.70	1.66	1.22	0.79	1.19	0.28
>65	0.70	1.66	1.22	0.79	1.65	0.28
Female						
<25	1.09	1.12	0.83	0.54	0.37	0.19
25–50	1.60	1.66	1.22	0.79	0.55	0.28
50–65	1.60	1.66	1.22	0.79	1.19	0.28
>65	1.60	1.66	1.22	0.79	1.65	0.28

Notes: Low and High values are the limits of the 95% confidence interval.

They were then asked how much extra tax they would be willing to pay each month to contribute to this scheme, starting with a value of £10 per month. Those who answered yes were then asked whether they would pay £20 and those who answered no were asked whether they would pay £5. A final question asked the maximum value they were prepared to pay.

Ten of the 23 participants with valid answers were not willing to contribute to the scheme. The willingness to contribute of the other 13 participants ranged from £1 to £40. The average value of the contribution was £8.90 (or £15.2 if excluding people not willing to contribute). Taking into account the participants' stated frequency of crossing the main road in their local area, then the average value per crossing is £0.48 (or £0.80 if excluding people not willing to contribute). These values are low, comparing with the value obtained using the stated preference exercise.

The large proportion of people not willing to contribute to projects that reduce severance can be explained as protest answers or strategic behaviour, as found in previous literature (Soguel, 1995). The differences between the values obtained using the two choice modelling and contingent valuation exercises also confirm issues usually found in stated preference models regarding different valuation methods, different types of value (willingness to accept or willingness to pay), and different payment vehicles (Pearce et al., 2006).

7. Reasons

Participants were asked the reasons for their choice after the first question of the stated preference exercise. These reasons were coded and counted. The charts in Fig. 3 show the proportion of participants mentioning each reason, split by choice in that question (cross and do not cross). The results suggest that the decision of crossing the road was to a large extent a trade-off between safety and saving money, as 65% of participants choosing to cross the road mentioned the value of the saving as a reason for their choice and 69% of those choosing not to cross mentioned danger (of collision with a vehicle).

The judgment on whether the crossing scenario presented was safe was in many cases done generically, without reference to particular characteristics of road and traffic. Only 6% and 4% of the participants who chose not to cross mentioned traffic density and speed, respectively. The number of traffic lanes and the existence of central reservation were not mentioned. In the case of choices for crossing the road, 13% of the participants identified the scenario as safe, the same proportion mentioning that the shown traffic density did not create a problem for crossing. Another 9% mentioned traffic speed and 2% mentioned the existence of a central reservation. The number of traffic lanes was not mentioned. A small minority of participants justified their choices with factors other than the attributes of the problem, such as habit, age, mobility restrictions, and concern with children.

Further insights into non-trading behaviour were obtained by asking the participants in the Birmingham survey for the reasons for their choices in the filter questions (not shown in the charts above). The main reason for crossing the road with the most adverse conditions was the saving (mentioned by 7 out of 15 valid answers to this question) and the main reasons for not crossing the road with the most benign conditions were safety (mentioned by 14 out of 17 valid answers to the question) and concern about children (mentioned by 10 people). The most frequent cited circumstance under which people in the "always cross" group would not cross was an increase in traffic speed (mentioned in 6 out of 13 answers).

8. Discussion and conclusions

This paper used a stated preference survey to assess the value of reductions in community severance caused by major roads. The survey included a choice exercise where participants could choose between crossing a road informally (away from crossing facilities) and pay a lower shopping bill or public transport fare, or avoid crossing and pay the current shopping bill or public transport fare. The analysis showed that

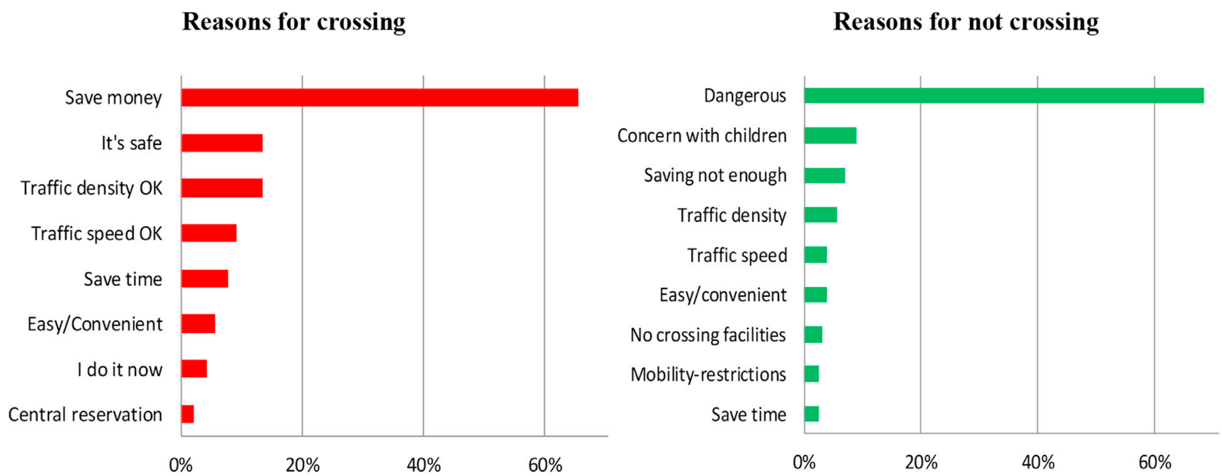

Fig. 3. Reasons for choices.
Notes: N = 142 (cross); 159 (don't cross). Charts show reasons mentioned in at least 1% of the answers. Proportions add to more than 100% because some participants mentioned more than one reason.

all interventions to reduce community severance have a positive value. However, the overall propensity to cross the road and the saving for which people would cross the road depend on personal characteristics such as age, gender, and factors limiting walking. The results confirm previous research that showed that older people, women, and people with mobility restrictions tend to be more vulnerable to losses in walking accessibility (Lucas and Jones, 2012) and emphasize the need to disaggregate analyses that estimate the values of the severance impacts in transport appraisal.

The methods used in the paper provide useful information for the inclusion of severance effects in the cost-benefit analysis for new roads, interventions to redesign existing roads (allocating more space to pedestrians by reducing the number of lanes for motorised traffic or adding a central reservation), and traffic policies (restricting traffic volumes or reducing speed limits).

The segmentation of values according to age and gender also provides input for the analysis of distributive issues arising from policy interventions. However, it should be noted that the analysis did not include income segmentations, as more than a third (34%) of respondents did not answer the survey question about income. This limits the use of weights, within cost-benefit analyses, to adjust the willingness to pay of low-income groups, which is usually lower than that of higher-income groups, due to a lower ability to pay.

The results were also obtained on a relatively small sample and in urban areas. The sample size limits the potential for segmenting the results according to the characteristics of pedestrians and walking trips, which may explain the inexistence of significant differences in the willingness to pay across different age groups for attributes other than traffic volumes, in our choice model. There are therefore some caveats in the application of the values in sites where the age composition of the population is considerably different from the one in our sample. Sample size also limits the information that can be derived from mixed logit models in terms of preference heterogeneity within the sample. In fact, in our analysis, the use of an alternative random-effects logit model specification (which assumes that coefficients are fixed across respondents) produced willingness-to-accept values that were broadly similar to those produced by a mixed logit specification.

The application of the values should also take into account the spatial context of the sites, especially the distribution of potential destinations for pedestrians across both sides of the road. The disutility of crossing the road is only relevant in cases where there is an actual need to cross. This issue was indirectly tackled in our models by testing the impact of dummy variables representing respondents living in areas with many potential destinations on their side of the road, and so with a lower need to cross the road. However, a full assessment of the importance of the need to cross the road requires a high degree of customization of the survey, relating the choice scenarios with the actual spatial context of each respondent, considering their residence location in relation to the road and to pedestrian destinations.

There are also more general questions about stated preference methods. The prevalence of non-trading behaviour and the low proportion of participants mentioning specific attributes of the road as reason for their choices in the main stated preference exercise also suggest that many people form a general perception of how safe it is to cross the road, not necessarily linked to the characteristics of road and traffic. One hypothesis is that individuals assess the safety of crossing the road considering the walking situation (for example, time of day and company). However, it is difficult to integrate these factors in stated preference experiments as separate attributes. Another hypothesis is that participants assess all the attributes as a whole, possibly ignoring some of the attributes shown, or considering attributes that are not shown. This may be due to limitations in using images, as it is difficult to represent attributes such as speed. Images also cannot capture aspects of exposure to traffic such as dust and noise.

Revealed preferences methods (modelling observed choices of pedestrians walking and crossing a road) could be used to validate the results of stated preference studies. For example, through the use of video surveys or pedestrian route tracking using mobile phone signals, and applications that allow for the observation of pedestrian choices. However, the main issue with this approach is to identify a real-world scenario where pedestrians could potentially trade-off crossing the road with a monetary cost.

More broadly, the valuation of community severance should be a component in a multidisciplinary assessment of the economic, social, health, and land use impacts of busy roads (Anciaes et al., 2016a; Mindell et al., 2017). The triangulation of the findings using different methods, both quantitative, and qualitative, validates the findings of individual methods, such as stated preference surveys, and provides a more holistic assessment of the impacts of busy roads on individual and community wellbeing, and of the benefits of policy interventions to reduce those impacts.

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