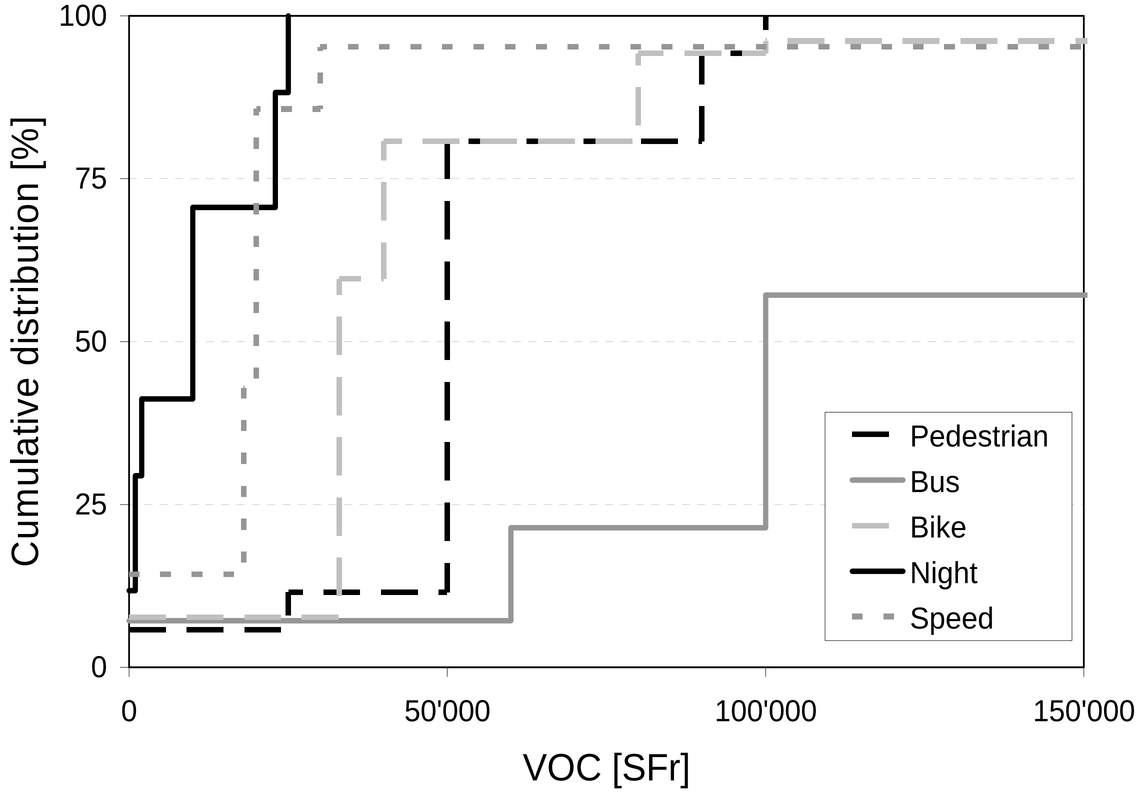
Valuation of a statistical live saved

Experimental results from the Ticino



Diploma thesis

Valuation of a statistical life saved:

Experimental results from the Ticino

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Table of content

List of tables

List of figures

List of abbreviations

VOL	value of a statistical life saved
VOC	value of a casualty avoided
WTP	willingness to pay
WTA	willingness to accept
SC	stated choice
SP	stated preferences
CV	contingent valuation
CA	conjoint analysis
PE	priority evaluator

Arbeitsbericht Verkehrs- und Raumplanung

Valuation of a statistical life saved: Experimental results from the Ticino

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Abstract

Safety, in particular traffic safety, is an issue very often only *implicitly* considered in many transport policies or projects. To enable an *explicit* evaluation of safety benefits related to a project or a policy, these benefits have to be expressed in monetary terms; in this way they can be introduced into cost-benefit analyses and weighted in the same way as all other costs and benefits. The problem now becomes: how to express these benefits in monetary terms? In the literature one solution proposed was to place an explicit value on the estimated reduction in fatality risk, known as *statistical value of life (VOL)*, representing the economic value associated with one life saved.

The thesis work will first approach the concept of VOL and then the discussion of the advantages and disadvantages concerning its use; subsequently different methods for its calculation will be introduced as well as some estimation procedures. The aim of this thesis, particularly, will be the application of two procedures from those described, the stated choice approach and the priority evaluator approach, with the aim of finding plausible estimates of the VOL.

The experimental part concerns the development of a survey for a sample of 500 people selected randomly in the canton of Ticino (Switzerland). The survey comprises three sections related to the different approaches employed, and a final person questionnaire. All steps concerning the realisation of the survey, the sampling, as well as the pilot survey, will be accurately described. The results of the returned surveys (179 out of 500, with a response rate of 36%) are then described and analysed. For the VOL evaluation, firstly a descriptive statistic is used, to determine the reference values by the means and medians of the responses. Then, a discrete choice model, specifically the Multinomial Logit model, will be applied within each approach to estimate the VOL. The results of the experiment, which show consistent values despite its limited size, demonstrate also that the estimated value of life can depend on many factors: the approach used, the variables and their values and the alternatives presented. A brief comparison with other studies in the literature involving empirical estimates of VOL will also be presented.

Key words

Value of life; Willingness to pay; Trade-off; Stated choice; Priority evaluator; Discrete choice model.

Estratto in lingua italiana

Nella seguente sezione sono descritti in lingua italiana i punti salienti sviluppati all'interno del lavoro di tesi. Dapprima verrà fatta un introduzione all'argomento trattato; successivamente sarà presentato l'esperimento e i principali risultati. Per eventuali approfondimenti si fa rimando alla versione integrale in lingua inglese.

1. Il valore statistico di una vita (VOL)

L’argomento centrale della tesi è la valutazione del valore statistico attribuito ad una vita salvata nell’ambito di incidenti stradali, o meglio, la disponibilità a pagare per ridurre il rischio di morire. Non si stima, di fatto, il valore che l’individuo attribuisce alla propria vita, che è sicuramente incalcolabile, ma il valore della cosiddetta vita statistica (Value of a statistical life VOL). Attraverso questa valutazione si vuole dare la possibilità di introdurre all’interno dei processi decisionali legati a politiche del traffico e dei trasporti e, nello specifico, all’interno di analisi costi/benefici legate a progetti mirati al miglioramento della sicurezza sulle strade, anche un fattore che permetta di misurare, esplicitamente, il beneficio dato dall’incremento della sicurezza. Al contrario dei costi, infatti, i benefici sono normalmente impliciti e non sempre direttamente misurabili. Rendere misurabile il beneficio legato ad un intervento per migliorare la sicurezza consente di ottenere una grandezza che permette di confrontarlo con altri costi e benefici e consente di dargli il giusto peso. Alcune obiezioni alla proposta di ricerca di un valore esplicito da associare ad una vita umana hanno come fondamento principale il fatto che darle un valore finito è estremamente difficile, se non impossibile. Di fatto, questo valore, viene associato implicitamente ogni volta che vengono fatte delle scelte legate direttamente o indirettamente alla sicurezza, sia a livello individuale che di istituzione o di governo. Nonostante le molteplici critiche, si è quindi deciso di considerare la proposta di stima del VOL come il sistema più adatto a misurare i benefici di interventi riguardanti la sicurezza. Per la sua stima è necessario trovare una misura che permetta di valutare le preferenze individuali in materia di sicurezza, ovvero, la disponibilità a pagare degli individui per ottenere un certo miglioramento del fattore sicurezza. La misura delle preferenze individuali maggiormente utilizzata nelle analisi costi/benefici, nel caso in cui si voglia analizzare il modo più efficiente per stanziare delle risorse limitate, è denominata ‘Disponibilità a pagare’(WTP) per un determinato miglioramento o per evitare di subire un danno o, in alternativa, ‘Disponibilità ad accettare’(WTA) una compensazione per tollerare il danno o il peggioramento subito. I metodi per rendere queste misure esplicite e per stimare in seguito il VOL sono vari e si distinguono per il tipo di informazioni che vengono reperite ed il modo in cui queste vengono raccolte.

2. Metodi per la stima del VOL

Alcuni tra gli approcci di valutazione utilizzati sono: il metodo delle preferenze rivelate (Revealed Preferences, RP), il metodo delle preferenze dichiarate (Stated Preferences, SP), il metodo di stima delle priorità (Priority Evaluator, PE). L'approccio delle *preferenze rivelate* ricava le preferenze dell'individuo da ciò che è osservabile sul mercato. Nel caso non esista un mercato per il bene considerato, viene osservato il comportamento degli individui in mercati in qualche modo collegati al bene considerato. I vantaggi di questo metodo consistono principalmente nell'affidabilità e nella validità dei dati raccolti, legati a preferenze reali degli individui, e secondariamente nel fatto che i risultati rappresentano la realtà del momento, il mercato e le restrizioni a cui gli individui sono soggetti. D'altra parte non è possibile analizzare le reazioni a realtà non ancora esistenti e, a causa della limitata flessibilità, questo metodo è adatto soltanto per previsioni a breve termine, che si differenziano moderatamente dallo stato attuale delle cose.

Il metodo delle *preferenze dichiarate*, SP, colma alcune lacune dell'approccio precedente. Si tratta di indagini tramite questionari sottoposti ad un campione di individui. A differenza delle preferenze rivelate, questo metodo può coprire un'ampia gamma di alternative non necessariamente esistenti e può raccogliere un numero più elevato di preferenze; grazie alla sua flessibilità viene inoltre utilizzato per previsioni più a lungo termine. Il metodo delle SP comprende diverse tecniche, di cui le principali sono Contingent valuation (CV) e Conjoint Analysis (CA). Nel CV agli intervistati viene chiesto di valutare direttamente un bene non di mercato o gli incrementi/decrementi di beni non di mercato, ricorrendo a 'mercati contingenti'. I punti deboli di questa tecnica sono principalmente dovuti alla possibilità di interpretare lo scenario proposto in modo errato o di rispondere in modo strategico o disonesto. Un' alternativa è proposta dalle Conjoint analyses, una classe di tecniche basate sull'idea che ogni bene può essere descritto attraverso i suoi attributi (variabili). Ogni alternativa presentata consiste infatti nella combinazione di due o più variabili relative al bene offerto. Agli intervistati viene richiesto di analizzare le combinazione di variabili e di scegliere, fare una classifica o dare dei valori alle alternative in base alla tecnica proposta (stated choice experiment, ranking or rating). I principali vantaggi sono legati al fatto che anche alternative al di fuori dall'esistente possono essere analizzate; inoltre, il numero delle informazioni che si possono ottenere rispetto alla precedente tecnica è molto più elevato.

Il terzo metodo, la *stima delle priorità*, si basa sulla simulazione delle scelte fatte nel mercato. All'intervistato vengono offerte alcune alternative, descritte attraverso diversi attributi, tra cui un costo; in base alla combinazione di alternative che vengono selezionate può essere analizzato quanto un attributo sia valutato più o meno di altri. Normalmente le alternative sono raggruppate secondo criteri quali il tipo di bene o di servizio offerto, l'effetto provocato sull'ambiente, ecc. La particolarità di questo metodo sta nella presenza di un ipotetico stanziamento da utilizzare nella scelta delle alternative; in questo modo, le scelte fatte non solo rappresentano come l'intervistato massimizza la propria utilità, ma rispecchiano anche il contesto reale del mercato, dove le risorse disponibili da investire sono normalmente limitate. Si conclude così l'introduzione teorica: rimandando per eventuali approfondimenti alla versione integrale della ricerca, si introduce di seguito la parte pratica.

3. L'esperimento

La sperimentazione ha interessato la ricerca del valore statistico attribuito ad una vita salvata (VOL) attraverso l'utilizzo di alcuni dei metodi citati. Sostanzialmente, è stata sviluppata una inchiesta, da condurre in alcune località del canton Ticino in Svizzera, strutturata in quattro parti: tre diversi approcci e un questionario finale. I risultati ottenuti sono stati quindi analizzati con lo scopo di ottenere, al termine, il valore statistico attribuito ad una vita salvata. Prima di mostrare i punti chiave che hanno caratterizzato la sua evoluzione, l'inchiesta verrà brevemente descritta nelle sue diverse parti. È importante notare che ognuna delle alternative presentate all'interno dei diversi approcci non è riferita ad alcuna situazione reale o ad alcun luogo. Si è infatti presa in considerazione, per ognuno degli approcci, un'immaginaria strada localizzata in città e lunga 5 km. Questa ipotesi, da un lato, dà la possibilità agli intervistati di fare le scelte non facendosi influenzare da un luogo familiare o da una particolare situazione; per contro, si è consci di aver fatto un'approssimazione della realtà, che porta alcuni valori delle variabili presentate a non essere sempre totalmente consistenti. Un esempio in versione originale dell'inchiesta è consultabile nell' Appendice A.

3.1 Test: miglioramento nel settore del traffico e dei trasporti

La prima parte dell'inchiesta consiste in un test in cui sono inclusi quattro ambiti di miglioramento legati al settore dei trasporti e del traffico (fermate e corsie degli autobus, sicurezza di notte, incrocio con scarsa visibilità, controllo della velocità). Ognuno di essi è rappresentato da cinque alternative, descritte attraverso i valori di quattro variabili – sicurezza, tempo di percorrenza, comfort e costo. Per ogni ambito è inclusa una sesta alternativa, che rappresenta la situazione attuale, cioè la possibilità di non fare nessuna modifica. L'inserimento di questo test, non conforme ai caratteri di alcuno dei metodi introdotti in precedenza, ha avuto lo scopo di mettere gli intervistati a contatto con gli ambiti proposti, la maggioranza dei quali viene reintrodotta nel PE test. In esso infatti, senza la restrizione dello stanziamento, l'attenzione dell'intervistato si dovrebbe spostare maggiormente verso i valori delle variabili e non solamente verso il loro costo.

3.2 Stima delle priorità

La seconda parte dell'inchiesta consiste nell'applicazione del metodo di stima delle priorità. Gli ambiti di miglioramento proposti sono: pedoni, agevolazioni per i ciclisti, controllo della velocità, fermate e corsie degli autobus e sicurezza di notte. Il fattore principale che differenzia il seguente test dal precedente è la presenza della restrizione di uno stanziamento, che può assumere tre diversi valori – 500,000-600,000-800,000 SFr. In questo caso, gli intervistati non possono solo calcolare il vantaggio legato ad ogni alternativa in base ai valori delle variabili associate, ma devono anche considerare la convenienza del suo costo e definire la combinazione più favorevole di alternative la cui somma dei costi non superi il valore dello stanziamento offerto.

3.3 Metodo delle Preferenze dichiarate (SP)

La tecnica SP utilizzata, tra quelle presentate, fa parte del gruppo delle 'conjoint analysis' ed è in particolare lo 'stated choice experiment'(SC): gli intervistati devono analizzare diverse combinazioni di attributi e fare una scelta tra due o più alternative. Nell'inchiesta sviluppata le alternative presentate sono due, ognuna delle quali è descritta da cinque variabili. In particolare, la prima alternativa rappresenta la possibilità di non fare nessun investimento per aumentare la sicurezza sulla strada immaginaria considerata, il che significa mantenere la situazione attuale. La seconda alternativa da la possibilità di fare un certo investimento. I valori che l'investimento può assumere sono: 500,000-800,000-1,000,000 SFr. Una particolarità di questo metodo rispetto ai precedenti sta nella definizione e nell'associazione dei valori con le variabili. Nei test precedenti ogni ambito comprendeva sei alternative e i valori delle variabili erano strettamente legati all'alternativa. In questo caso le alternative non cambiano e le variabili sono: no. vittime/anno in incidenti come autista o passeggero di auto e moto, no. vittime/anno in incidenti come ciclista, no. vittime/anno in incidenti come pedone, tempo di percorrenza della strada per automobilisti, % di automobili che superano i limiti di velocità. Riguardo ai valori che le variabili possono assumere, per la prima alternativa sono stati fissati, mentre per la seconda alternativa sono stati selezionati tra quattro livelli, definiti come una variazione dalla situazione presente. In realtà agli intervistati sono mostrati solo i valori assoluti, ottenuti come differenza tra la situazione presente e la variazione. Nella costruzione delle combinazioni utilizzata – detta 'factorial design' – tutti i possibili valori che una variabile può acquisire sono combinati con ogni possibile valore di tutte le altre variabili. Questo design normalmente è ortogonale; ciò significa che tutte le combinazioni di valori ottenute sono indipendenti le une dalle altre. Le suddette combinazioni sono state ottenute con l'aiuto del software SPSS. Tra queste combinazioni ne sono state selezionate 54, facendo attenzione che non fossero dominanti o dominate; sono state quindi create nove versioni, ognuna con sei diverse combinazioni. Una delle maggiori difficoltà trovate nell'approccio con questo metodo è stata la presenza di situazioni apparentemente illogiche. I valori delle variabili, infatti, non rappresentano sempre solo un miglioramento rispetto alla situazione attuale (prima alternativa) – in alcuni casi, per esempio, nell'alternativa con l'investimento aumenta il numero di vittime rispetto alla prima alternativa. Ciò permette da una parte di simulare meglio la realtà, dove investendo non necessariamente si può migliorare in tutti i campi, ma, d'altra parte, mette in difficoltà gli intervistati nella loro scelta.

3.4 Questionario

L'ultima parte dell'inchiesta consiste in un questionario con domande relative a caratteri socio-demografici degli intervistati. Per la struttura delle domande si è fatto riferimento a UNIVOX, un'inchiesta svolta annualmente in Svizzera con un campione di 5000 persone, riguardante le attitudini dei cittadini in diversi ambiti. Le domande presenti nell'inchiesta possono essere suddivise in cinque gruppi, secondo il contesto:

- domande relative all'intervistato: età, sesso, luogo di residenza, etc.;
- domande relative all'uso dell'automobile;
- domande relative all'uso dei mezzi pubblici;
- sensazione di sicurezza e incidenti avuti in diversi ambiti;
- reddito familiare.

Tutte le domande proposte sono a scelta multipla, una caratteristica che facilita sia gli intervistati che le successive analisi delle risposte.

4. Evoluzione dell'inchiesta

I punti chiave che caratterizzano l'evoluzione dell'inchiesta sono di seguito elencati e brevemente descritti:

- sviluppo dei tre approcci: creazione delle alternative e delle variabili associate. Sono state realizzate nove diverse versioni dell'inchiesta (capitolo 7.3. versione integrale);

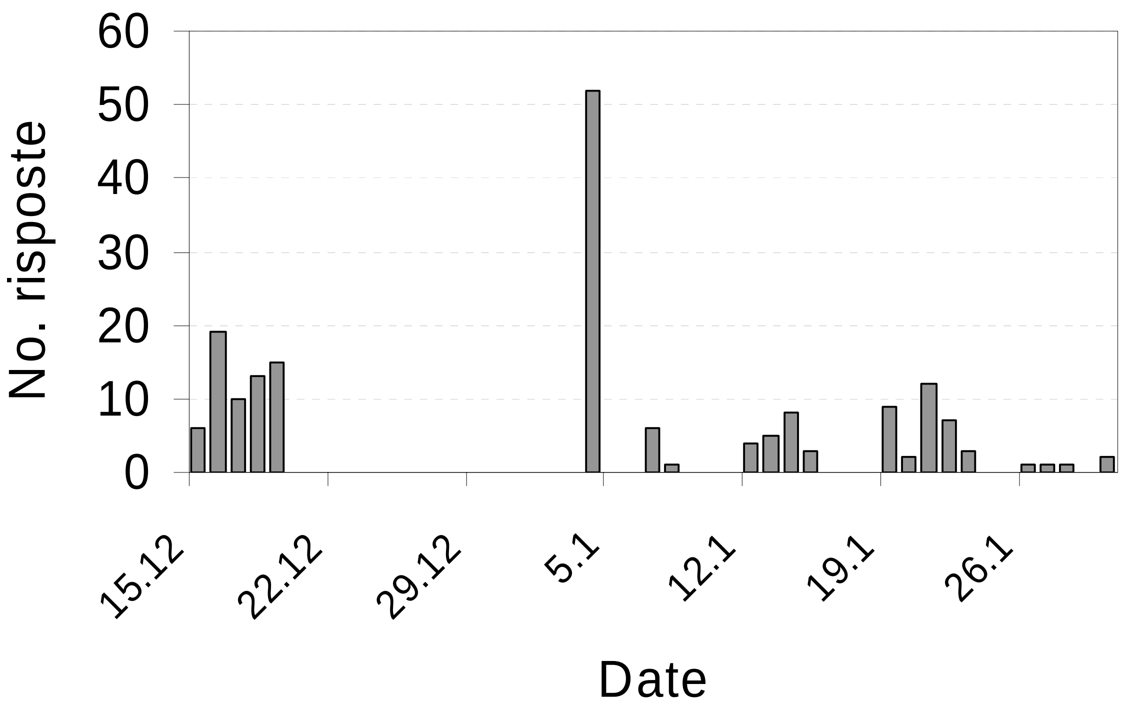
- pre-test: ultimata la prima versione dell'inchiesta, è stato svolto un pre-test con 23 persone di età diverse e di diversi contesti territoriali – non necessariamente il canton Ticino. Il pre-test è stato utile per cogliere eventuali lacune o problemi legati alla forma e al contenuto dell'inchiesta. In base ai suggerimenti ottenuti sono state fatte alcune modifiche e semplificazioni;

- scelta del campione e invio dell'inchiesta: un campione di 500 persone residenti in canton Ticino e precisamente nelle località di Lugano, Locarno, Bellinzona, Biasca e Airolo sono state selezionate in modo casuale dall'elenco telefonico dell'anno 2003. Le località sono state scelte poiché sono le maggiori località del Ticino (Lugano, Locarno e Bellinzona) o per la posizione strategica – sulla via di transito del traffico nord-sud attraverso il tunnel del San Gottardo – (Biasca e Airolo). La versione definitiva dell'inchiesta è stata quindi inviata il 5 Dicembre 2003 al campione selezionato via posta, includendo una busta affrancata per rispedire la risposta. Dopo l'invio c'è stato, con la maggioranza degli intervistati, un contatto telefonico per chiarire eventuali dubbi, dare maggiori informazioni e motivare ulteriormente a prendere parte all'inchiesta;

- risposta: il trend delle risposte ha avuto un andamento irregolare, principalmente a causa delle periodo natalizio molto vicino alla data dell'invio. Dalla Figura 1 è osservabile che le prime risposte sono arrivate 10 giorni dopo l'invio; la maggioranza è pervenuta all'inizio di gennaio e in particolare dopo una lettera di sollecito inviata a 120 persone selezionate dall'elenco iniziale. Le risposte pervenute in totale ammontano a 205, quelle valide a 179, pari al 36% del campione selezionato;

- codifica: i dati ottenuti sono stati codificati in SPSS, per mezzo del quale sono state svolte anche le prime analisi. La codificazione è avvenuta in modo tale da mantenere, per le variabili che assumono valori continui (p.e. l'anno di nascita, il numero di incidenti) il valore assunto; per le variabili in cui sono specificati più livelli tra cui l'intervistato deve scegliere, sono state create 'binary dummy variable' per ogni livello della variabile, le quali assumono valori 0 o 1;

Figura 1 Risposte ricevute



- analisi descrittiva: le prime analisi sono state fatte per cogliere sia i caratteri socio-demografici degli intervistati che le scelte fatte nei tre approcci proposti. Successivamente, prima di introdurre il modello per la stima del valore statistico di una vita salvata, è stata fatta un'analisi del VOL, ottenuto come rapporto tra costo dell'alternativa scelta e vittime evitate. Sono stati analizzati i valori medi e le mediane;

- sviluppo del modello per la stima del VOL: un modello per le scelte discrete – il modello LOGIT multinomiale – è stato creato per stimare, per mezzo dei risultati ottenuti, il valore statistico di una vita salvata;

- confronto con VOL ottenuti in altri studi: i VOL ottenuti sono stati paragonati a valori trovati in studi precedenti e opportune correzioni sono state applicate.

5. Analisi dei dati

5.1 Caratteristiche socio-demografiche

Dalla seguente analisi gli elementi più rilevanti che si possono ricavare riguardo gli intervistati sono i seguenti:

- la maggioranza degli intervistati che hanno preso parte all'inchiesta è di sesso maschile (68%) contro il 32% di sesso femminile e abita in una piccola città. Riguardo all'età degli intervistati, suddivisa in cinque classi di appartenenza, gli uomini sono distribuiti abbastanza regolarmente tra le diverse classi, mentre le donne si concentrano maggiormente nelle fasce più giovani;

- la maggioranza assoluta degli intervistati possiede un'automobile e l'ha sempre disponibile, indipendentemente dal luogo di residenza e dall'età. Una minoranza utilizza un'auto aziendale. Riguardo ai km fatti lo scorso anno in automobile, si riscontra che coloro che abitano in città ha fatto mediamente più km di coloro che abitano in paesi vicini alla città o in zone rurali;

- riguardo all'uso dei trasporti pubblici, gli intervistati che possiedono uno degli abbonamenti proposti sono principalmente coloro che non hanno un auto disponibile, e la maggioranza è rappresentata, sebbene in percentuali molto basse rispetto al totale, da coloro che abitano in città piuttosto che in paese. Le percentuali dei possessori di abbonamenti sono comunque molto basse per tutte le fasce di età rispetto al totale. È visibile infatti, anche dal numero di giorni della settimana in cui si è viaggiato in auto o con altri mezzi, che la media dei giorni in automobile è sempre molto più elevata di quella relativa ad ogni altro mezzo. Anche il reddito sembra influenzare leggermente il mezzo di trasporto utilizzato: chi ha un reddito più elevato tende ad utilizzare maggiormente l'auto di altri, sebbene l'auto rappresenti il mezzo principale in ogni caso;

- la maggioranza degli intervistati si sente abbastanza sicura dopo le 10 di sera nel proprio quartiere. Riguardo all'uso dei mezzi pubblici si rileva che una percentuale abbastanza rilevante non ne fa uso dopo le 10 di sera, ma non per motivi di sicurezza e indipendentemente dal luogo di residenza, dall'età o dal sesso;

- il reddito mensile della maggioranza degli intervistati varia tra 4,000 e 6,000 SFr se la persona che contribuisce è una, tra 6,000 e 8,000 SFr se le persone che contribuiscono sono due.

5.2 Analisi del VOL

Il VOL, sottinteso nelle scelte fatte dagli intervistati, rappresenta la WTP di una persona per una vita in più salvata. Per i primi due test è calcolato come:

VOL = Costo dell'alternativa scelta / Numero di vittime evitate (1)

Entrambi i fattori – costo e numero. di vittime evitate – sono legati all'alternativa scelta. Nello SC test il VOL è calcolato come:

VOL = Stanziamento / Numero di vittime evitate (2)

Il numero di vittime evitate in quest'ultimo test è calcolato, per ogni tipo di vittima – automobilista, motociclista, ciclista o pedone – come la differenza tra il numero di vittime nella situazione attuale e il numero di vittime con lo stanziamento. Il valore al denominatore del VOL rappresenta la somma dei tre tipi di vittime evitate. Nel caso in cui il denominatore è negativo o nullo e lo stanziamento maggiore di zero, il VOL si considera infinito. Per la rappresentazione grafica gli viene di fatto associato un valore maggiore rispetto a tutti gli altri. L'analisi dei primi due test è divisa in due sezioni: la prima raggruppa, per ogni esperimento, tutte le situazioni presentate – nessuno stanziamento e i tre diversi stanziamenti offerti (vedi Figura 2); la seconda raggruppa, per ogni situazione, tutti gli esperimenti. In entrambi i casi, i valori analizzati sono il VOL medio e la mediana. Tenendo conto che la media è particolarmente sensibile agli outliers (valori estremi), per il suo calcolo i VOL molto elevati sono stati esclusi. Per il calcolo della mediana, al contrario, tutti i valori sono stati inclusi. Nella Tabella 1 sono consultabili i valori di media e mediana riferiti a Figura 2.

Nel SC test, a causa della sua struttura, che non si differenzia per tipo di esperimento bensì per le situazioni – sono state create 54 diverse combinazioni di valori – tutte le 54 situazioni presentate sono analizzate contemporaneamente. In aggiunta sono stati però analizzati i casi in cui gli intervistati hanno negoziato o meno tra i valori delle variabili all'interno delle sei diverse situazioni ricevute, escludendo coloro che hanno fatto sempre la stessa scelta in tutte le situazioni ricevute – 28 intervistati su 150 test validi. È importante notare che, essendo inclusi nel termine 'vittima' non solo i morti, bensì anche i feriti gravi o leggeri, i valori calcolati nelle Equazioni 1 e 2 non rappresentano la WTP per una vita salvata, ma per una vittima evitata. I risultati verranno per questo motivo indicati come VOC (Value of a casualty avoided) e al termine verrà introdotto un opportuno fattore per ottenere il VOL.

Figura 2 'Fermate e corsie degli autobus lungo la strada' nelle diverse situazioni

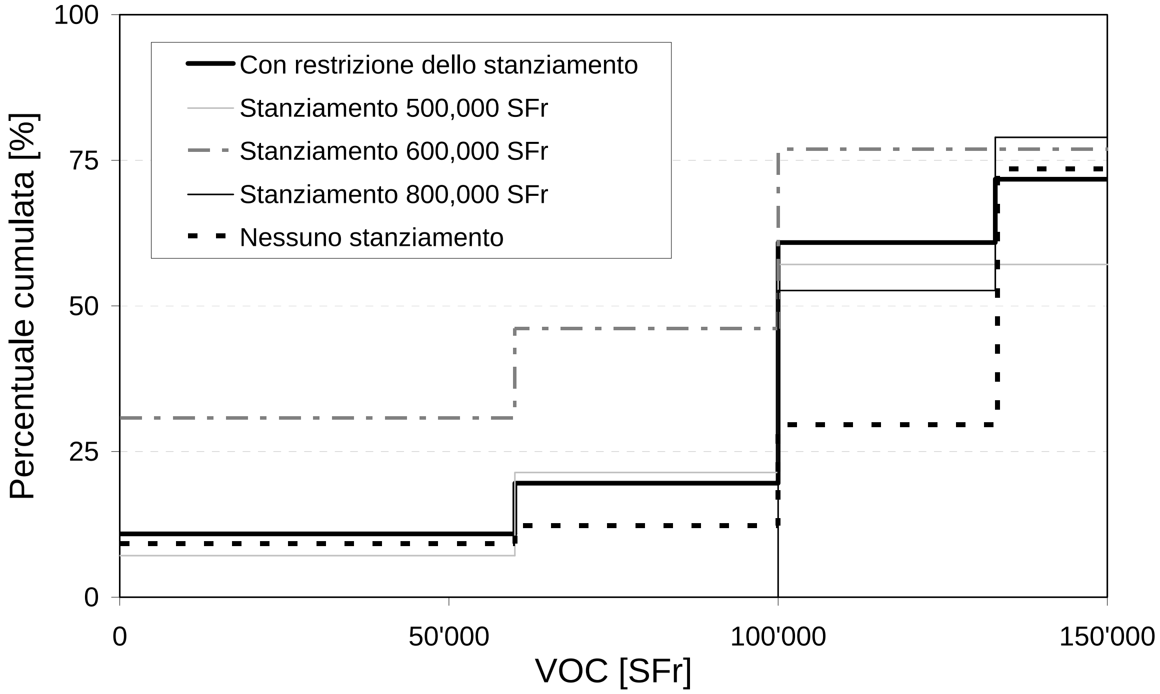


Tabella 1 Media e mediana in diverse situazioni

	Con restrizione stanziamento	Stanziamento 500,000 SFr	Stanziamento 600,000 SFr	Stanziamento 800,000 SFr	Nessuno stanziamento
N[1]	(33) 46	(8) 14	(10) 13	(15) 19	(72) 98
Media (SFr.)	85'051	77'500	52'000	111'111	105'741
Mediana (SFr.)	100'000	100'000	100'000	100'000	133'333

1 Numero di casi considerato per il calcolo di medie e mediane; i valori in parentesi rappresentano i numeri di casi ottenuti escludendo i valori più elevati.

6. Il modello

Il modello utilizzato, precisamente il modello logit multinominale, è un modello per le scelte discrete in cui il choice set è costituito da due o più alternative e si basa sulla probabilità di scelta, in funzione delle caratteristiche delle alternative e delle caratteristiche individuali. Uno dei presupposti per la costruzione di questo modello è l'ipotesi che le scelte dell'intervistato avvengano in base alle sue preferenze, ma soprattutto all'utilità legata ad ogni alternativa. L'utilità di un'alternativa, U_i, può essere espressa come la somma di una componente sistematica, V_i, e di una componente casuale ε_i. La componente sistematica è la parte che può essere osservata dall'analista, mentre la componente casuale racchiude i valori di variabili non osservate o di possibili errori di misura. La casualità all'interno della funzione utilità nasce dal fatto che l'analista non può osservare tutti i possibili fattori che influenzano le scelte degli individui, ma può soltanto arrivare a spiegare la probabilità delle loro scelte. Lo scopo di un modello per l'analisi delle scelte discrete è la stima dei fattori che influenzano la componente sistematica della funzione utilità. Questi fattori interagiscono tra di loro all'interno di una funzione lineare nei parametri e additiva. In queste funzioni possono esserci:

- *costanti*, che rappresentano l'influenza netta di tutte le caratteristiche o alternative non osservate;

- variabili *generiche*, che appaiono nelle funzioni utilità di ogni alternativa con uguali coefficienti;

- variabili *specifiche,* le quali variano da alternativa ad alternativa. Nel modello sviluppato tutte le variabili introdotte sono di tipo generico.

L'*approccio statistico* utilizzato per la stima dei parametri è la stima della massima verosimiglianza (MLE). Questo approccio permette di ottenere i valori dei parametri (θ) che massimizzano la funzione di verosimiglianza $L(\theta)$ per ogni possibile valore delle variabili. Il software utilizzato per questa stima è stato BIOGEME, un pacchetto realizzato per la stima col metodo della massima verosimiglianza di modelli per valori estremi generalizzati (GEV), di cui il modello utilizzato fa parte. I principali *output* della stima effettuata sono: le stime dei parametri, i valori del T-test relativi a questi ultimi ed i valori degli indici di adattamento (goodness-of-fit values), tra cui il valore finale della funzione di massima verosimiglianza e il Rho-square.

6.1 Definizione del modello e test dei parametri stimati

Per definire un modello logit multinomiale la procedura seguita è stata la seguente:

- definizione del set di valori da attribuire ad ogni variabile: nei primi due test i valori delle variabili sono strettamente legati alle alternative e agli esperimenti considerati. Nel terzo test ogni variabile può assumere quattro valori, escluso l'investimento che ne assume tre;

- definizione del set delle scelte disponibili per ogni individuo: nei primi due test ogni individuo riceve un set di tre esperimenti per il test senza investimento e tre per il PE test; nel SC test ogni individuo riceve sei situazioni, la cui combinazione di valori dipende dal numero della versione. Le versioni create sono nove e le combinazioni sono reperibili nel capitolo 7.3. della versione integrale;

- selezione delle variabili da inserire nella funzione utilità: le funzioni utilità definite hanno forme leggermente diverse a seconda del test considerato. Nei primi due test è stata associata una funzione utilità ad ogni alternativa, contenente, nella versione base, le variabili esplicitate nei singoli test. Nel SC test le funzioni utilità sono due, di cui la prima rappresenta la situazione attuale e la seconda la situazione con l'investimento. Un esempio di funzione utilità relativa ad un'alternativa nel primo test è la seguente:

$$U_1 = C*one + SICUREZZA*vittime1 + TEMPOdiPERCORR.*\ tempodipercorr1 + CONFORT * confort1 + COSTO * costo1 \qquad (3)$$

  I parametri e le relative variabili sono quelle presentate negli esperimenti e sono riferite in questo caso alla prima alternativa di ogni esperimento.

Definiti i diversi modelli ed eseguita le stime, i risultati possono essere esaminati attraverso una serie di test. Il *primo* consiste nell'analisi dei segni dei parametri ottenuti, per i quali normalmente c'è una certa aspettativa – per esempio, il coefficiente relativo alla sicurezza dovrebbe avere un segno positivo, in quanto l'utilità aumenta con la sicurezza e il costo un segno negativo, in quanto l'utilità diminuisce con il costo. Il *secondo* test è legato alla significatività statistica delle stime, verificata attraverso il valore del T-test. Se il valore assoluto del T-test è minore del valore critico 1.96 (per un livello di confidenza del 95%), la stima non è statisticamente significativa. La ragione per la non significatività può essere la presenza di valori estremi, la mancanza di dati, o il fatto che la variabile considerata potrebbe non influenzare la funzione utilità. Il *terzo* test riguarda l'analisi degli indici di adattamento del modello, particolarmente utile se vengono stimati più modelli e deve essere scelto quale sia il più rappresentativo.

7. Principali risultati e conclusioni

Lo scopo principale dell'analisi effettuata è la stima del VOL. Una stima mano a mano più accurata di questo valore è stata ottenuta inserendo nei modelli alcuni caratteri socio-demografici degli intervistati o raggruppando le alternative e gli esperimenti in classi. Attraverso i tre test dei parametri citati è stato possibile individuare, tra i modelli formulati, quelli più significativi, nonostante la combinazione di modelli possibili sia infinita. Sono stati quindi ottenuti i VOC facendo la seguente ipotesi, riferita al modello base del primo test, mostrato in Equazione 3:

$$SICUREZZA*vittime + COSTO*costo = 0 \quad (4)$$

SICUREZZA e COSTO sono i parametri stimati dal modello, *vittime* e *costo* sono le variabili corrispondenti. Per calcolare la disponibilità a pagare dell'individuo per una vita in più salvata è stato dato il valore uno alla variabile *vittime* e dall' Equazione 3 si è ricavata la variabile *costo*, quale WTP dell'individuo. Nel caso in cui siano stati introdotti altri fattori l'equazione mostrata risulta leggermente più complessa. Nei modelli relativi al PE test la variabile costo è stato inserita come rapporto tra costo e stanziamento offerto; di conseguenza il VOC calcolato nel PE test rappresenta la percentuale dello stanziamento che l'individuo è disposto ad investire per una vita in più salvata. I risultati ottenuti dal modello base per l'esperimento 'Fermate e corsie degli autobus' nel primo test sono mostrati in Tabella 2.

Nelle Tabelle 3 e 4 sono mostrati, per il primo test senza stanziamento e per il PE test, i VOL calcolati per le combinazioni di variabili risultate più significative. SC test purtroppo non ha prodotto risultati consistenti; di conseguenza i VOC relativi a questo test non sono stati riportati. Paragonando i risultati ottenuti con VOC stimati durante ricerche svolte nel passato si è rilevato che l'ordine di grandezza in questo esperimento è generalmente 10^5, mentre per gli altri è più elevato. Si è quindi ipotizzato, come introdotto in precedenza, che un problema all'interno dell'inchiesta sviluppata potrebbe essere stato nella definizione del termine 'vittima': nel significato del termine infatti non sono inclusi soltanto i morti, bensì anche i feriti gravi o leggeri. Il valore calcolato, dopo questa considerazione, non mostrerebbe quindi la disponibilità a pagare per un morto evitato, ma includerebbe anche i diversi tipi di feriti, portando ad una sottostima del valore ottenuto. Per ottenere la disponibilità a pagare esclusivamente per una vita salvata i VOC dovrebbero essere moltiplicati per un fattore F che permetta di esprimere le vittime solo in termini di morti. Questo fattore è stato calcolato considerando le statistiche degli incidenti in Svizzera nel 2003, classificati per tipo di vittima, e i costi sociali associati ad un incidente, sempre secondo il tipo di vittima. Il fattore F ottenuto, moltiplicato alla variabile 'vittime', permette di ottenere un valore con un ordine di grandezza maggiore, il quale si avvicina maggiormente ai valori ottenuti da ricerche precedenti.

Tabella 2 Esperimento 'Fermate e corsie degli autobus'- Modello base del primo test

Parametri		Valore	t-Test
COMFORT		-0.09540	-0.4489
COSTO		-0.00002	-1.8627
TEMPO DI PERCORRENZA		-1.32410	[2]**-2.9751**
SICUREZZA		3.83950	**2.3389**
Goodness-of-fit			
Numero di parametri stimati:	4		
Dimensione del campione:	95		
Null log-likelihood:	-170.217		
Final log-likelihood:	**-138.468**		
Likelihood ratio test:	63.4989		
Rho-square:	**0.1865**		
VOC (SFr/anno)		[3]181'595	

2 I valori del t-Test evidenziati in grassetto sono quelli significativi, quindi maggiori, in valore assoluto, del valore critico (1.96).

3 Valore ottenuto dalla risoluzione di Equazione (2) rispetto alla variabile *costo.*

Tabella 3 VOC più significativi dal primo test, senza stanziamento

VOL (SFr/anno)		<4000 SFr/mese	4000-8000 SFr/mese	>8000 SFr/mese
Piccole infrastrutture	Città	284'239	435'135	449'757
	Paese in zona rurale	**131'745**	282'642	297'263
Grandi infrastrutture	Città	624'731	775'627	**790'249**
	Paese in zona rurale	472'237	623'133	637'755

Tabella 4 VOC più signifivativi dal PE test

	Miglioramento nel servizio	Piccole infrastrutture	Grandi infrastrutture
VOC[4]	0.0029	0.0696	0.3309

Il risultato ottenuto con l'inclusione del fattore F, considerando per esempio i valori maggiore e minore in Tabella 3, sono i seguenti:

$$131{,}745 * 17.12 = 2{,}255{,}474 \text{ SFr} \quad (5)$$

$$790{,}249 * 17.12 = 13{,}529{,}062 \text{ SFr} \quad (6)$$

Per concludere, l'inchiesta e la stima del valore statistico attribuito ad una vita salvata, nonostante le dimensioni limitate dell'esperimento, hanno portato a risultati soddisfacenti. Deve essere comunque sempre considerato che la gamma dei VOL può essere molto vasta a causa di errori di misura, imprecisioni nelle risposte o semplicemente per il fatto che, lavorando con dati empirici, una percentuale di incertezza è sempre presente, essendo la realtà difficilmente uniformabile.

4 Questi valori rappresentano la percentuale dello stanziamento offerto che gli intervistati sono disposti ad investire per una vita in più salvata, suddivisi per tipo di intervento proposto. Il risultato mostra che la percentuale maggiore riguarda grandi infrastrutture, interventi nei quali gli intervistati sembrano voler investire quasi un terzo dello stanziamento disponibile.

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1. Introduction

The valuation of transport safety, looking at the annual number of road deaths and injuries, is a step of great importance within decision making processes related to transport projects and policy related to safety measures enhancement. Safety is not a free good and the society's resources are not limitless. When scarce resources have to be allocated efficiently and fairly among different projects, safety improvement measures related to each of them must be evaluated and weighted, *explicitly*, against all other costs and benefits (cost related to the traffic, damages costs, etc.). That will allow an informed decision for or against any proposed safety improvement: in particular, it will be judged whether or not the reduction in risk afforded by the improvement justifies its cost of provision. To make this comparison in the cost-benefit analysis possible, a monetary value should be associated with all costs and benefits of the safety improvement. The monetary value related to the *costs* of safety improvement measures can be calculated without great difficulty; however the relative *benefits* are not so straightforward to evaluate. Most of them in fact are non-monetary benefits and must therefore be transformed in monetary terms. But how are monetary values of safety defined and estimated? The method pondered in this thesis will consider the possibility of placing an explicit value on safety measures related to reduction in fatality risk, known as *statistical value of life* (VOL). Conscious of all the discrepancies in this method, stemming for example from the difficulty to trade-off between road safety and money, or the differences in perception of risk level, which make trading-off very difficult, it is in any case considered one of the more logical methods with this aim. It is also essential to be aware of the fact that, referring to the concept of *statistical value of life*, what will be evaluated is the change of risk rather than the valuation of the life of a specific individual. Since the monetary value of safety should reflect the preferences of those who are or will be affected by the decisions taken about the policy measures, this value will be expressed as the aggregate individual 'willingness to pay (WTP)' for safety improvements. The VOL will be calculated as the WTP for one victim avoided. The aim of this thesis will be the evaluation of the VOL for the experimental area of canton of Ticino, with the help of different estimation procedures.

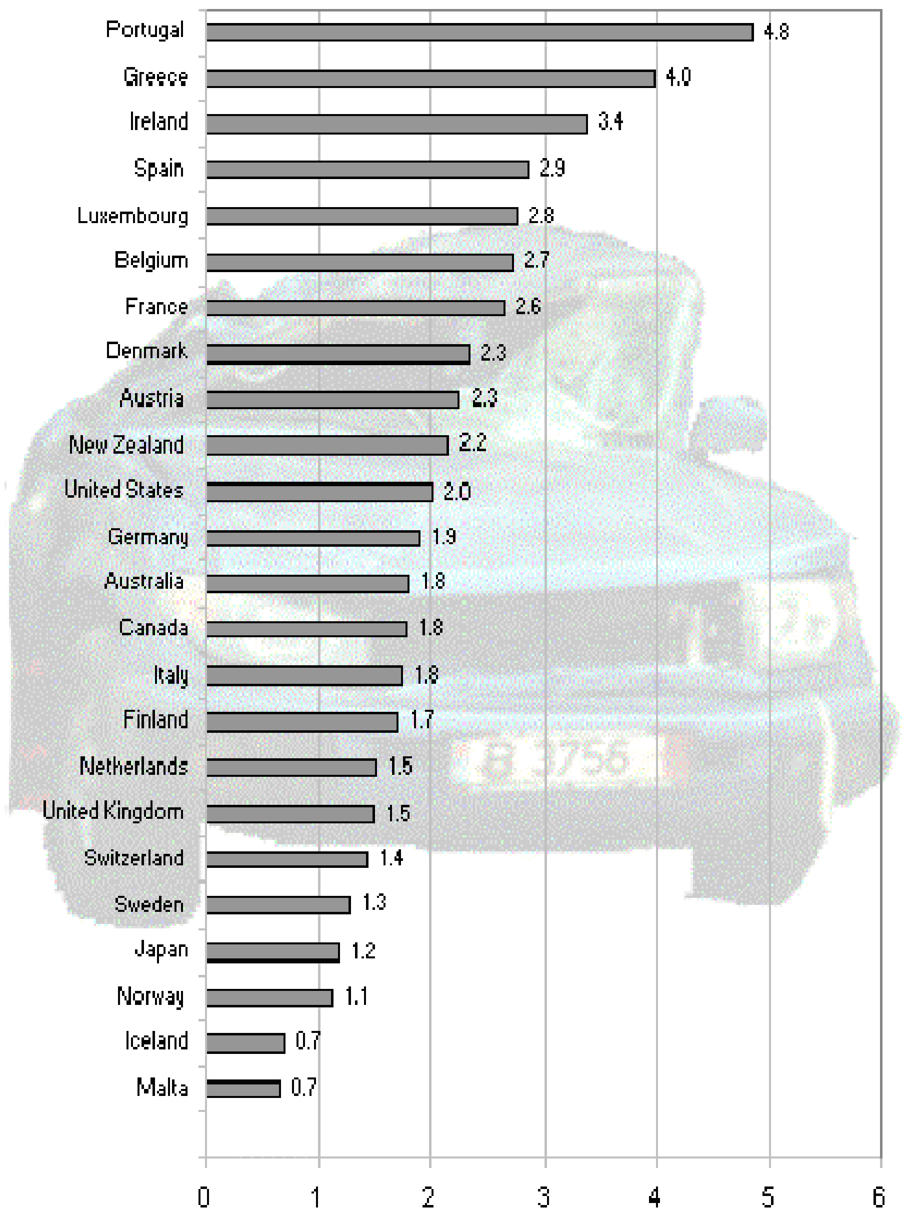
2. The problem of traffic safety

In recent years the growing importance of road accidents as a cause of death and injury has been identified. Recent studies relating to causes of death world-wide, such as ‘Global Burden of Disease’ (World Health Organisation, World Bank and Harvard University,1996) and the ‘World Health Report – Making a Difference’ (WHO, 1999) show that in 1990 road accidents as a cause of death or disability were the ninth most important cause out of a total of over 100 separately identified causes. However, by the year 2020 forecasts suggest that as a cause of death, road accidents will move up to sixth place.

In the highly motorised countries of Western Europe, USA, Canada and Japan, over the last years, the number of road accidents has decreased. These countries in fact, although they have the majority of the world’s vehicles (60%), account only for 14-15 per cent of the global fatalities. Most of them (see Figure 2.1) have fatality rates of about 2 per 100,000 residents, and even those of the poorest countries of the region, Portugal and Greece, whose rates are twice as high, are still low compared with the levels of other countries in the world (see Figure 2.2│Figure 2.5). This means that in many developed countries the *safety record has improved* over the past few decades, although the motorization of the population has almost doubled. This continued reduction in fatalities is due to the combined effect of many measures: road safety awareness campaigns, legislation (e.g. making the wearing of seatbelts compulsory), driver training, road engineering and higher safety standards for vehicles.

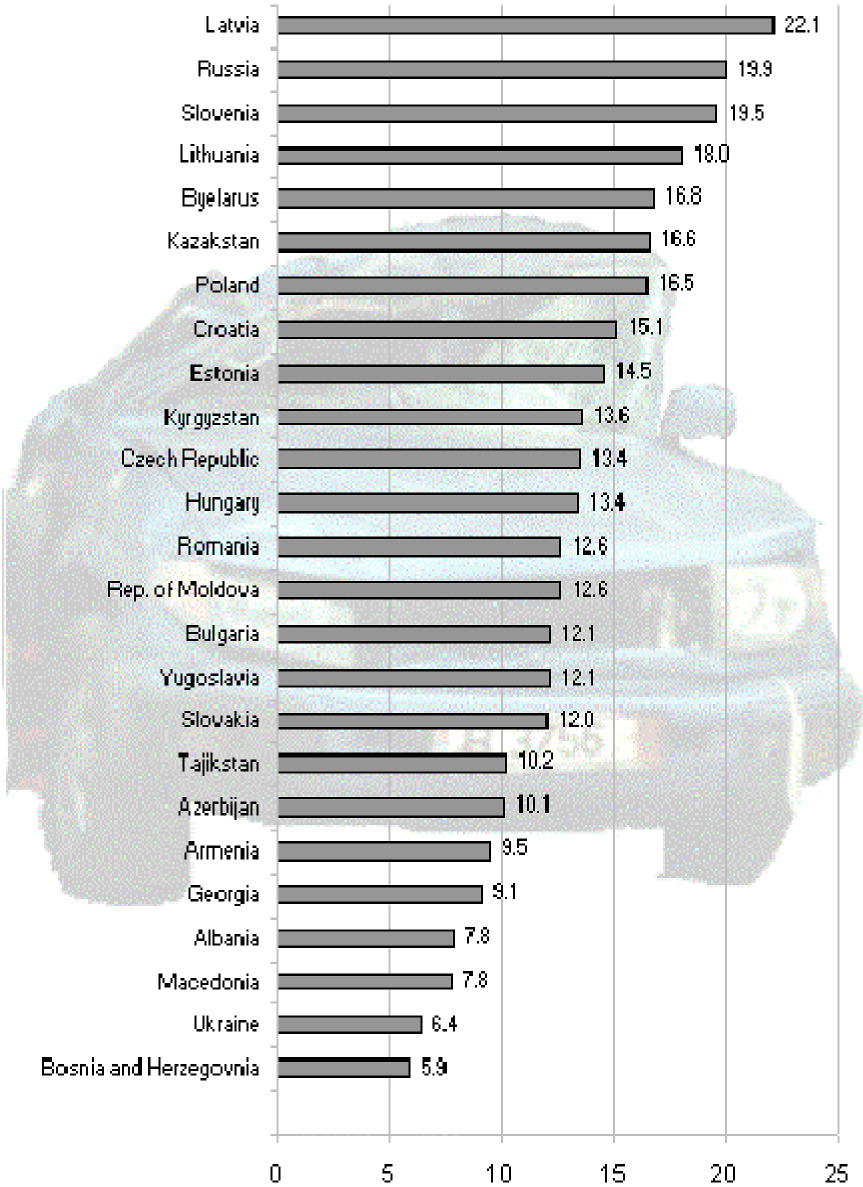
Whatever the reasons, this experience demonstrates that it is possible to reduce the number of road accidents through investment in road safety measures whilst the number of vehicles on the roads is increasing.

Figure 2.1 Fatality risk in Highly motorised countries per 100,000 population



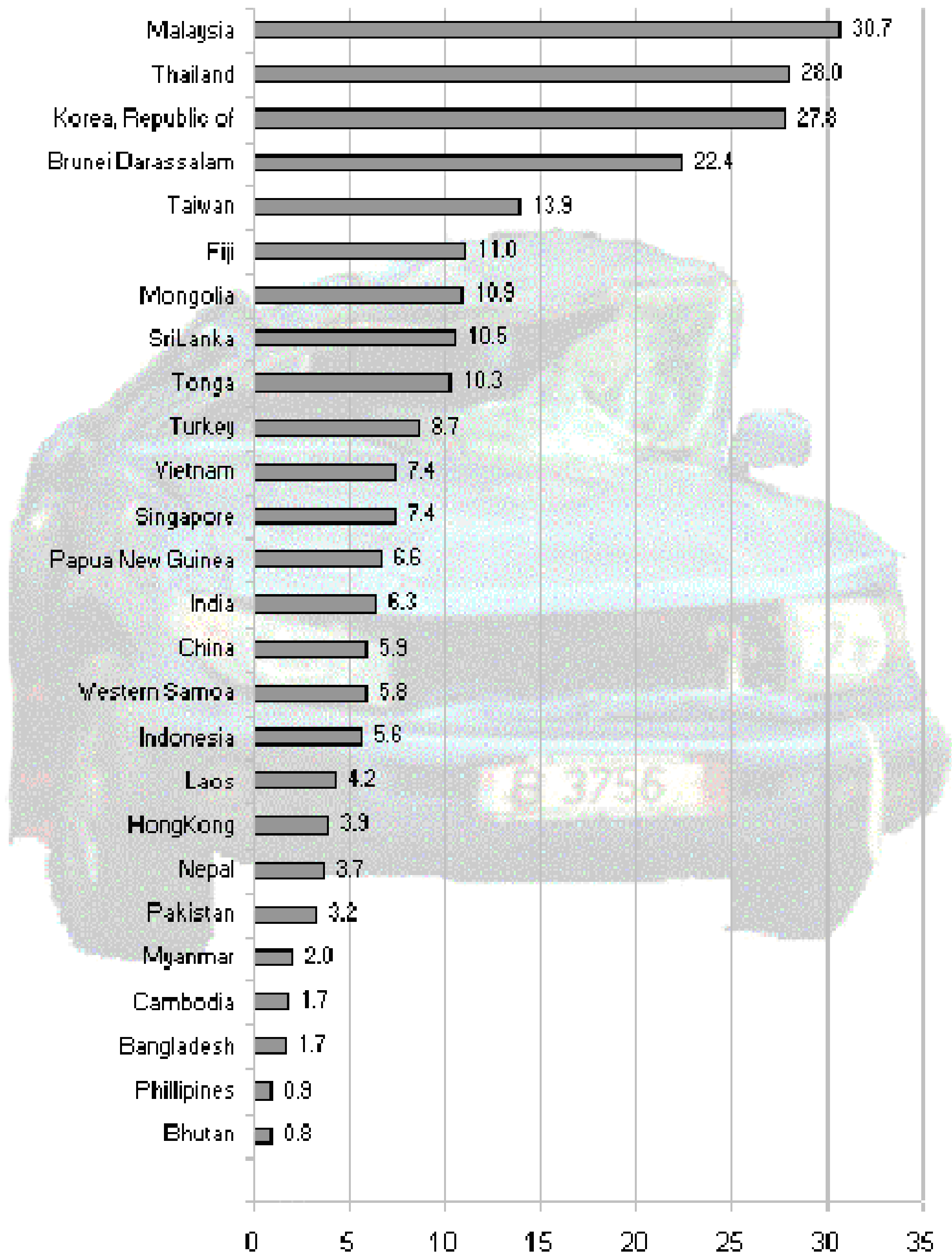
Source: www.factbook.net/EGRF Exec Summary.html

Figure 2.2 Central/Eastern Europe fatality risk in1996 per 100,000 population



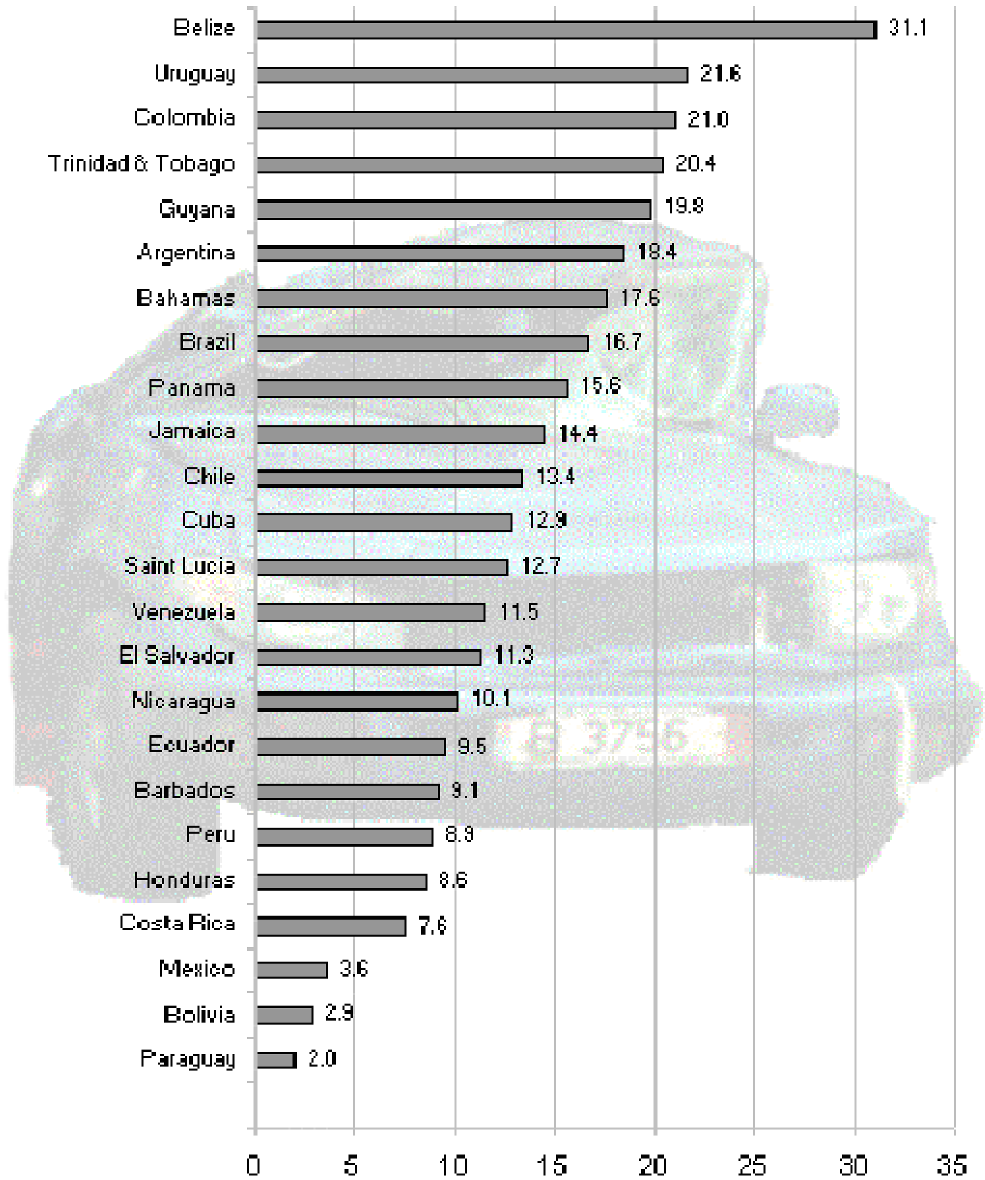
Source: www.factbook.net/EGRF_Exec_Summary.html

Figure 2.3 Asia/Pacific fatality risk in1996 per 100,000 population



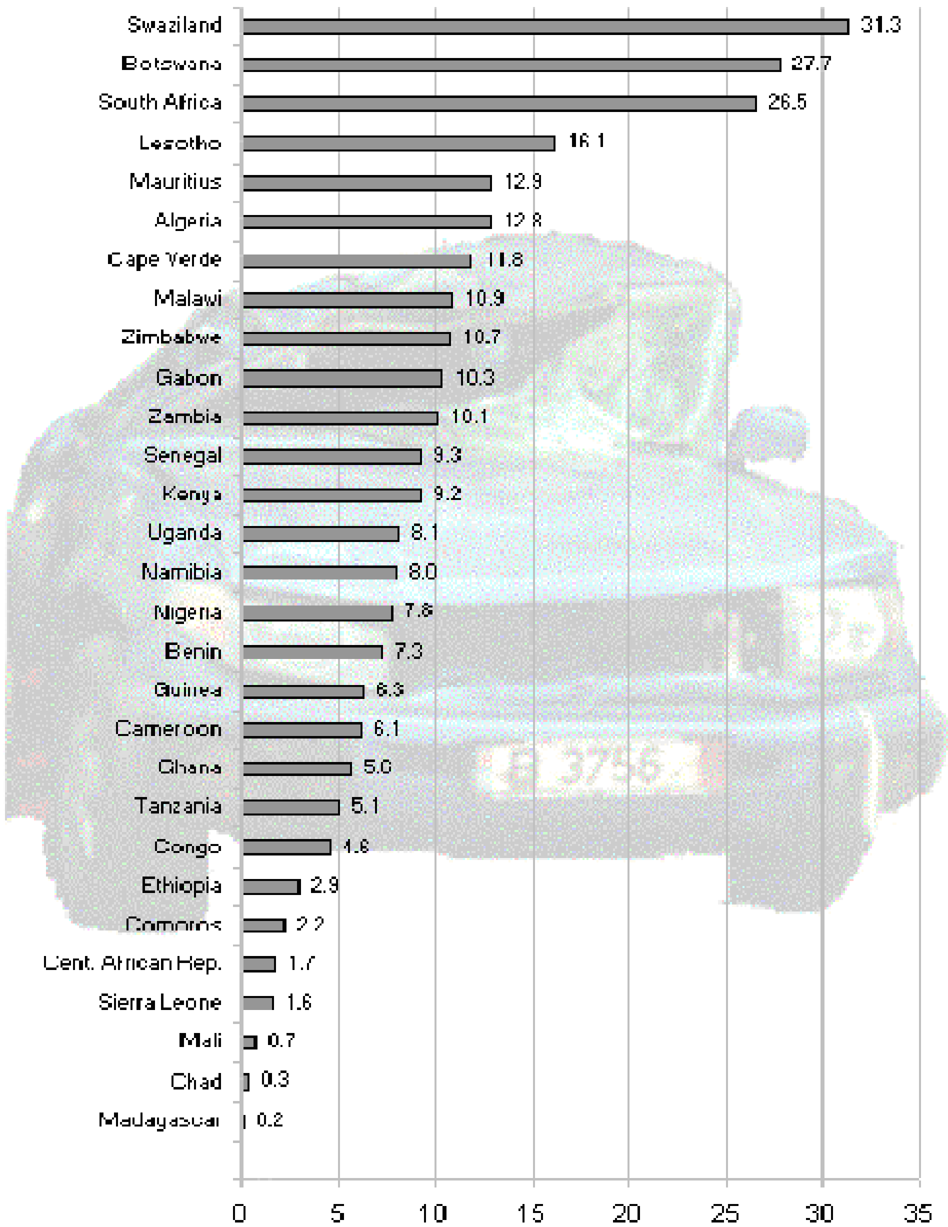
Source: www.factbook.net/EGRF Exec Summary.html

Figure 2.4 Latin/Central America and the Caribbean fatality risk in1996 per 100,000 population



Source: www.factbook.net/EGRF_Exec_Summary.html

Figure 2.5 Africa fatality risk in1996 per 100,000 population



Source: www.factbook.net/EGRF Exec Summary.html

In any case, just in Europe, about 40,000 fatalities are caused by in traffic accidents every year. In addition, the number of non-fatal accident amounts to several times this number. Accident rate is still too high, and the danger on the road as well, especially for vulnerable road users, such as pedestrians, cyclists and motorcyclists.

Concerning Switzerland, in Table 2.1, with data from UST statistics, the number of casualties in the all country from 1995 to 2002 is visible. More specifically for the area that will be considered throughout this thesis, the canton of Ticino, the data collected by the canton's police (see Table 2.2 and Table 2.3) show that in the year 2002, in Ticino alone, 2120 road users were *victims of a road accident* (2096 injured and 24 dead). The total number of *road accidents* was *7645*, of which 5608 (73%) were in the cities. As can be seen from Table 2.2, during the last seven years these values diminished by about 10%, but they are still too high to be acceptable, considering the size of the canton. Surely it must be accounted that in approximately 90% of incidents the individual road user is responsible; nevertheless the vehicle and the road also make a significant contribution to matters of security.

Table 2.1 Switzerland: road casualties, 1995-2002

Year	Total Injures	Fatalities
1995	28,759	692
1996	26,539	616
1997	27,286	587
1998	27,790	597
1999	29,527	583
2000	30,058	592
2001	30,160	544
2002	29,774	513

Source: Bfu 2003, USV T.02

Table 2.2 Ticino: Road accidents, 1995-2002

Year	Number of accidents	Property damages	Injures	Light injures	Serious injures	Fatalities
1995	8,537	6,860	1,642	1,252	390	35
1996	8,195	6,581	1,586	1,235	351	28
1997	8,465	6,860	1,577	1,209	368	28
1998	8,652	7,093	1,530	1,166	364	29
1999	8,649	7,059	1,545	1,223	322	45
2000	8,037	6,384	1,620	1,246	374	33
2001	7,910	6,281	1,602	1,205	397	27
2002	**7,645**	6,042	1,581	1,171	410	21

Source: Ticino cantonal police

Apart from the humanitarian aspect of reducing road deaths and injuries, there is also a question of reducing road incidents for *economic reasons*, as they consume an impressive amount of financial resources which countries can hardly afford to waste. In fact, hard decisions normally have to be taken on the (usually limited) resources that a country devote to road safety, to avoid under-investment in this sector. Some more data from Ticino police (see Table 2.4) show the expenses in SFr. which the canton sustained because of road accidents during the last years.

In order to assist this decision-making process it is very important to know or determine these costs and to provide a way to estimate, in monetary terms, the reduction in road fatality risk These two factors are needed: *first* at the level of national resource planning, to ensure that road safety is fairly ranked in terms of investment in its improvement; *secondly* to ensure that the best use is made of any investment and the best possible safety improvement, in terms of benefits it they will generate, are introduced.

Table 2.3 Ticino: Road casualties, 1995-2002

Year	Persons involved in accidents	Lightly injured	Seriously injured	Total injured	Dead	Victims[5]
1995	16,754	1,790	444	2,234	37	2,271
1996	15,976	1,751	396	2,147	29	2,176
1997	15,989	1,742	426	2,168	30	2,198
1998	16,006	1,646	402	2,048	36	2,084
1999	15,960	1,759	391	2,150	45	2,195
2000	15,045	1,782	402	2,184	34	2,218
2001	14,923	1,691	445	2,136	45	2,181
2002	14,405	1,645	451	**2,096**	**24**	**2,120**

Source: Ticino cantonal police

Table 2.4 Ticino: Expenses for road incidents

Year	Costs (SFr)
1995	33'330'000
1996	31'320'000
1997	27'900'000
1998	29'000'000
1999	27'510'000
2000	23'510'000
2001	38'050'000
2002	26'370'000

Source: Ticino cantonal police

5 Victims are injured or dead persons

3. The value of life for public decisions

This work aims to support the decision-making process by researching methods to enable the evaluation, in monetary terms, of improvements in road safety. Since the resources available to invest in safety measures in each country are limited, as already mentioned, it is important to achieve the maximum safety benefit for society by selecting which project to undertake and how much money to invest in different options. For an efficient allocation of resources it is therefore necessary that safety measures are weighted, and their monetary costs compared against the non-monetary benefits, such as reduction in fatal and non-fatal causalities.

But *how to compare the monetary costs of safety measures against these non-monetary benefits?*

To apply cost-benefit analysis in safety investment decisions, these non-monetary benefits – the benefits of lives saved – must be expressed in monetary terms. One solution is to place an *explicit value* on the estimated reduction in fatality risk, known as statistical value of life (VOL).

3.1 Objections

The first and biggest objection to the application of this evaluation is that searching for a numerical value of life can be seen as a nonsense, that is "being alive is infinitely more important than all else" or " Human life is infinitely valuable".

Additionally it seems impossible to make choices when one of the prospects involves one's own death, as "choice" and "preferences" have meaning only if one expects to experience the consequences of the choices. Moreover it is argued that people do not have sufficiently accurate preferences to make a trade-off between road safety and money; the perceptions of changes in risk are so small that making a trade-off is very difficult. In response, it is asserted that an *implicit* value is already placed on safety by individuals, institutions, government and society, in the choices they make every day. If this value is made *explicit*, is possible to better examine the assumptions used in the decision making project and to see the reasoning behind the decisions taken.

The second question is whether all lives should be evaluated equally. Furthermore, economic methodology is criticised as it does not possess the sophistication to deal with many aspects of value in a human life and in society like ours, concerned with much more then just getting the most lives saved for least money. These aspects are, for example, people's altruistic concern for others' well being, liberty, civil rights, the value of future generations, which should also be taken into consideration but can not be easily reflected in terms of monetary value. All these factors remain outside the monetary social balance sheet. Their existence, however, does not preclude the use of the VOL, but emphasises the fact that the VOL and cost-benefit analysis can only be used as a decision-aiding tool, not a substitute for policy analysis, which must also incorporate these other factors.

3.2 Alternatives proposed

There has been much discussion of these problems and some alternatives to monetary analysis have been proposed (Jones-Lee, 1993):

- ignore this kind of estimate, as there is not a way to evaluate the safety effect correctly and take all factors into consideration; that means to place the value of life at zero or infinity.

- use informal judgement or common sense to estimate the value of additional safety. In this case the choices may be inconsistent, inefficient or will not maximise the social good.

- set safety standards that all projects must meet, regardless of cost. In this case the allocation would often result in inefficient or oversized measures.

- use cost-effectiveness analysis to select the option that provides the most safety for the least money. This will not provide the appropriate size of safety budget or it will be difficult to apply when projects provide more than one kind of benefits.

This analysis of the alternative options reveals that each of them contains equal, if not greater, limitations. Despite the imperfections and defects of the VOL measurement, it is possible to consider this method more logical and consistent than the others. Therefore it has also to be accepted that in certain situations a life's value is not infinite: conversely, a finite value of life is legitimate, to be comparable with other kinds of benefits. This is also the kind of rational thinking which most people implicitly do when they make everyday choices like driving the car fast, crossing the road with the light at red, doing dangerous sports, etc.

Furthermore, the value of life considered refers to the value of a *statistical life:* that is, the valuation of the change in risk, rather than the valuation of the life of a particular individual. For example, to assert that, statistically, the risk of a fatal accident is 1:100,000 implies that there is one death per 100,000 people each year.

4. Different methods to the estimation of VOL

The estimation of the VOL is greatly influenced by the valuation method used. A number of different techniques have been proposed to define and estimate the VOL, as Jones-Lee (1981) says, but the appropriate method to use in any particular context may depend upon the objective and priorities of those who are intended to use the values concerned. The reasons for costing road safety are either the maximisation of national output or the pursuit of social welfare objectives (such as the minimisation of injuries accidents or fatalities in relation to traffic). The only valuation methods that appear to be directly relevant to these two objectives are:

a) the 'gross output' or 'human capital' (HC) method (suitable for the objective of maximising the wealth of a country);

b) the 'willingness to pay' (WTP) method (especially for social welfare maximisation and for use in cost-benefit analyses).

If the value of safety estimate is ultimately intended for use in conventional cost-benefit analyses in order to determine the most efficient way of allocating scarce financial resources, as in our case, then the most appropriate method to use is the WTP.

4.1 Gross output method

The "gross output method" has up to now been the one generally employed by countries which associate explicit monetary values with transport safety. In this method, the major component of the cost of an incident involving a fatality is the discounted present value of the victim's future output (or income). In the case of individuals, whose service is not marketed, or other economic effects such as vehicle damage, police and medical costs, an allowance is added. In some countries an arbitrary allowance is also added for pain and suffering of the victim. In turn, value of accident prevention is defined in terms of costs avoided (Jones-Lee, 1981).

As such, the "gross output method" aims to measure the impact of death or injury on current and future levels of national output, including also non-marketed services, which also have to be expressed in monetary terms. The aim of this method is to look also towards the future, not only at the present. On the other hand the major objection is exactly the fact that most people value safety principally because of an aversion to the prospect of their own and others' deaths, rather than because of a interest to preserve current and future levels of output and income. The basic principle of this method then seems not to reflect people's real preferences for safety.

To define this, some way of measuring people's real preferences for safety is required. A possible measure can be "the maximum amount that the person would be willing to pay for it", known as "willingness to pay" method.

4.2 Willingness to pay (WTP) method

This method reflects first the person's valuation of the desired good or service (in our case the level of safety) relative to other potential expenses, and secondly the individual's ability to pay, a factor which often influences implicitly people's choices and is itself a manifestation of society resource constraint . The aims is to determine the amounts that those affected by a certain policy measure would individually be willing to pay for improvements in their own and others' safety (Jones-Lee, 1981). An alternative to the WTP which can also be used is the 'Willingness to accept' (WTA) a compensation' for a certain increase in risk levels. To arrive at an overall value for the safety improvement considered, since WTP and WTA represent both *individual trade-offs*, those values are aggregated across all individuals considered. In this way the result will reflect how much value the safety improvement has, or which are the preferences and perceptions concerning the risk of those members of the public that will be affected. In essence, the approach simulates a market, which does not exist in reality. In some cases, in which a policy has a large impact on individual's welfare, the divergence between WTA and WTP may be very large: for example, a respondent, to accept a 30% risk of death, may be unwilling to accept any amount of money as compensation for this risk, but he will be willing to pay a certain amount to eliminate a 20% risk of death. It may be than evaluated, regarding to the policy considered, which method is more appropriate. An important consideration is that this measure may be influenced from measurable factors as age, place of residence or income, but also not measurable factors: i.e. the WTP of one person for himself and for other persons close to him (relatives, friends) might be higher than the WTP of the same person for an unknown of undefined individual.

5. Estimation procedures for VOL

After the examination of the basic principles of WTP methods, the one used in conventional cost-benefit analyses in order to determine the most efficient way of allocating scarce financial resources, the question will be '*How to obtain empirical estimates of values of avoidance of statistical fatalities and non-fatal injuries'*(M.W. Jones Lee, 1990). In the following chapters different techniques will be described, which are used to discover individual preferences and in particular elicit individual's monetary valuation of costs and benefits. For risk in general, and transport risk in particular, three types of estimation procedures have normally been employed. These are known as *revealed preference* (or implicit value), *stated preference* and *priority evaluator*. Each of them will be introduced in the following chapters.

5.1 Revealed preferences (RP)

The RP technique use information from markets associated with the service that is being evaluated; the WTP can be inferred from individual's actual decisions. For example, if a person actually pays *x SFr* to buy something, is possible to infer that his WTP for that thing is at least *x SFr.* In cases where no market exists, as for public goods and externalities such as clean air, traffic noise, etc., RP techniques have to rely on information from markets of goods which are a precondition for benefiting from the relevant public goods. For example, it may be possible to infer WTP for the absence of traffic noise by studying the difference in prices between houses affected by different levels of noise. In other words, RP techniques solve the problem of evaluating priority among components of different options and predicting the resulting future demand by using observations of existing behaviour; in fact, the way consumers currently use a facility, in comparison with others open to them, provides some indications of their preferences. The main features of RP data can be listed as following (Louviere, 2000):

- they reproduce the world as it is now;
- they describe only those alternatives that exist;
- they reflect market and personal constraints (e.g. information availability, income) ;

- they have high reliability and face validity (they are real choices made by individuals).

Unfortunately, there can also be problems with these approaches, summarised as follows (Pearmain, 1991):

- observations of existing behaviour may not vary sufficiently for the construction of accurate statistical models for evaluation and forecasting. The variables may also be correlate, so that accurate measurement of the importance which people attach to different factors will not be obtainable;

- the observed behaviour may reflect factors that are not of interest to the policy maker and these factors may cover the effect of the variables that are of interest;

- in situations where a policy is completely new, there is not information on how people will respond;

- to obtain adequate observations of behaviour, very large and therefore very expensive surveys may have to be carried out;

- because of their inflexibility, RP data are appropriate for short-term forecasting of small departures from the current state of affairs.

To solve these and others difficulties different techniques, such as stated preference (SP) have been developed. It may in any case be useful to compare results based on SP data with those based on RP, if RP data of sufficient quality is available, to emphasize the fact that the set of situations presented to the respondents must be as realistic as possible.

5.2 Stated preference techniques (SP) or Stated Choice (SC)

The main feature of SP techniques is that they allow the researcher to experiment: in real life, a transport planner, for example, cannot easily afford to install a new transport system or continuously alter the fare situation of a bus service to observe the different reactions of the people. SP techniques have been developed in response to these problems and to the weakness detailed for RP, for cases where the information needed – the WTP in our case – cannot be inferred from markets. SP data have characteristics which are largely related to the drawbacks of RP techniques (Permain, 1991- Louviere, 2000):

- they are flexible, as they describe hypothetical or virtual decisions;
- each SP interview produces multiple observations per individual, compared to the single observation per individual available from RP data;
- the effect of variables of interest can be isolated from the effect of other factors;
- if a policy is completely new and no RP data are available, SP techniques may represent the only basis for evaluation and forecasting;
- they can cover a much wider range of attributes and levels than RP data and capture a wider array of preferences;
- they are appropriate for forecasting change in behaviour, being particularly rich in attribute trade-off information. This is due to the wider attribute range which can be built into the experiments.

The principal weakness of SP techniques is that the data obtained represent individuals' statements of what they would do given *hypothetical* choices. Therefore, they cannot easily represent changes in market and personal constraints effectively. Furthermore, the SP data are reliable when respondents understand and can respond to the tasks proposed. That places an emphasis on presenting respondents with as realistic and credible a set of situations as possible.

Although the positive features of SP data are emphasised, it is important to note that RP and SP data can be used complementary, so that the weakness of one can be compensated for the strength of the other. Thereby, it can be instructive to combine them. A key role for SP combined SP-RP analyses lies in data enrichment.

Coming back to SP techniques, they refer to a number of different approaches. The common feature of these different techniques, as introduced above, is their use of experimental designs to construct a series of alternative imaginary situations. The researcher has complete control over the factors presented and individuals are asked to indicate how they would respond if these situations faced them in reality. In the following chapter two SP approaches will be introduced: *contingent valuation* and *conjoint analysis* (or *Choice modelling*). The latter is the one used in the survey presented later.

5.2.1 Contingent valuation (CV), SP

The aim of a contingent valuation approach is to elicit individual preferences, in monetary terms, for changes in quality or quantity of a non-market good or service (Bateman, 2002). For example it could involve questions about the WTP for improved safety, of willingness to accept compensation for increased risk. The change described can be the result of a hypothetical or actual policy or project. In contrast to most other types of approaches, the policy change is described in detail before respondents are asked to evaluate it, so that it should be perceived as realistic and feasible. Within this method respondents are then asked to make a direct monetary valuation of the change in question. A big influence on the effectiveness of this method is given by the choice of the policy change to be evaluated, that is, which quality or quantity change is of interest, and in what particular non-market good or service. Once the policy change of interest has been identified, it is then time to put together a valuation scenario to be shown to respondents, since all values estimated are contingent on various aspects of the scenario presented.

The main weakness of this approach is that questions can be misinterpreted, responses can be distorted by the questions and respondents can behave strategically or dishonestly. As a consequence, values that would apply in a real market are not easy to obtain. An alternative to this is presented in the following chapter, where the concept of trade-off is introduced, which is fundamental to human behaviour and so to the making of choices.

5.2.2 Conjoint analysis (CA), SP

This approach includes different techniques, all based around the idea that any good can be described in term of his attributes, or characteristics, and the level that these take (Bateman, 2002); for example, a bus service can be described in terms of its cost, timing and comfort. Changing attributes levels will result in a different good being produced, and it is on the value of such changes in attributes that these approaches focus. The main features of all conjoint analysis approaches are the following (Pearmain, 1991):

- they involve the presentation to respondents of hypothetical options;
- these options represent packages of different attributes, which represent a particular product or service;

- the values of the attributes are defined by the researcher in terms of their outcomes; they differ in the level of one or more outcomes and one of the outcomes will be monetary;

- the options are usually constructed on the basis of an experimental design, which ensures that variations in the attributes are statistically independent of one another;

- respondents state their preferences for each option by either *ranking* them in order of preference, *rating* them on a scale or simply *choosing* the most preferred option from a group of options. To make their choice they may, in any of these cases, trade off between benefits offered and cost to be incurred.

Regarding this last feature, in which different techniques can be used to measure respondents preferences, the diverse types of CA can be enumerated as (Bateman, 2002):

a. choice experiment;

b. contingent ranking;

c. contingent rating;

d. paired comparisons.

In a *choice experiment* respondents are presented with a series of alternatives and asked to choose their most preferred. A baseline alternative, corresponding to the *status quo*, is usually included in each choice set. The respondents are forced to trade off changes in attribute levels against the cost of making these changes, but they can also opt for the *status quo*, that is, no change in quality and no extra cost. In a *contingent ranking experiment* respondents are required to rank a set of alternative options. Each alternative is characterised by a number of attributes, which are offered at different levels across options. In a *contingent rating* experiment respondents are presented with a number of scenarios one at a time and are asked to rate each one individually on a semantic or numeric scale. This and the previous kind of experiment can be used to determine whether a particular effect is valued more or less than a particular threshold. In the *paired experiment* respondents are asked to choose their preferred alternative out of a set of two choices and to indicate the strength of their choice on a semantic or numeric scale. This approach combines elements of *a.* and *c.*

Discrete choice approaches offer simpler and more realistic choice exercises, but the information acquired is limited. Ranking and rating methods offer richest form of data but less realistic choice exercise.

The main design stages of a conjoint analysis experiment can be listed as follows:

1. selection of relevant attributes to be valued;

2. assignment of levels, which should be realistic and practically achievable;

3. choice of experimental design to combine the levels of the attributes into a number of alternatives scenarios to be presented to the respondents (design *full factorial* or *factorial fractional*). To generate choice sets specialised computer software can be used;

4. construction of choice sets where the profiles identified by the experimental design are grouped to be presented;

5. choice of the survey procedure and conduct of survey.

Each of these stages is better described in Chapter 7.1., where the design of the survey developed will be illustrated. Coming to the advantages and disadvantages of these approaches compared with those presented previously, the discussion will be focused on *choice experiment* (CE) rather than the others; CE being the most realistic approach. The main *advantages* are:

- CE designs can reduce the extreme multi-collinearity problems in models based on variations in actual attribute values, since in CE the attribute levels are designed to be orthogonal (that is, independent);

- CE can be used to study preferences for attribute levels beyond the existing. For this reason CE has been used in transport research to look at new modes, infrastructures and service levels that may not currently exist;

- CE may avoid some of the response difficulties in CV.

As well as the advantages also some *disadvantages* related to this approach can be listed:

- in order to estimate the value of an environmental good from a change in value in one of its attributes, if a linear utility function is calculated, it is necessary to assume that the value of the whole is equal to the sum of the parts. One of the problems which can arise is that there may be additional utility-generating attributes of the good not included in the design. To test whether this is a valid objection, it is necessary to compare whole values obtained from CE with values obtained for the same resources using some other techniques. In the transport field, research from London underground and London buses has shown clear evidence that whole packages of improvements are valued less than the sum of the component values, all measured using CE (Steer Davies Gleave, 2000, 1999);

- the values estimates obtained with CE, as with CV, are sensitive to study design. The choice of attributes, the levels chosen to represent them and the way in which choices are relayed to respondents may all impact on the values of estimates.

To conclude on the subject of these techniques it might be interesting to mention the *analytical procedures* to measure the relationship between behavioural intentions and choices, which will differ depending on the type of responses (ranking, rating, choices). The theory of choice behaviour common to all of them is based on the concept of utility from the consumption of a particular product, which represents the benefit that a person enjoys when spending his resources on different things. The utility concept implies that individuals make their choice with the purpose of gaining the maximum utility. To model the utility another concept must be introduced, which is the random component of the utility, essential to reflect unobservable elements of choice behaviour. The random element implies that the utility is related to the *probability* of an individual giving a certain response; to be exact, the probability of making one choice instead of another reflects the difference in utility between them. The most popular analysis technique which implements the concept of random utility is *logit analysis*. A more detailed explanation of this technique will follow in Chapter 10.

5.3 Priority Evaluator (PE)

The PE method is another technique which was created, like CV, as an alternative to RP techniques. RP approaches can provide an oversimplified view of the preferences, since the respondents might not in reality have access to alternatives between they have to choose, or they might not be forced to trade off some of their preferences against others. Additionally, it is not possible with an RP experiment to describe long-term effects. A method of combining actual behaviour and attitudes of respondents, as Hoinville (1970) said, is to see at first how they describe their present situation and then establish the direction in which they would prefer change to occur. By forcing them to choose only a limited number of improvements it is possible to determine a pattern of trade-off preferences. The principle on which this approach is based is the simulation of choices in a market situation: by seeing which mixture of variables provides more satisfaction, it may be seen how one aspect is valued more or less than others. These are just some of the features which distinguish a PE method. This method was pioneered by Hoinville and Berthoud (1970) to value travel time, road safety, vehicle pollution and congestion in London. The main features of this method can be described as follows, as Hoinville (1970) and Permain (1988) report:

- the aim of PE approach is to identify the *relative priorities* by asking respondents to choose a mix of variables from a range of competing alternatives. The alternatives are grouped in items, which can include market goods, environmental effects of interest, kinds of service etc. The way in which respondents choose between them provides an identification of the trade-off values associated with individual items. An analogy with that can be found in every day purchasing situation;

- each alternative among the different items is described with various attributes, as for example safety, cost, level of noise, etc., all of which are given a value. The attribute cost is particularly meaningful within this approach, since the respondents receive also a hypothetical *budget* to allocate between the ranges of alternatives chosen. The budget might be increased (or reduced) and the respondents invited to add, subtract or alter the set of selected options;

- some restrictions stem from the necessity to accept one alternative from each dimension presented and to spend all or as much as possible the budget available, but not more than this limit;

- due to the first restriction, it is necessary to include a base situation, which can be selected if respondents do not want to spend money at all on this dimension;

- to increase the degree of realism PE maximises the flexibility of the choices, allowing respondents to move gradually toward their ideal combination by modifying their choices until the combination of choices represent the optimum outcome from the allocation of the budget, rather than force them to indicate an optimum solution in one attempt;

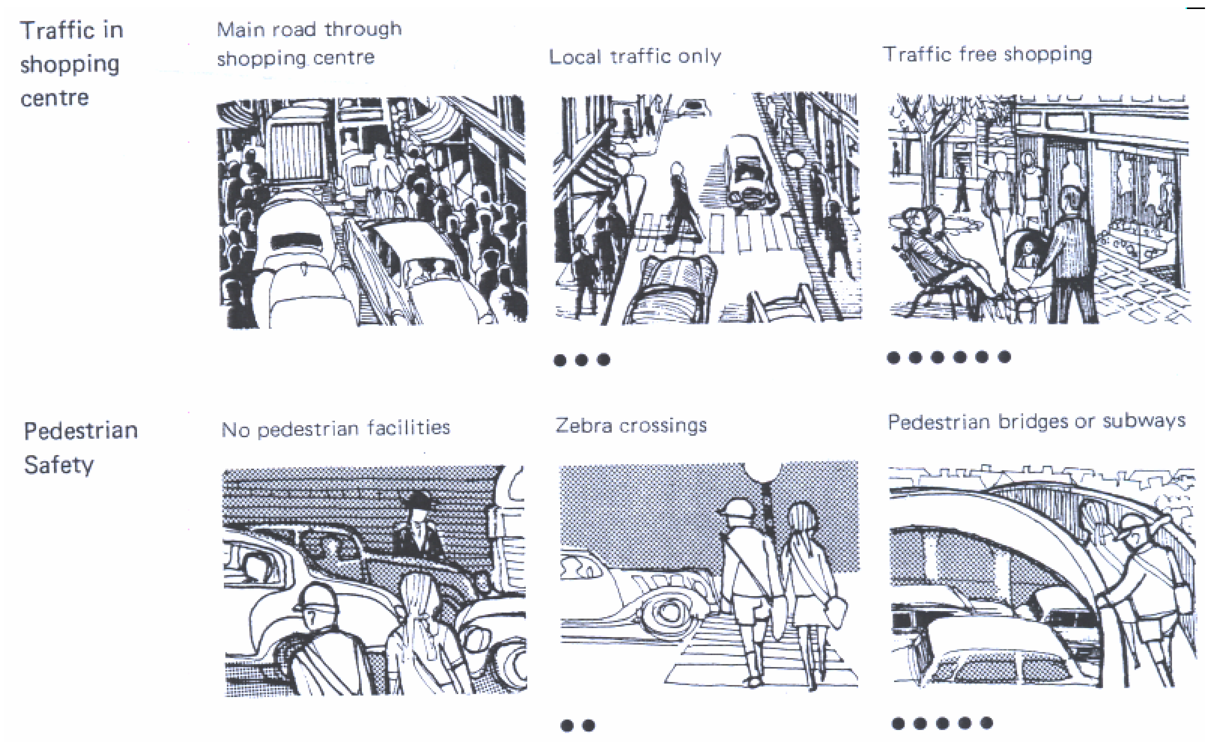
- as with any hypothetical method presented, the PE needs to be inserted into a *realistic context.* A criticism of this approach was that as respondents are asked to consider a choice situation normally faced by operators rather than users, their true opinion as consumers could be distorted. Nevertheless, distortion will only reflect constraints imposed by pricing structure and budget limits used in the exercise.

To summarise, the basic task of the respondent is to weigh up the value of each attainable attribute, consider the attractiveness of the cost attached to it and define the most attractive combination of the options within the limited budget available. The purpose is to understand the *trade-off decisions*, in order to see how people balance some factors against others, aiming to maximise their overall utility (Hoinville, 1970). This aim is similar to that of SP; the important difference lies in the nature of the exercise that respondents must perform. Instead of evaluating pre-constructed packages of attribute levels and choosing, ranking or rating them, respondents are instead required to aggregate their optimum combination of attributes. In this way respondents are able to consider a larger array of alternatives (Pearmain, 1988). The implication is that a wider number of options can be presented to respondents than is possible with other types of SP analyses.

As Permain (1988) described, the *budget* may represent for example public wealth or private cost. In any case, it determines the degree of choice open to respondents. If the budget varies across different version of an experiment, it should be considered that increase or decrease in small increments can give more detailed information on respondent's priorities. Larger increments in fact, enabling groups of facilities to be purchased each time, would make choices easier. The *price* structure employed represents an approximation to reality and it is the factor which determines the degree of choice available to respondents. The relative priorities derived from the analysis are only relevant to the price structure which was used; if a different set of prices is attached, as with a different budget, this will generate a different set of trade-offs. The *outlook* of the experiment can occur in different ways: one is to present cards for each item proposed, each with different levels of the attributes. This method allows respondents to arrange the items and to order the different alternatives, so that they are not constrained in the way they can combine them. Another possibility is to use a board, like the one shown in Figure 5.1, where all items are presented to the respondents in scales (with progressive degrees of quality). The items can be represented pictorially or can be described.

Regarding the analytical approach, the most popular has been the *relative value index* (Pearmain, 1988). This approach considers the purchasing of each variable level as movement across a boundary, in which individuals weigh up the price of each level against the marginal utility they place upon it. The proportion of respondents choosing to cross each boundary is an indication of how much the attribute level is under or over-priced. D*iscrete choice analysis* may also begin successively to be applied. In this case each respondent's budget allocation is identified as the combination most preferred over all other possible combinations within the budget and price constraint. A logit model is used in which coefficients for each attribute level are calibrated using maximum likelihood procedure.

Figure 5.1 Example of board presented in PE experiment



Source: Hoinville, 1970

To conclude the description it is important to evaluate its possible applications as an alternative to other methods, its advantages and disadvantages. As Hoinville (1970) said, the main strength or weakness of the PE approach is not in the method itself but in its application. If the alternatives posed to the respondents are too hypothetical or the situation is too unreal, it cannot be expected to produce satisfactory answers. In fact, as a data collection operation, the main difficulty is to maintain simplicity and to approach the complex reality of a multi-choice situation in an understandable way. Furthermore, the PE cannot be used as a kind of simulator to replace completely or to remove the need for experience: it is a means of communicating with respondents which allows understanding of the nature of their attitude and, at the same time, reminds people of similar experiences and enables them to arrive at a balanced judgement. It must be recognized that it is not very meaningful to examine priority preferences covering a wide range of variables, amongst respondents with a limited range of experience. But, on the other hand, it would be useful to relate preferences to level of experience, treating experience as an analysis variable and see how much choices vary between people with different backgrounds. After all, the main advantage of the PE approach is its *flexibility*. It can examine the preference structure in order to establish differences between different types of persons, different types of situations, large and small changes in individuals' variables. For example, it can see how younger generations have values different from their fathers; or establish the relationship between income and preferences. Finally, it can provide a genuinely wide range of combinations.

Following the theoretical description of the three more common techniques to estimate the VOL, it is time to introduce the practical experiment which was developed and relate it to the VOL research presented previously. The next chapter is intended to give an overview of the different steps of the work.

6. The experiment

The experiment conducted, after the review of the VOL theory – covering the definition, the methods of measuring it and the estimation procedures – is intended to estimate the VOL related to road safety, with the help of two of the reported estimation techniques. In particular, the methods employed are *stated choice analysis*, applied to data obtained with the conjoint analysis technique and the *priority evaluator.*

Owing to the differences between these two techniques, another intention was to compare the values of VOL obtained from each of them and analyse how they differ. This experiment, in practice, consisted of the design, test and conduct of a survey, which is a form of data collection involving the elicitation of preferences and/or choices from a sample of respondents.

The survey was conducted in the Canton of Ticino, in Switzerland, between December 2003 and January 2004. Chapters 7, 8 and 9 will provide an detailed explanation of all the steps of the work: design, pre-testing and main study. After these steps, with approximately 200 usable returns from the initial sample of 500 persons selected randomly, a descriptive analysis of the respondents who replied was performed (chapter 9.4). Subsequently, all data having been coded, chapter 9.6, 9.7. and 9.8. present descriptive analyses of the different approaches. The VOL was at first calculated as median and mean VOL for each of the situations proposed (see chapter 9.9) and then, with the help of a Multinomial Logit Model and the software BIOGEME, a package designed for the maximum likelihood estimation of Generalized Extreme Value (GEV) models, it (the VOL) was evaluated by linking the choices made from respondents with various attributes relatives to them (age, place of residence, income, etc.). The values obtained were finally analysed step by step, compared with the VOL obtained within the median and mean VOL study and finally compared with VOL obtained in previous studies. A complete description of the model adopted and all analyses performed is presented in chapter 10.

7. Survey design

The description of the survey design is divided into four sections, which also represent the four elements of the survey itself. The respondents were presented with three different approaches, trading-off transport safety against public investment, and a final personal questionnaire, with questions about the respondent himself. The survey was designed to be sent out by post, a circumstance which brings some constraints in terms of the kind and level of explanation: each approach is introduced with a short description and with a pre-filled example of one table, showing which kind of reasoning has to be done and how the choice should be made. The comments and the results of the pilot survey proved very useful in improving the survey in this respect.

One important thing to state is that the alternatives presented for each kind of approach did not refer to any real situation, place or project; instead they are presented as possible improvement on one *imaginary street*, *5 km long, within the city*. This assumption makes it possible to scale the safety performance, journey time, comfort and cost, defined in the following sections, connected to each alternative. Each respondent then, while responding, could imagine the improvement in a situation or place which is familiar to him. Another reason for this hypothesis is to make the alternatives more comparable with each other and to build a survey which is not only relevant to a specific environment. On the other hand it must be remembered that this hypothesis is a rough approximation of the reality, and therefore many other factors, which are not fully considered during the survey design must be taken into consideration for each of the alternatives and situations proposed.

7.1 The three approaches

The three approaches presented are:

1. traffic and transport improvement test, with different combinations of the following four experiments and no budget constraints: bus stop and/or bus lane, night time security, speed control and junctions with bad visibility;

2. priority evaluator approach with different combinations of the following five experiments and three levels of budget constraint: pedestrian facilities, bike facilities, bus stop and/or bus lane, night time security and speed control;

3. stated choice approach with different combinations of variables regarding possible consequences of modifications connected to traffic and transport.

7.1.1 Traffic and transport improvement test

In this first test, for each of the four experiments, five alternatives, which represent different possible traffic and transport improvements, are presented along with a sixth alternative, which represent the present condition, that is, not changing anything. For each alternative a safety level, a journey time, a comfort level and a cost are presented. For the present situation all these variables are zero. This kind of test, as introduced, has no budget constraint; this feature gives the respondent the chance to get in touch with the situations, some of which are also used in the following "Priority Evaluator approach", putting attention more on other attributes than on the cost of each alternative.

Safety is expressed in number of victims avoided per year and shows how the safety on the road considered changes for each alternative. The victims avoided can be any kind of road user involved with the alternative pondered. To define the levels of this variable it is necessary first to consider the kind of alternative proposed for each experiment (e.g. "High and larger bumps every 800 m" within the experiment "Speed control on the road") in comparisons with all the others proposed. Thus, more significant than the value itself is the relation between the five different values in each experiment. In fact, to scale each of them the main consideration was that every alternative should not look illogical compared with the others and that no alternative dominates others within the same experiment. All of them, during the survey design and after the pilot survey, have been reconsidered and slightly modified. It must be stated that no real data could be consulted, since the situation is abstract and not really connected to a specific road user or a particular situation.

The *journey time change,* expressed in minutes, shows the journey time it takes for the whole distance (5 km), specified for different road users. To scale the values of this variable for the different alternatives the following considerations were made:

- the average time needed by car, with a speed of 50 km/h, without any junctions, is 6 minutes;
- the average time needed by bike, with a speed of 18 km/h, is 20 minutes;

- the average time needed by bus, with a speed of 50 km/h and 8 stops (one every 600 m) is 14 minutes. One extra minute for each stop has been added to the time needed by car;

- if the journey time variation increases, it will take longer for the whole distance; if it decreases, it will take less time. For the alternatives which do not influence the journey time the variable is zero;

- some small corrections were made, by slightly increasing the values, to show the differences between the alternatives presented or to avoid possibly dominant alternatives.

The *comfort change* shows, if positive, an increase in comfort for the road user involved in the alternative presented; if negative, a decrease. It is expressed not on a numeric scale but as a progression where the negative values are“---”, “--” and “-”and the positives “+++”, “++” and “+”. The introduction of this variable, not directly connected to the safety problem, was intended to give the respondents an additional variable to trade off between the alternatives proposed, in cases where the others do not vary very much. These variables were assessed alternative by alternative.

The *cost* shows the amount needed for the realisation of the alternative considered. As specified also in the survey itself, only the “realisation” cost has been taken into consideration and we are aware that before and during the realisation of each of the alternatives further costs, including for example planning, study of the alternatives, maintenance, etc.have to be taken into consideration. To create the values presented some examples more similar to those proposed were consulted, although, as said, a definition of a cost in such a generic situation is quite complicated. Therefore, also if the values adopted are not chosen very rigorously, the ratio of the costs between the alternatives is always consistent with the kind of intervention proposed. It must also be stated that, provided the combination of values proposed for the attributes in each alternative are considered feasible, the relation of the budget and costs to real values is of lesser importance. The cost structure may therefore be much simpler than that allowed by an approximation of real supply costs.

One complete example, for the experiment *Bus stop and/or bus lane improvement on the road* can be seen in Table 7.1; all the others can be found in the survey included in Appendix A. The five alternatives and the present situation are listed in the headline. Other then the present situation, the variables for all the alternatives have values equal to or greater than zero. Safety improves once the new bus stop get the own space and a lane independent from the car lane; in fact, the more the space of the bus is distinct from the space of the car, the probability of an interaction, as an accident between bus and car or passengers going to take the bus and car, diminishes, and the number of victims avoided increases. The last two alternatives do not produce any safety change, being not involved with safety, but they look more convenient under other aspects such as journey time or comfort. Regarding the journey time, a new bus stop produces an increase in journey time for passengers, because of the time spent to stop and to rejoin the traffic; this time decreases when the bus is more independent from the car lane, not depending on interactions with other road users as cars, bikes or motorbikes. The values of comfort are scaled mostly to compensate the other variables, although they reflect as well, even if roughly and subjectively, the difference between the alternatives. Finally the cost, for the first three it is increasing, the circumstances being nearly the same, but with expanding facilities. The cost of "All existing bus stops with more information and facilities" and "More frequent buses through existing bus stops" are not simply comparable with the others being quite different; their cost is more significant to the trade-off with the other alternatives than for the level itself. An important factor, visible already in Table 7.1, is the absence of dominated alternatives, so that the respondent does not have the chance to reject a priori any of them.

In each survey type only three of the four situations are alternatively included within the "Traffic and transport improvement test". The selection is coordinated with those alternatives included in the PE test.

Table 7.1 Example of “Transport and traffic improvement test” experiment (Bus stop and/or bus lane improvement on the road)

	New bus stop, bus lane not independ.	Space for new bus stop, bus lane not independ.	New bus stop, bus lane independ. from the car lane	All existing bus stops with more information and facilities	More frequent buses through existing bus stops	Present situation (8 bus stops, every 600 m)
Safety (No. of victims avoided)	1	2	3	0	0	0
Journey time change for passengers	+ 3 min	+ 2 min	+ 1 min	0	-2 min	0
Comfort variation	+	+	++	++	+++	0
Cost (SFr)	60,000	200,000	400,000	20,000	70,000	0

7.1.2 Priority Evaluator approach

The experiments presented within this approach are partially the same as in the previous test, apart from “Pedestrian on the road” and “Bike facilities on the road”. The outlook and the features of the experiments within the survey do not vary. The main difference to the previous test is the presence of a budget constraint, which is, as mentioned in the theoretical description, one of the main peculiarities of the PE approach. Three different budgets were employed for the experiment: 500,000 SFr, 600,000 SFr and 800,000 sFr; each respondent received just one of them, depending on the survey version he received. Only three experiments of the five mentioned are presented in each survey; they are alternatively included, except for “Pedestrian on the road” and “Bike facilities on the road”, which are fixed. The respondent may refer to these three experiments, with alternatives representing different level of quality or improvements. The present condition is included as a benchmark, which delineates the respondent’s perception of the present real-life situation. Examples of the different versions are shown in the Appendix. The task now is not only to weigh up the value of each attribute, but also to consider the attractiveness of the cost attached to each alternative and define the most preferable combination of alternatives within the limited budget available. In this way the respondent cannot ponder the values of the attributes separately for each situation as before, but has to find the most convenient combination of choices from the three situations proposed, with the sum of the costs not exceeding the size of the budget.

7.1.3 Stated choice approach (SC)

This third kind of approach is the stated choice approach, which has some similarity with the others but also differs in a number of ways. First of all it has to be stated that, of the different forms of stated choice approaches presented previously, the stated choice experiment was used, in which the individual simply selects the most preferred option from a pair or group of options. The survey developed display a dichotomous choice, which always consists of the present situation and one alternative. In this way the SC exercise is presented in realistic terms which are easily understandable for the respondents, who should make the choices in a contest with which they can identify. The present situation or 'Alternative Zero' corresponds to the situation without any investment for the next year in improvements related to transport and traffic safety; the second alternative represents the option with a certain investment (see Table 7.2). Both of them are still related to an imaginary street, 5km long, in the city. Coming back to similarities and differences with regard to the previous approaches, the common feature is the presence of imaginary situations, where the respondents might state their preference depending on the level of the variables offered; the main difference is that both the options proposed are predefined packages of variables (see Table 7.2) which represent features correlated with transport and traffic in a city, which may vary once some modifications are introduced into the system. Regarding the levels of the variables, for the 'Alternative Zero' they are fixed, for the second alternative they are selected from four levels, defined as change relative to the level of the present situation. Thus, the values written in the brackets represent the change, otherwise they are the absolute values, as shown to the respondents (see Table 7.2).

Table 7.2 Variable levels of the stated choice experiment

Variables name	Present situation	Range of levels for second alternative			
No. of victims/year in accidents as car drivers and motorcyclists or passengers	4	(-4) 0	(-2) 2	(+1) 5	(+2) 6
No. of victims /year in accidents as cyclist	2	(-2) 0	(-1) 1	(+1) 3	(+2) 4
No. of victims /year in accidents as pedestrian	3	-(3) 0	(-1) 2	(+1) 4	(+2) 5
Journey time for cars along the road (minutes)	9	(+2) 11	(+1) 10	(-2) 7	(-3) 6
Car which exceed speed limits (in %)	60	(-30) 30	(-20) 40	(+5) 65	(+10) 70
Investments (SFr)	0	500,000	800,000	1,000,000	

To define the levels of the five variables the following criteria have been followed:

- the *number of victims/year*, for all three kinds, cannot truly reflect any real situation, given that the situation considered in reality depends not only on the length of one road, but on many other factors as size, role and position of the road inside the city, infrastructures already present, number and kind of junctions, etc. Furthermore, the number of victims, which includes injured and dead persons in one year, along a road only 5km long, cannot be very high. With these restrictions the delineation of the levels was done, first consulting the statistics of the percentage of road accidents for different road users obtained from Ticino's police (see Table 7.3). It can be seen that 2002 shows car drivers and motorcyclists as the most likely victims, then, already with much lower levels, pedestrians and finally cyclists and other road users. This percentage magnitude distribution is evident even in the statistics concerning Switzerland as a whole. The proportions within the small size of the environment assumed could not be completely respected. In any case, the intention is for the levels assigned to be always higher for car drivers and motorcyclists, slightly lower for pedestrians and lowest for cyclists. The changes from 'Alternative zero', i.e. the levels of the second alternative, have a quite small range, according to the limited length of the road considered;

- the *journey time for cars along the road*, expressed in minutes, is calculated considering that cars driving a distance of 5 km in the city with a speed limit of 50km/h will need about 6 minutes with no stops. With decelerations for crossroads and pedestrian crossings, an average of 9 minutes was considered as the base for the ‘Alternative zero’. As before, the changes from the base value, in order not to be implausible, range from –2 minutes to (maximum) +3 minutes;

- to define the *percentage of cars which exceed the speed limit* it was unfortunately not possible to find any measured value as a reference. The assessment of it and its variations was done subjectively, trying to be as realistic as possible;

- for the *investments,* as for the previous variable, it was hard to find good references for such general cases. They can vary very much depending on factors such as the aim of the project of improvement, the region or the city considered, whether the improvement is at local or regional level or to which road user it is addressed. Again, the values were chosen to be as realistic as possible.

Table 7.3 Victims of road accidents for different road users, 2002

	Value	Percentage
Car driver	1,223	58%
Motorcyclist	574	26%
Lorry driver	59	3%
Biker	103	5%
Pedestrian	149	7%
Others	17	1%
Total	2,125	100%

Source: Ticino cantonal police

Another important feature of this approach is the *factorial design*, used to construct the hypothetical situation to present the respondents. The factorial design, a design where each level of an attribute is combined with every level of all other attributes, is usually *orthogonal*, that is, the values presented to respondents vary independently of one another. The result is that the effects of each of the four attributes upon responses are easily isolated. As mentioned above, the values in the present situation are fixed: only the second option was submitted to this kind of design. One possible design used for this survey is known as *full factorial*; this is because every possible combination of variable levels is used. The number of combinations is the result of the number of levels raised to the power of the number of variables; if variables with differing numbers of levels are used, the raised values are simply multiplied together. In this case, with five four-level variables and one three-level variable, the design would have 4^5 x 3^1 = 3072 possible options. This number of options is obviously too high, and remote from the range of options normally acceptable. One way of making the number of options smaller is to have a lower number of variables and/or levels; this method was excluded, as it was necessary to integrate the variables concerning different kinds of victims with the last two, relating to journey time and respect for speed limits. The inclusion of these last variables can in fact reduce the predisposition of respondents to imagine a pattern among the options. The other possible strategy to reduce the number of options is known as *fractional design*, which uses only some of the combinations of the full factorial design, and excludes those options which are dominant or are dominated by all other options in the choice set. For this survey the second strategy was used: by using the 'orthogonal design' function in the SPSS software it was possible to create up to 64 combinations of variables and levels not dominant or dominated. Since nine different versions of the survey were created and within this approach each respondent received six situations, just 54 combinations out of the total number of combinations generated were used. The use of this experimental design has consequences. First, the situation sometimes does not look reasonable for the respondents and the choice by trading off between the values of the variables might result in complications (i.e. when the number of victims or the journey time increases by investing). Secondly, that makes possible that, contrary to logic, the investment may not always improve each variable, but rather can also worsen it or leave it unchanged. An example of how the situation is presented to the respondents is shown in Table 7.4. An overview of this part of the survey may be found in the Appendix A.

Table 7.4 Example of Stated choice approach situation

Variables	No investment	Investment 1,000,000 (SFr)
No. of victims/year in accidents as car drivers and motorcyclists or passengers	4	6
No. of victims/year in accidents as cyclists	2	0
No. of victims/year in accidents as pedestrians	3	4
Journey time for cars along the road (minutes)	9	10
Car which exceed speed limits (in %)	60	70

The possibility of illogical situations mentioned before is clearly visible in Table 7.4. It is noticeable, for example, that investing 1 million SFr in this case results in an improvement in only one measure, that is, "No. of victims/year in accidents as cyclists", while all the other measures get worse: the number of victims is larger, the journey time increases, as does the proportion of cars which exceed the speed limit. In this case, since most of the variables are worsened by making the investment, the choice of the respondents is almost predictable; in other combinations presented, the situation is not so obvious, and the respondents must genuinely trade off among the values of the five variables.

7.2 Person questionnaire

The last part of the survey it is a person questionnaire, employed to analyse the socio-demographic and economics attributes of the respondents. These questions are used to feature the respondents and study how 'Willingness to pay' varies according to respondents characteristics. The composition of the questions was performed with reference to UNIVOX, which is a yearly poll of a sample of around 5000 persons in Switzerland regarding attitudes towards most aspects of life in the country, undertaken by GfS, Zürich. The topics of interest for this survey, among the various aspects developed in UNIVOX, are grouped into five areas:

- demographic questions such as year of birth, place of residence and sex;
- use of the car: driving licence, car availability, km driven last year;
- possession of season ticket and days travelling by different modes;
- feeling of safety and number of accidents had;
- family gross income.

All the questions in each of the various areas are multiple-choice questions, which are easier to handle for the respondents and the answers are conveniently classified in defined categories. The results of the questionnaire are analysed, first to investigate the character of the sample, secondly to combine them with the answers from the previous parts of the survey. In fact, as described in chapter 10, the model describing the choices can be slightly improved, once the sample is better defined with respect to its socio-demographic attributes. The Appendix includes an example of the personal questionnaire, both the Italian version as sent out and an English translation.

7.3 The different versions

To give each part of the survey a wider range of values and to cover a larger number of combinations, rather than just one version, nine versions were created. While assessing the number of versions to be created, a few points should be considered. Concerning the PE test, three different budgets (500,000, 600,000, and 800,000 SFr) and three combinations of experiments were available, as follows:

- PE version 1: Speed control, Pedestrian, Bike facilities;
- PE version 2: Bus stop and/or lane, Pedestrian, Bike facilities;
- PE version 3: Safety at night, Pedestrian, Bike facilities.

For the SC experiment more than 50 diverse situations of values were attainable. As can be seen in the survey in Appendix, the final version of the survey presents three experiments within the "Traffic and transport improvement test" (T), three experiments within the PE and six situations within the SC. Therefore nine different versions were created, where each version of PE is presented for all three budgets available, as may be seen in Table 7.5. Since each version includes six SC situations, a total of 54 different combinations of values from those created were employed. Table 7.5 shows how these combinations are associated with the versions. In the previous description the test without budget constraint was not mentioned. It must be considered that, since the outlook of this test is similar to the PE test, the six experiments created are used alternatively in both of them. The test without budget constraint associated with each PE version includes always the three experiments which are not shown in the PE test. That is, also this test has three different versions, which are complementary to the PE versions.

Table 7.5 Combinations representing the different versions

Versions	PE Budget available	PE versions	SC situations
1	500,000 SFr	1	1-6
2	500,000 SFr	2	7-12
3	500,000 SFr	3	13-18
4	600,000 SFr	1	19-24
5	600,000 SFr	2	25-30
6	600,000 SFr	3	31-36
7	800,000 SFr	1	37-42
8	800,000 SFr	2	43-48
9	800,000 SFr	3	49-54

The distribution of the different versions among the sample of 500 persons, randomly selected, was done so that approximately equal numbers of each version of the survey could be distributed: 55 surveys were sent out for versions 1, 2, 7 and 8 and 56 for versions 3, 4, 5, 6 and 9.

8. Pilot survey

A pilot survey is a pre-test, with a small sample of respondents, and it is essential to test the adequacy of the way in which the survey is presented, the suitability of the design, the attitude of the respondents to different approaches and possible problems. In this case, a pilot survey was conducted with a sample of 23 respondents, from varying territorial and age contexts. Some of them were completed in the presence of the researcher, with the opportunity to comment at any stage; others were conducted by post, self-completed by the respondents and commented on. Because of the different contexts, no statistical analysis of this pilot survey was performed; instead the impressions of the respondents, their suggestions, doubts and attitudes to the choices in the three approaches were observed and used to improve the form and the content. In fact the pilot version of the survey was different in some respects: first, each approach was introduced only with a verbal description concerning the procedure and the parameters, without examples or direct instructions of how to answer. The first test, without budgets, consisted of six experiments, three of which were reused within the PE test: the idea was to make the respondents familiar with the kind of questions during the first test, so that in the PE, when the budget also had to be considered, the choice process would be less complicated. The PE approach looked almost the same; the SC approach consisted of ten tables instead of six and the personal questionnaire was the same as in the final version. The modifications made throughout the survey were made mainly following remarks and comments from respondents. The most frequent observations and impressions received from respondents were the following:

- it is not always easy to understand how to make the choice without an example, which shows a situation and some direct instructions;
- the recurrence of the experiments from the first test in the PE makes the survey too long and too complex. Additionally, some persons suggested presenting the alternatives in the first two tests ordered according to the value of one attribute, to make the comparisons easier;
- the selection, especially within the first test, is mostly guided by the preference of the kind of alternative, rather then by the levels of the attributes safety, comfort, cost and journey time. Some of the respondent even declared that the choice in this test were led by personal habits and perceptions with the alternative proposed, for example the annoyance from speed bumps while driving. Additionally, some respondents declared that they did not agree with the values of the attributes proposed, which led them to select an alternative without reference to the attributes related to it;

- concerning the SC approach, the most common reaction concerned the complexity and the lack of logic among the values of the two options. Some respondents proposed varying just one attribute among the five proposed each time; others suggested reducing the number of situation. These observations were driven by the difficulty of finding a means of evaluating all the attributes at once and the difficulty of accepting the attribute levels.

Beside the impressions of the respondents, it was also interesting to observe their attitude while making the choices, especially the change in opinions between the test without budget and the PE test. For the majority of them the alternatives selected in the first test, within the experiments reproduced in the PE test, were different from the alternatives chosen in the PE test. Some of them made completely different choices, some changed just one or two options, whose price was too high for the budget given, in favour of cheaper ones; others excluded completely one context of improvement to maintain the same high-cost alternative they chose in the test without budget. Another quite common tendency in the test without budget was to choose alternatives with high prices; furthermore, the present situation, with zero changes for all variables proposed, was selected mostly in the PE test, where the constraint of the budget led people to exclude some contexts of improvement. Finally, the person questionnaire did not seem to be a problem for any of them, except in respect of some particular questions. With the help of the observations reported and of many other small criticisms, a few modifications were implemented, such as introductions with examples and some instruction for each approach, the reduction of experiments presented, a short explanation about the calculation of the levels, particularly for the SC test. In addition, the possibility of having telephone contact with the respondents after their received the survey, to resolve possible doubts, emerged.

9. Main study

The final version of the survey was defined after conducting the pilot survey described previously. This chapter will describe first the sampling, a very important issue while conducting a survey and the contacts with the respondents (Chapter 9.1., 9.2.). Secondly the features of the area considered will be briefly introduced (Chapter 9.3.). A fourth section will provide an analysis of the response (Chapter 9.4.), and a fifth an analysis of the respondents considering all socio-demographic features drawn from the person questionnaire (Chapter 9.5). The next three sections are descriptive analyses of respectively 'Traffic and transport improvement test', the PE approach and the SC approach (Chapter 9.5., 9.6., 9.7.). The last chapter will start to consider also the Value of life (VOL) and analyse it for the three approaches used.

9.1 Sampling

Sampling is the act, process, or technique of selecting a suitable sample, or a representative part of a population for the purpose of determining parameters or characteristics of the whole population. When dealing with people, the sample can be defined as a set of possible respondents selected from a larger population for the purpose of a survey. There are many kinds of samples, which differ in the manner in which the elementary units are chosen. The one used in this survey is the random sample, which attachs a probability that each elementary unit can be chosen. Among the different types of random sample, this can be classified as a cluster sample. Since the sample had to consist of 500 people living in the Canton of Ticino, five different localities were chosen, which represent the clusters. The samples were selected on the basis of simple random sampling from the 2003 telephone directory. The five localities selected are Lugano, Locarno, Bellinzona, Biasca and Airolo; Lugano, Locarno and Bellinzona were selected by virtue of being the biggest towns in Ticino, whereas Biasca and Airolo, smaller in size, by being located on a strategic route. Considering the different number of inhabitants in each of the five localities, the size of the sample selected in each of them was consequently adjusted (see Table 9.1.).

Table 9.1 Size of localities and sample selected

Locality	Inhabitants (2003)	Size of the sample
Airolo	1700	12
Biasca	5969	100
Bellinzona	45,100	125
Locarno	49,400	125
Lugano	117,300	138
Total		500

9.2 Contacts with the respondents

Once the respondents were selected, the survey, all four parts, including a postage paid return envelope, was mailed to their home address. Afterwards, to motivate the people and clarify more precisely the aim of the work, most of the persons were contacted by phone, and asked whether they had some difficulty in understand the questionnaire, or if they had some doubts or questions about it. It was possible to reach about 416 of the 500 respondents selected within a period of two weeks before the Christmas holidays and some more in the days after. Most of the respondents reached by phone had received the survey (73%) and about 65 % of them said they would take part or they were interested. It was also appreciated that someone was contacting them, making the distance between researcher and respondent a bit smaller; in some cases the phone call, and the fact that it was part of the work for a university thesis, could change completely their first impression of the survey.

The most common reactions of the people who were not interested (35 % of those who received the questionnaire) were the following: “I’m too old, this is not my problem any more”, “I feel already safe enough, there is not so much to do”, “I’m not responsible, since I don’t drive”, “We are sent too to many surveys these days and we don’t see any change”, “The problem of safety exists but the solution is to make people respect the Rules of the Road”, “It is difficult to evaluate such an abstract situation and not a specific project, there are many other factors to be taken into consideration”, “It is not so useful to change the road, is better to make people understand what is wrong or right to do” . Those comments should be considered for a later development and improvement of the survey.

9.3 Features of the area considered

The area considered, as mentioned previously, is composed of five towns in Ticino -Lugano, Locarno, Bellinzona, Biasca and Airolo- which are all different in size and location. Their location is shown in Figure 9.1, which shows the canton and its main features,. As already mentioned, three of them were chosen by virtue of being the biggest towns in Ticino, whereas the last two (Biasca and Airolo) are smaller in size and were chosen for their location on a strategic route, mainly for international traffic and transport of goods. Both of them are situated on the A2 motorway, which provides one of the main north-south connections, via the Gotthard tunnel.

The Ticino, as De Gottardi (2003) said, can be divided into two distinct areas:

- the very attractive area, which is the main valley that starts at Biasca and runs down as far as Locarno and Chiasso. It is represented by the light grey area in the figure. This area, which constitute 15% of Ticino's land area, has 80% of the population and 90% of the workplaces;

- the rest of the canton (85% of the total land area), which accounts for 20% of the total population, mainly elderly people.

Ticino has a population of about 310,000 persons, which is 15% more than its population of 20 years ago. Depending mainly on the topography, the development of urban areas and mobility in Ticino took place along specific axes. The five poles of the canton can be identified as the cities of Bellinzona, Locarno, Chiasso, Mendrisio and Lugano, with the last one as the central element of the system. Other factors which influenced and still influence territorial development and mobility can be the following: one tendency of the last 20 years was the concentration of workplaces, economies and consequently, population, especially around the pole of Lugano and to a lesser degree also the others. Nevertheless this tendency does not involve city centres but rather the suburbs. This fact is the origin of the increase in commuter numbers and in general of mobility within the canton. For instance it can be considered that in 1960 50% of the population was not working in their place of residence; in 1990 this value reached the 70%. As consequence of that, as well as for other reasons like the increase in international traffic and goods transports, the traffic on the main sections of the road network has tripled. This trend is a very important factor which can explain phenomena such as the dispersion of people from the cities toward the periphery and as consequential higher demand for mobility to and from workplaces, shopping centres, services, etc. (De

Gottardi, 2003). Some statistical data from a census performed every five years in Switzerland to quantify aspects of people's mobility provide an overview of mobility and travel behaviour in Ticino in comparison with the rest of Switzerland. At first it is interesting to analyse the mobility conditions, which is the ownership of cars, bikes, driving licences and season-tickets. As may be seen in Table 9.2 compared with the rest of Switzerland, Ticino has a higher motorization (no. of cars for household), a lower number of bikes per household and a much lower percentage of households with public transport season tickets. Concerning the season-tickets, the bigger difference between Ticino and the rest of Switzerland is for people with a Halbtax season ticket: 16% of people in Ticino as against the 35% in Switzerland as a whole.

Table 9.2 Mobility conditions: Ticino and Switzerland

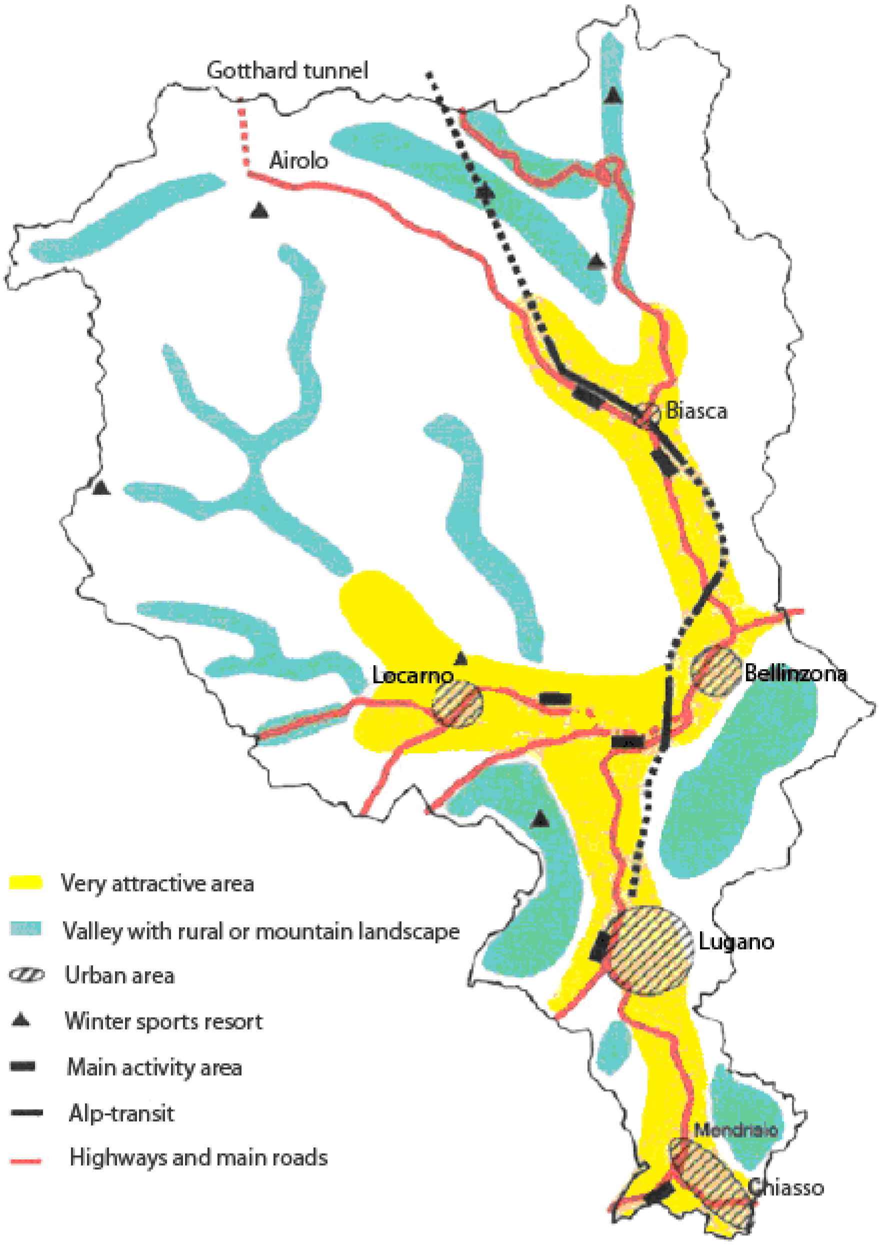
Indicator	Ticino	Switzerland
No. of cars per 100 households	129	117
Percentage of households with at least one car	85%	80%
Percentage of households with at least one bike	57%	72%
Percentage of households with public transport season-tickets	22%	48%

Source: UST-ARE 2001, elaboration Rapp trans AG

Still from the census it is possible to ascertain that the most common modes of transport are private modes (car, motorcycle), which dominate in terms of both number of trips and distance travelled; public transport covers just 14% of the distances and 6% of all day trips, while 37% of the all day trips, but 6% of the distance are made by bike or walking. On the other hand, when asked for their view on the Swiss transport policy, 85% of Ticino respondents seemed favourable to measures to improve and promote public transports, but mostly opposed to measures which penalise private traffic.

To conclude, Ticino households seem to have a rather moved behaviour from the Swiss average, as explained previously. The factors which may influence this situation are the following: the culture, the topography, the settlement structure and the transport supply (Moreni, 2003). First, the culture – more similar to the neighbouring Italian regions than to the rest of Switzerland – might be one factor working against greater use of bikes and public transport. Moreover, the use of private modes is favoured by the topography and the dispersion of settlement, factors which are adverse to bike and public transport use. Lastly, it might also be that the public transport supply, as well as cycling infrastructure do not reach yet the level of other parts of the country and do not sufficiently satisfy the mobility demands of Ticino's inhabitants.

Figure 9.1 Ticino territory with its main components and cities

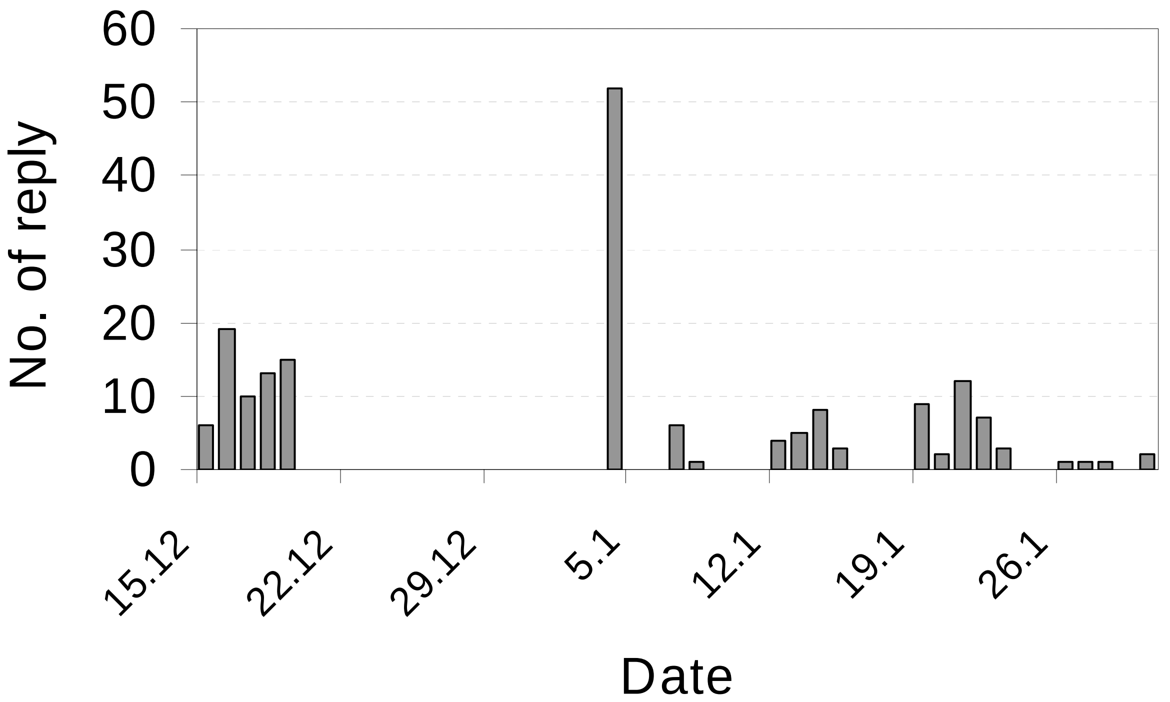


Source: UPD, may 2002

9.4 Response

The number of returned surveys from the sample of 500 persons chosen is 205. Within them, surveys 179 are usable, which represent a response rate of 36%. The survey was sent out on December 5. Figure 9.2. shows that the first answers arrived after 10 days; a large number was then received after the Christmas holidays and the last 10% was returned during January, after a follow-up reminder, sent to 120 persons selected from the previous list. The closing date for the data collection was January, 31st. In 114 usable surveys returned was also possible to identify the origin: that gave the possibility to analyse from which localities the respondents answered.

Figure 9.2 Responses received



9.5 Organising the data

Before the beginning of the analysis, the survey data need to be correctly organised. Since the survey was performed via post, a method to code the data must be chosen. Data are collected per individual, on the choice within the three approaches presented and on socio-demographic variables. Each respondent made choices from the choice set available and gave answers to the questionnaire. These choices are described in term of their variables. To code them, at first, each alternative got a number, which for the first test and the PE test varies from one to six and for the SC test varies between zero and one; the choices made from the respondents were coded with the number associated to the alternative. Secondly, with the help of a program, the variables level specific to the alternative chosen can be associated to the respondent. This routine was in this case performed with the help of the statistic program SPSS. The previous process can be clarified with one example. Let us consider the choice set presented in Table 7.1, concerning 'Bus stop and/or lane' experiment. For each of the six alternatives presented, as described previously, a value of safety, journey time, comfort and cost are listed. Referring to the coding method introduced previously, in the table considered, for example, alternative number five is 'More frequent buses through existing bus stops' and the relative value of safety is '0 victims avoided', of journey time is '-2 minutes', of comfort is '+3' and of cost is 70,000 SFr. If the respondent select the fifth alternative, with the help of SPSS, these variable levels are automatically associate to his choice within this experiment. A data set is then created, where each respondent generates *n* rows, one for each choice made. Decision must be taken over coding of attributes. There are different possibilities:

- some variable may take scalar values (i.e. the year of birth or the km driven last year). Such variables can simply be entered in their own units;

- other variables may take two or a predefined number of values (K). It is possible to differentiate them in two groups:

  - the values which the variable may take are ordinal; it is possible to establish an order across all of them (i.e. the no. of days travelling by car or by bike, the income), even if they are nominal. Such variables can be entered in their own units or can be grouped in categories; a binary dummy variable can then be created for each category;

  - the predefined number of values which the variable may take are categorical and it is not possible to order them (i.e. the feeling of safety after 10pm, described as very safe, enough safe, very unsafe, etc). In this case the only solution is the creation of K-1 dummy variables, each of them representing a different feeling of safety. The coding would be as shown in Table 9.3. As may be seen in this case K = 6 and the dummy variables are five (K-1). In fact, the last variable is recognized when none of the others have a value one.

Table 9.3 Coding of the question concerning 'Feeling of safety after 10pm in public transport'

	Dummy 1	Dummy 2	Dummy 3	Dummy 4	Dummy 5
Very safe	1	0	0	0	0
Safe enough	0	1	0	0	0
Rather unsafe	0	0	1	0	0
Very unsafe	0	0	0	1	0
I'm not around after 10pm for safety reasons	0	0	0	0	1
I'm not around after 10pm, but not for safety reasons	0	0	0	0	0

More specifically for the survey developed, it must be assessed that all variables within the three approaches used take ordinal values. Other variable types may be found within the personal questionnaire, coded as well for each respondent. In this way, the *n* rows representing the choices made from one respondent in the three approaches can be also associated with socio-demographic characteristics of the respondent himself.

9.6 Socio-demographic characteristics

The first analysis which will be done is a descriptive statistical analysis of the characteristics of the respondents and their habits.

9.6.1 Gender, Year of birth and Place of residence

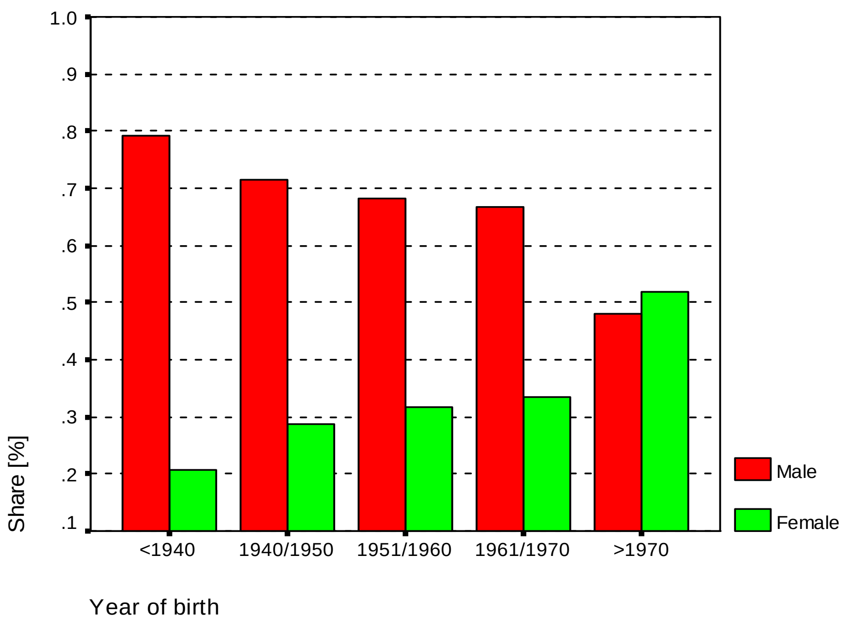
As clearly visible in Table 9.4, the majority of the 179 respondents (68 %) are men; 32% are women. This preponderance can also be seen within each age class, with a small majority of women only in the youngest category (see Figure 9.3).

Table 9.4 Year of birth by gender

Year of birth	Male	Col %	Row %	Female	Col %	Row %	All	Col %
<1940	23	19 %	79%	6	10%	21%	29	16%
1940-1950	30	25%	71%	12	21%	29%	42	23%
1951-1960	30	25%	68%	14	24%	32%	44	25%
1961-1970	26	21%	67%	13	22%	33%	39	22%
>1970	12	10%	48%	13	22%	52%	25	14%
All	121	100%	**68%**	58	100%	**32%**	179	100%

The *year of birth*, for the analysis, is divided in five classes, each comprising ten or more years. The respondents are distributed without noticeable peaks among the years of birth. It may be remarked that, despite the request for the survey to be filled out by the "member of the family, over 17 years old, whose birthday is the next to come up", which was included to make the sample more random, the impression, noticeable already from the phone calls, was that the household member who filled it was mostly a male of the family, husband or young son.

Figure 9.3 Year of birth by gender



Regarding the *place of residence*, as already mentioned, the sample was chosen from the five localities listed above. The answers (see Table 9.5) reflect that the most respondents live in a medium-sized city or a village close to a city. It can be noted that, although Lugano could be considered a big city, with more than 80.000 inhabitants as defined, just a few people referred to it as such. For this reason in the following analysis the category "big city" will be merged with "medium city" and this category will be named just "city".

After that consideration, also the origin of the usable surveys was analysed – for those were the origin was available in the form of address of the respondents. The origin could be identified from 114 out of 179 usable surveys returned. The results of this analysis are summarised in Table 9.6. As can be seen, already excluding the returned survey with missing address, in reality, respondent answering from Lugano were more than three, as the results from who declared to live in a big city show (see Table 9.5). This confirms the supposition that, even if many respondents are living in suburbs of Lugano or Locarno, which can be still considered as villages close to the city, also respondents living in the city themselves did not consider it as a big city, rather a medium city.

Table 9.5 Place of residence distribution

	Frequency	Percent
Big city (>80,000 inhabitants)	3	2%
Medium city (20,000 – 80,000 inhabitants)	105	**59%**
Village close to a city	44	25%
Village in a rural area	27	15%
All	179	100%

Table 9.6 No. of usable survey by place of residence

	City	Villages in the surroundings	All
Lugano	10	15	25
Locarno	13	10	23
Bellinzona	33	2	35
Biasca	26	–	26
Airolo	8	–	8
Address missing	62	–	62
All			179

9.6.2 Car availability, Disposition of the car and Km driven last year

It is noticeable from the values shown in Table 9.7 that most of the respondents, have a car available at all times, and the majority of the total number of respondents (see Table 9.8) owns the car. Some of them use a company car, also for private trips, but no one uses, for example other forms such as car-sharing. By looking at Table 9.9, which shows the different age classes for the respondents who have a car always available, it is visible that in each year class the majority of the respondents *owns a car*. The other categories are not very significant.

Table 9.7 Car availability distribution

	Frequency	Percent
Always	154	**88%**
Often	8	5%
Seldom	5	3%
Never	9	5%
All	176	100%

Table 9.8 Disposition of the car by car availability

	Car availability		
	Always	Not always	All
I own a car	142	3	145
	92%	14%	**82%**
At least one family member owns a car	6	7	13
	4%	32%	7%
A friend owns a car		3	3
		14%	2%
I have access to a company car, also for private trip	6		6
	4%		3%
Other form		1	1
		5%	1%
I do not have the use of a car		8	8
		36%	5%
All	154	22	176
	100%	100%	100%

Table 9.9 Disposition of the car by year of birth

	<1940	1940/1950	1951/1960	1961/1970	>1970	All
I own a car	20	40	37	27	18	142
	91%	98%	93%	84%	95%	92%
Other	2	1	3	5	1	12
	10%	2%	8%	15%	5%	8%
All	22	41	40	32	19	154
	100%	100%	100%	100%	100%	100%

Comparing the disposition of the car with place of residence, for respondents who have the car always available (see Table 9.10) it is relevant to see whether they live in a city, in a village close to a city or in a village in a rural area. The majority owns the car. The habit of owning a car does not depend on the size of the place of residence but is the normal status in this region.

Evaluating the variable Km driven by car in the last year (see Table 9.11) among people who own a car, the majority last year drove between 10,000 and 15,000 km; few people are driving more than 30.000 Km/year. It is also significant to analyse how the km driven are connected to the place of residence: it is visible that people living in the city are driving more km per year than people living in villages do. This could be seen from the higher percentage in the higher km classes (see) and from the higher number of mean km driven for people living in the city (see). This could mean that people living in villages use the car for shorter trips – for example, from and to the villages – where the car could be more competitive than public transport. People living in the city might use more public transports for shorter trips within the city and more the car for longer trips.

As can be seen in the tables already presented and in the following ones, the value representing the total number of surveys returned, in some cases, is slightly different from the total number of surveys returned (179). The reason for that is the presence of missing answers related to some questions.

Table 9.10 Disposition way of the car by place of residence

Disposition of the car	City	Village close to a city	Village in rural area	All
I own a car	85	35	22	142
	93%	92%	88%	92%
Some familiar owns a car	2	1	3	6
	2%	3%	12%	4%
Access to a company car, also for private trips	4	2		6
	4%	5%		4%
All	91	38	25	154
	100%	100%	100%	100%

Table 9.11 Km driven by car last year among people who own a car

km driven by car	Frequency	Percent
0-5000	14	10%
5001-10.000	28	20%
10.001-15.000	35	25%
15.001-20.000	27	19%
20.001-30.000	26	19%
>30.000	10	7%
All	140	100%

Table 9.12 Mean number of km driven by car last year by places of residence

Places of residence	Mean number of km
City	20,933
Village close to the city	14’907
Village in rural area	15’945

Table 9.13 Km driven by car last year by places of residence

km driven by car	City	Village close to a city	Village in rural area	All
0-10,000	26	19	9	54
Row %	48%	35%	17%	100%
Col %	27%	46%	41%	34%
10,001-20,000	44	15	7	66
Row %	67%	23%	11%	100%
Col %	46%	37%	32%	42%
>20,000	26	7	6	39
Row %	67%	18%	15%	100%
Col %	27%	17%	27%	25%
All	96	41	22	159
	100%	100%	100%	100%

9.6.3 Public transport usage

The analysis shows the ownership of public transport passes by year of birth, place of residence and by car availability (see Table 9.14 - Table 9.16). Concerning the *GA*[6], within each age group the great majority of the respondents do not possess it; nor does the place of residence make any difference. Even the influence of the factor car availability is not discernible, owing to the very small numbers of owners. In order to explain this result, an assumption could be that for an inhabitant of Ticino it is not worth buying this kind of (Swiss-only) season ticket because of the short travel distances within the canton and the few possible direct journeys to other regions of Switzerland. On the other hand, knowing that the national average of people owning a GA is only slightly higher (personal communication, Prof. Axhausen), the previous interpretation should be corrected. It might be then assumed that not particularly the factor territory displacement within Switzerland influences the possession of the GA; rather, the GA is not yet evaluated as competitive as the car, especially for people

6 'General Abonnement': Swiss season ticket covering all public transports within Switzerland for a fixed period of time (one, two years).

who make only small displacements, even if the directs and indirect cost associated with a car can be much higher than a GA – perhaps more hidden.

For the *Halbtax*[7] season ticket the difference between who does and does not possess it is slightly smaller. That is visible for respondents born between 1951 and 1960, of whom about 37% do possess it, rather than for younger and older categories. Among different places of residence the difference is smaller for respondents living in the city, who may be better served by public transport than in villages and thus more motivated to use it. Table 9.16 shows also that, in any case, among respondents who do possess the Halbtax-Abo, the majority has a car always available. This means that also this discount card is not really seen as a substitute for the car.

Lastly, the *regional season ticket* is also not very common. A minimal increase is observed for younger respondents and for those living in villages in rural areas. The reasons can be the kind of trips, which might be the regular ones to schools or shopping places. Another explanation might be the availability of the car, not always possible for younger and older people.

Table 9.14 GA, Halbtax Abo, Season ticket by year of birth

Year of birth	<1940		1940/1950		1951/1960		1961/1970		>1970	
GA YES	1	3%	2	5%	1	2%	3	8%	1	4%
Halbtax-Abo YES	7	24%	3	7%	16	37%	4	10%	6	24%
Season ticket YES	4	14%	4	10%	3	7%	4	10%	4	16%

7 Swiss season ticket which gives 50% reduction for trains and other public transports within Switzerland for a fixed period of time (one, two years).

Table 9.15 GA, Halbtax Abo, Season ticket by place of residence

Living Place		City	Village close to the city		Village in rural area	
GA YES	7	6%			1	4%
Halbtax-Abo YES	24	22%	8	19%	4	15%
Season ticket YES	12	11%	3	7%	4	15%

Table 9.16 GA, Halbtax Abo, Season ticket by car availability

Car availability classes	Not always available		Always available	
GA YES	3	14%	5	3%
Halbtax-Abo YES	5	23%	30	20%
Season ticket YES	7	32%	11	7%

The results of these last three analyses are clearly connected with the answers about the number of days travelling by car, public transport and bike last week. From Table 9.17 it is noticeable that, within each age group, the mean of days travelling by car is between four and five, by public transport is below one, except for younger respondents, and by bike is not even reaching one, although factors such as the season might have a big influence. Among different places of residence (see Table 9.18), the highest mean number of days travelling by car occurs for inhabitants of villages close to a city, who also have the lowest mean of days travelling by public transport. From Table 9.19, which shows just the days travelling by different modes grouped for different places of residence, can also be clearly observed that a high number of respondents use the car most of the time. It is particularly interesting to note, as mentioned before, that people who travel frequently by car (5-7 days/week), mostly live in village close to the city, whereas people travelling by car less often (1-4 days/week), are living mostly in cities or villages in rural areas. Concerning public transport, even if the values are not really significant, it is observable that the highest percentage of respondents not using public transport is among inhabitants of cities and the highest percentage of respondents using public transport often is among inhabitant of villages in rural areas. Finally, Table 9.20 relates the mean number of days travelling by different modes with the gross family income per month. Concerning the mean number of days travelling by car, the distribution among the different incomes shows that the higher values are related to respondents with an income between 4,000 and 8,000 SFr/month, which is the income class, as will be seen later, that represents the majority of the respondents. Respondents with lower income seem to use less days per week the car and more the public transports; it represents probably the category of younger respondents, as visible in Table 9.17. Concerning mean number of day travelling by bike, the values are nearly the same for all income levels.

Table 9.17 Mean number of days travelling by car, bike and public transport last week by year of birth

Year of birth	Days travelling by car last week	Days travelling by public transport last week	Days travelling by bike last week
<1940	4.11	0.81	0.11
1940-1950	4.78	0.78	0.37
1951-1960	4.84	0.84	0.89
1961-1970	4.59	1.00	0.74
>1970	4.57	1.13	0.35
All	4.62	0.90	0.54

Table 9.18 Mean number of days travelling by car, bike and public transport last week by place of residence

Place of residence	Days travelling by car last week	Days travelling by public transport last week	Days travelling by bike last week
City	4.43	0.93	0.56
Village close to a city	5.02	0.77	0.65
Village in rural area	4.73	0.96	0.27
All	4.62	0.90	0.54

Table 9.19 Days travelling by car, bike and public transport last week for different places of residence

	Days travelling last week	City		Village close to a city		Village in a rural area	
By car	0	8	8%	3	7%		
	1-4	41	39%	10	23%	11	42%
	5-7	56	**53%**	30	**70%**	15	**58%**
All		105	100%	43	100%	26	100%
By public transport	0	74	70%	29	67%	17	65%
	1-4	22	21%	12	28%	6	23%
	5-7	9	9%	2	5%	3	12%
All		105	100%	43	100%	26	100%
By bike	0	88	84%	34	79%	23	88%
	1-4	11	10%	6	14%	3	12%
	5-7	6	6%	3	7%		
All		105	100%	43	100%	26	100%

Table 9.20 Mean number of days travelling by car, bike and public transport last week by gross family income

Gross family income (SFr/month)	Days travelling by car last week	Days travelling by public transport last week	Days travelling by bike last week
<4,000	3.39	1.48	0.52
4,001-8,000	4.86	0.81	0.36
>8,000	4.79	1.18	0.88
All	4.61	1.01	0.51

9.6.4 Accidents and ownership of driving licence

An overview on the experience of respondent's accidents is shown in Table 9.22. Among all respondents about 61% had an accident within the categories listed. It must be mentioned that a category is only listed when it was used by at least three respondents. A more specific analysis is then performed for the accidents while driving a car, as it is the category with larger values. It is interesting to compare this category with others such as age groups , year of acquisition of driving licence and km driven by car last year. As shown in Table 9.21, the majority of respondents have a driving licence, so that we could even consider non-drivers as being exceptional.

Table 9.21 Possession of driving licence

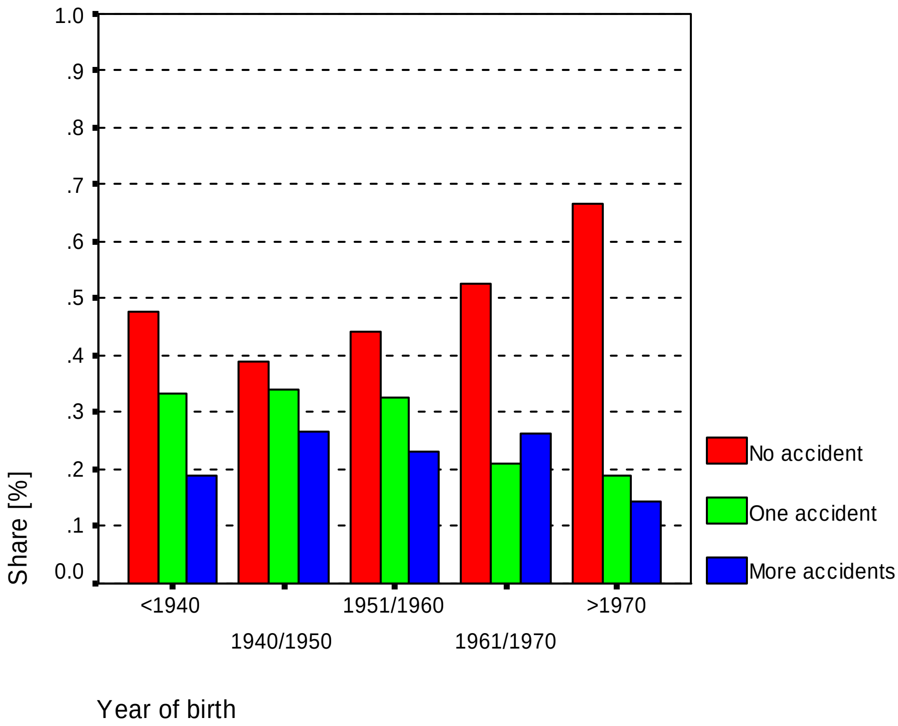
Answers	Frequency	Share
No	10	6%
Yes	169	94%
All	170	100%

Table 9.22 Overview of the number of accidents with different transport modes

Accident-type	Number of accidents	Frequency	Percent
All types	0	68	39%
	≥1	107	61%
No. of accidents while driving a car	0	89	51%
	1	47	27%
	2	23	13%
	3	8	5%
	5	5	3%
No. of accidents while car passenger	0	144	82%
	1	23	13%
	2	6	3%
No. of accidents while driving a motorbike	0	160	91%
	1	14	8%
No. of accidents while riding a bike	0	161	92%
	1	10	6%
	2	3	2%
No. of accident while walking	0	170	97%
	1	3	2%
No. of accident while travelling by public transport	0	171	98%
	1	4	2%

Within different *age groups* (see Figure 9.4), excluding respondents without driving licence the percentage of respondents who had had no accidents gets higher the younger people are, as the time spent driving is less and the probability to have an accident is low. Conversely, the percentage of respondents who had one or more accidents decreases from older to younger respondents. An exception is represented from the lowest year of birth class, which shows a really high percentage of respondents reporting no accidents and a lower percentage reporting one or more accidents, which does not follow the general trend.

Figure 9.4 Accident while driving a car by age class, excluding respondents without driving licence



Among different classes of *year of acquisition of driving licence*, the distribution seems slightly different. The percentage of respondents with more than one accident shows a decreasing trend over years; the trend is different for respondents who had no accidents or just one. The second category has a peak for driving licence acquired between 1971 and 1980; the first has a peak for driving licence acquired between 1961 and 1970 and high values for younger categories. Comparing Figure 9.4 and Figure 9.5 different suppositions can be made: the category of older respondent, with high percentage of "no accidents" may have acquired their driving licence later than people usually do nowadays; the performance and the kind of car at present are substantially different from fifty years ago and that led to an increase in the percentage of older respondents with more than one accident; many older people do not drive any more and the few who drive have had one or more than one accident.

Figure 9.5 Accident while driving a car by different year of acquisition of the driving licence

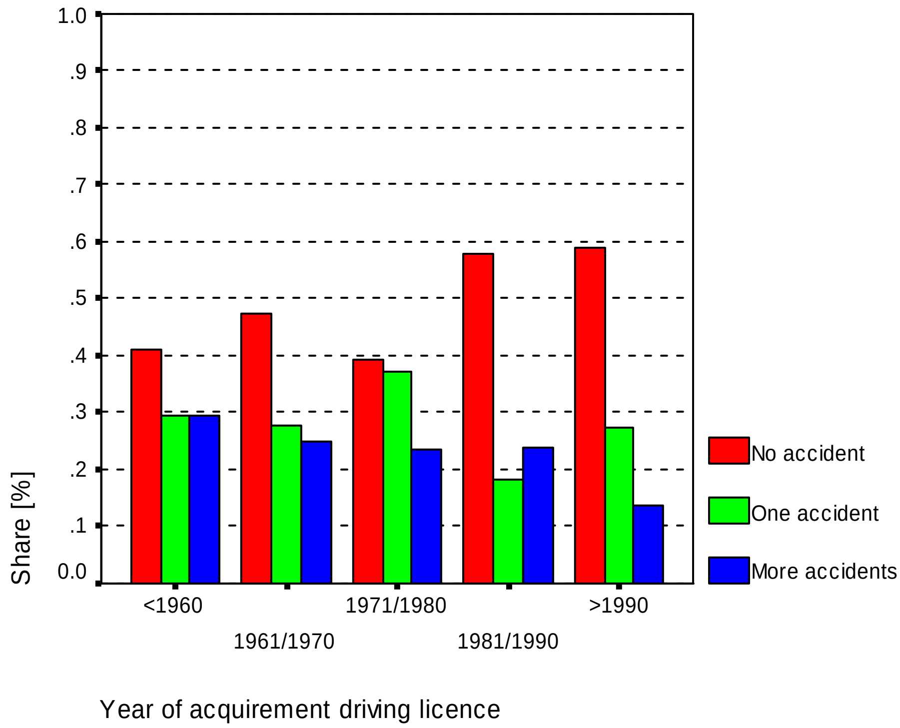
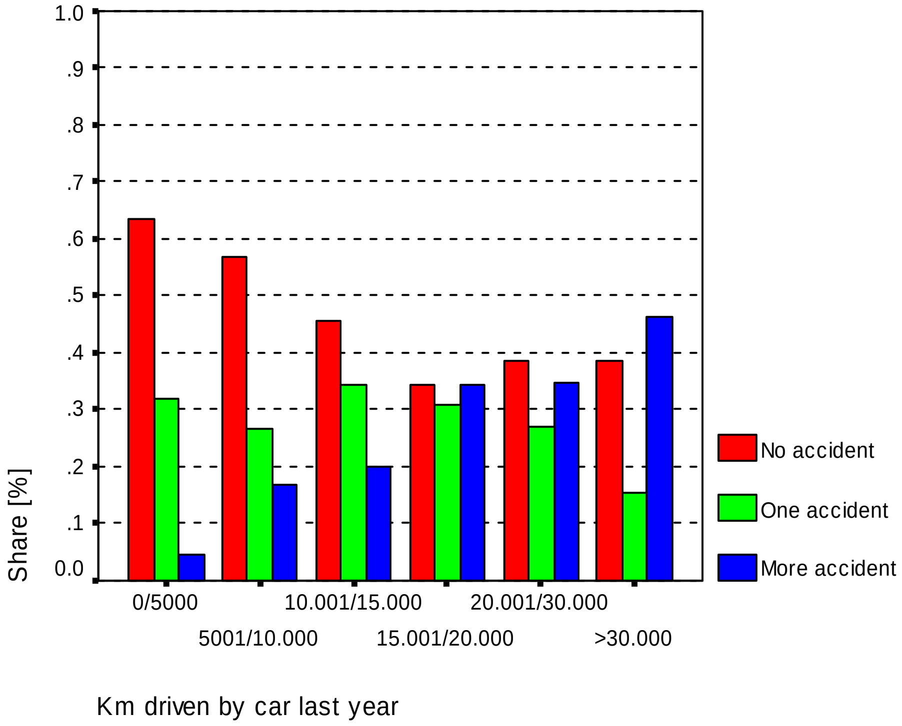


Figure 9.6 shows that the percentage of respondents with no accidents decreases with the km whereas the percentage of respondents with more than one accident increases. On the other hand, the percentage of respondents with one accident varies quite irregularly among the different km classes: this could represent the randomness of an accident occurrence, that depends not only on the number of km driven, but also on many other factor such as, for example, condition of the driver, quality of car, purpose of the trip etc.

Figure 9.6 Accident while driving a car by different km driven by car last year



9.6.5 Feeling of personal safety after 10pm

The questions addressed referred to the feeling of safety after 10pm in residential area and the feeling of safety after 10pm in public transport. The answers will be analysed by gender, year of birth and living places.

Concerning *residential area*, distinguishing by gender (see Table 9.23) the tendency of males is to feel very safe or safe enough, where most females feel "safe enough". Furthermore, no one seems to avoid travelling for safety reasons. Within different age groups (see Table 9.25) it is noticeable that people of any age feel mostly safe enough and the older people who travel after 10pm even very safe. The place of residence analysis (see Table 9.24) shows a similar result, with a slightly higher percentage of city dwellers who feel unsafe.

Table 9.23 Feeling of safety after 10pm in residential area by gender

	Male		Female	
very safe	46	38%	6	11%
safe enough	50	**42%**	26	**47%**
rather unsafe	8	7%	10	18%
very unsafe	2	2%	2	4%
not around after 10pm for safety reason			4	7%
not around after 10pm but not for safety reasons	14	12%	7	13%
All	120	100%	55	100%

Table 9.24 Feeling of safety after 10pm in *residential area* by place of residence

	City		Village close to a city		Village in rural area		All	
very safe	31	30%	11	26%	9	35%	51	29%
safe enough	46	**44%**	18	**42%**	12	**46%**	76	44%
rather unsafe	13	12%	3	7%	2	8%	18	10%
very unsafe	2	2%	1	2%	1	4%	4	2%
not around after 10pm for safety reasons	4	4%					4	2%
not around after 10pm but not for safety reasons	9	9%	10	23%	2	8%	21	12%
All	105	100%	43	100%	26	100%	174	100%

Table 9.25 Feeling of safety after 10pm in *residential area* by year of birth

	<1940	1940-1950	1951-1960	1961-1970	>1970
very safe	9	13	11	9	9
	33%	32%	25%	23%	39%
safe enough	6	19	21	21	9
	22%	**46%**	**48%**	**54%**	39%
rather unsafe	3	3	5	3	4
	11%	7%	11%	8%	17%
very unsafe	1	1		1	1
	4%	2%		3%	4%
not around after 10pm for safety reason	2	1		1	
	7%	2%		3%	
not around after 10pm but not for safety reasons	6	4	7	4	
	22%	10%	16%	10%	
All	27	41	44	39	23
	100%	100%	100%	100%	100%

In *public transport* the situation is almost the same for all the different specific analyses (see Table 9.26 -Table 9.28); it is perhaps remarkable that most of the respondents do not use public transport after 10pm, but not for safety reasons. The main exception is younger respondents, who mostly feel safe enough. These results on safety mirrors, first, the locality's size – medium-sized city or town – where people still tend to feel safe. Secondly, it could reflect the lack of a really well-developed night public transport system.

Table 9.26 Feeling of safety after 10pm in *public transport* by gender

	Male		Female	
very safe	17	15%	4	
safe enough	37	32%	14	26%
rather unsafe	7	6%	12	22%
very unsafe	1	1%		
not using public transport for safety reasons	1	1%	2	4%
not using public transport but not for safety reasons	54	**46%**	22	**41%**
All	117	100%	54	100%

Table 9.27 Feeling of safety after 10pm in *public transport* by year of birth classes

	<1940	1940-1950	1951-1960	1961-1970	>1970
very safe	6	3	4	4	4
	22%	8%	9%	11%	17%
safe enough	3	14	15	9	9
	11%	36%	34%	24%	**39%**
rather unsafe	3	1	5	7	3
	11%	3%	11%	19%	13%
very unsafe			1		
			2%		
not using public transport for safety reasons	3				
	11%				
not using public transport but not for safety reasons	12	21	19	17	7
	44%	**54%**	**43%**	**46%**	30%
All	27	39	44	37	23
	100%	100%	100%	100%	100%

Table 9.28 Feeling of safety after 10pm in *public transport* by place of residence

	City		Village close to a city		Village in a rural area		All	
very safe	13	13%	5	12%	3	12%	21	12%
safe enough	32	31%	11	26%	7	28%	50	29%
rather unsafe	13	13%	4	10%	2	8%	19	11%
very unsafe	1	1%					1	1%
not using public transport for safety reasons	2	2%	1	2%			3	2%
not using public transport but not for safety reasons	42	**41%**	21	**50%**	13	**52%**	76	45%
All	103	100%	42	100%	25	100%	170	100%

9.6.6 Gross family income/month

The last two questions addressed to the respondents were concerned with the *gross family income per month* and the *number of persons contributing to the family budget*. These questions, not directly connected to the others, are significant to the following analysis. An overview of the respondents' situation can be seen in Table 9.29. It can be seen that in the majority of the families one or two members are contributing; with one contributor, the income is mostly between 4000 and 8000 SFr/month, with two contributors between 6000 and 8000 SFr/month. As visible from the total number of valid answers to this question, 22 respondents did not answer to this question – 19 did not specify the income, 3 did not specify the number of persons contributing. These respondents represent about the 12% of the total usable survey received.

Table 9.29 Gross family income per month and number of persons contributing

Income	No. of contributors to the family budget									
	1		2		3		4		All	
<2000	6	7%	1	2%					7	4%
2000-4000	12	13%	5	8%	1	33%			18	11%
4001-6000	30	33%	12	20%			2	50%	44	28%
6001-8000	26	29%	14	23%					40	25%
8001-10,000	8	9%	12	20%	1	33%	1	25%	22	14%
10,000-12,000	3	3%	7	12%	1	33%			11	7%
> 12,000	5	6%	9	15%			1	25%	15	10%
All	90	100%	60	100%	3	100%	4	100%	157	100%
No answer										22

It is interesting to compare income with possession of a season-ticket such as GA or Halbtax-Abo, to analyse how much the factor "income" influences the choice of purchasing them or not (see Table 9.30). Concerning the GA this analysis does not give much information, but concerning the Halbtax-Abo it is noticeable that, when income is growing, although the majority of the respondent in any income class do not possess it, the percentage of those with Halbtax-Abo is also increasing. It must be explained that the two percentages highlighted in bold may look smaller than those calculated in Table 9.15 and Table 9.16: the reason is the presence of missing values related to the question of gross family income.

Table 9.30 Ga and Halbtax Abo possession compared with gross income per month

	GA Yes		Halbtax-Abo Yes	
<2000			1	14%
2000-4000			2	11%
4001-6000	5	11%	4	9%
6001-8000			11	28%
8001-10,000	2	9%	5	22%
10,000-12,000			5	45%
>12,000			5	33%
All	7	**4%**	36	**20%**

9.7 Descriptive analysis of the test without budget constraint

As introduced previously, this first test, similar in shape to the PE approach, does not include any budget constraint. Its aim is mainly to get the people in touch with the questions proposed afterwards. The following analysis investigates which kind of alternatives the respondents preferred among the six proposed in each improvement situation. Each subchapter will present one of the four situations proposed linked with socio-demographic characters of particular interest for the results obtained. The number of usable test without budget constraint received is 166; those not usable are either missing or the respondents selected more than one alternative in each experiment presented.

9.7.1 Bus stop and/or bus lane improvements

This situation is interesting to observe by comparing the three different places of residence considered in the previous analysis. As may be seen in Table 9.31, the majority of respondents for each place of residence considered chose the alternative ‘New bus stop, bus lane independent from the car lane’. The highest percentage of respondents who made this choice is found among the inhabitants of villages close to the city. By consulting the survey in Appendix it may be seen that this alternative is the most expensive proposed, but also the one which avoids more victims per year. Among the other alternatives the least appreciated in every place of residence is the possibility of having 'All existing bus stops with more information and facilities'. The interpretation could be that there is more need of improvement in the bus service rather that in the existing bus stops. It is also noticeable that, without any budget restriction the respondents are inclined to choose the bus stop alternative which provides the larger improvement.

Table 9.31 Bus stop and/or bus lane improvement by different places of residence

	City	Village close to the city	Village in rural area	All
New bus stop, bus lane not independent from car lane	3			3
	5 %			3 %
Space for new bus stop, bus lane not independent from car lane	10	5	2	17
	17 %	26 %	11 %	18%
New bus stop and bus lane independent from the car lane	24	10	8	42
	40 %	**53 %**	44 %	**43 %**
All existing bus stops with more information and facilities	2		1	3
	3 %		6 %	3 %
More frequent buses through existing bus stops	15	4	4	23
	25 %	21 %	22 %	24 %
Present situation (8 bus stops, every 600 m)	6		3	9
	10 %		17 %	9 %
All	60	19	18	97
	100 %	100 %	100 %	100 %

9.7.2 Night security

In this situation too the factor place of residence might bring some interesting information (see Table 9.32). It may be seen that within each place of residence the majority –almost half of respondents– selected the increase in lighting. Despite the relatively small sample size, it is also possible to observe a different distribution among the other choices by place of residence. Although the increase in lighting seems to be the dominant choice, also the improvement concerning the increase of night buses is to some extent remarkable. This second observation can somehow be linked with the high percentage of respondents who do not use public transport in the evening, not for security reasons, but rather because of the lack of service offered (see Table 9.28).

Table 9.32 Night security by different places of residence

	City	Village close to the city	Village in rural area	All
More night buses	8	3	2	13
	11 %	11 %	10 %	11 %
More night security guards or policemen	5	1	4	10
	7 %	4 %	20 %	8 %
Increase in the lighting	36	14	8	58
	48 %	**50 %**	**40 %**	**47 %**
All traffic lights also working at night	17	6	2	25
	23 %	21 %	10 %	20 %
Illuminated road signs	6	1	1	8
	8 %	4 %	5 %	7 %
Present situation	3	3	3	9
	4 %	11 %	15 %	7 %
All	75	28	20	123
	100 %	100 %	100 %	100 %

9.7.3 Speed control

The analysis of the speed control options on the road will be by different classes of days travelling by car last week. Thus, respondents not travelling by car are excluded from this analysis, but, as may be seen from Table 9.33, the percentage of those travelling by car more than one day a week is are much higher than that for bus and bike. It may be observed that, although the number of respondents in each category is not very high, therefore not so representative, the majority, in each of them, chose the alternative of two intelligent traffic lights provided with a photocell, which detects whether or not the speed limit is respected. This option is in fact one of the solutions which does not represent a disadvantage to all road users, but only for those not respecting the speed limits. By looking at the variables associated with this alternative (see survey in Appendix), also the value of safety is quite positive, as well as the comfort; the journey time increases, but just in the case the limit is not respected.

Concerning the other alternatives, it may be seen that, for example, the solution with speed camera – and thus the likelihood of receiving a fine – or high and larger bumps every km are less appreciated by people who drive more often, who are also more satisfied with the present situation than people who rarely drive. The percentage of respondents satisfied with the present situation is anyhow much lower than those who prefer one kind of improvement.

Table 9.33 Speed control by days travelling by car last week.

	0	1-4	5-7	All
Obligatory route with many curves		1	6	7
		3%	10%	6%
Narrow and low bumps every 800 m		5	6	11
		13%	10%	10%
High and larger bumps every km	1	8	13	22
	20%	20%	21%	20%
Two intelligent traffic lights	4	17	25	46
	80%	**43%**	**40%**	**43%**
Speed camera every km		8	2	10
		20%	3%	9%
Present situation		1	11	12
		3%	17%	11%
All	5	40	63	108
	100%	100%	100%	100%

9.7.4 Crossroads with bad visibility

This last situation, as shown in Table 9.34, is analysed in correlation with the three different places of residence. Once more, even if the fairly low values do not seem representative of the places of residence classes, it is noticeable that the majority of the respondents, from each places of residence, selected the alternative Traffic light with photocell, which, looking at the survey in Appendix, results in a relatively expensive but very safe and comfortable alternative. A second quite high percentage of respondents in all places selected the alternative of the roundabout, which is very expensive, but also safe, time saving and comfortable. A difference between city and villages is visible for other choices: higher percentages of village inhabitants selected traffic light regulated "a priori"– perhaps not so convenient in a city with a higher traffic density; mirrors in every corner with bad visibility, were perhaps not felt to be safe enough solution in a city. Lastly, it is noticeable that for all three places of residence the percentage of respondents satisfied with the present situation is quite low.

Table 9.34 Crossroads with bad visibility by places of residence

	City	Village close to the city	Village in rural area	All
Roundabout	29	11	7	47
	29%	29%	26%	28%
Mirrors just in corner with angle ≤ 90°	2	2		4
	2%	5%		2%
Mirrors in every corner with bad visibility	3	5	4	12
	3%	13%	15%	7%
Traffic light with photocell	52	14	10	76
	52%	**37%**	**37%**	**46%**
Traffic light regulated "a priori"	11	5	4	20
	11%	13%	15%	12%
Present situation	3	1	2	6
	3%	3%	7%	4%
All	100	38	27	165
	100%	100%	100%	100%

9.8 Descriptive analysis of the PE approach

Within this second approach, as specified in Chapter 6.1.2., the respondents received a set of three experiments, in part similar to those of the previous test, and a budget constraint. Because of this restriction, most respondents in the pilot test changed their choices, slightly or completely, to adapt the combination of options to the budget. The following analyses, instead of being matched with socio-demographic characteristics as previously, are looking at the three levels of budget offered; this will allow for the comparison of the influence of a smaller or larger budget constraint and the evolution of the respondents choices. In each section the alternatives and the relative costs are also presented, in order to compare the choices directly with their costs. Some of the experiments are the same as in the previous test, for example 'Bus stop and/or bus lane improvement', 'Night security' and 'Speed control' so that is possible to contrast them with the situation without budget.

Before the analysis of the experiments it is interesting to give some information about the PE tests received. The total number of usable PE tests received is 162: 52 with a budget constraint of 500,000 SFr, 57 with a budget constraint of 600,000 SFr and 53 with a budget constraint of 800,000 SFr. The PE test was considered usable when the sum of the costs of the three choices made did not exceed the budget given. Exceptionally, since some respondents made their choices exceeding the budget given, those whose surplus was equal or less than 50,000 SFr were also taken into consideration – in this case seven more PE tests were considered (one exceeded 5,000 SFr, two 10,000 SFr, one 15,000 SFr, two 20,000 SFr and one 50,000 SFr). Among the respondents whose surplus was more than 50,000 SFr, if the address was available, a new PE test was sent explaining the misunderstanding and asking for a new reply. 27 PE tests were sent back, 24 respondents replied (14 for budget 500,000 SFr, 7 for 600,000 SFr and 3 for 800,000 SFr), which allowed the value of 162 usable PE tests to be reached.

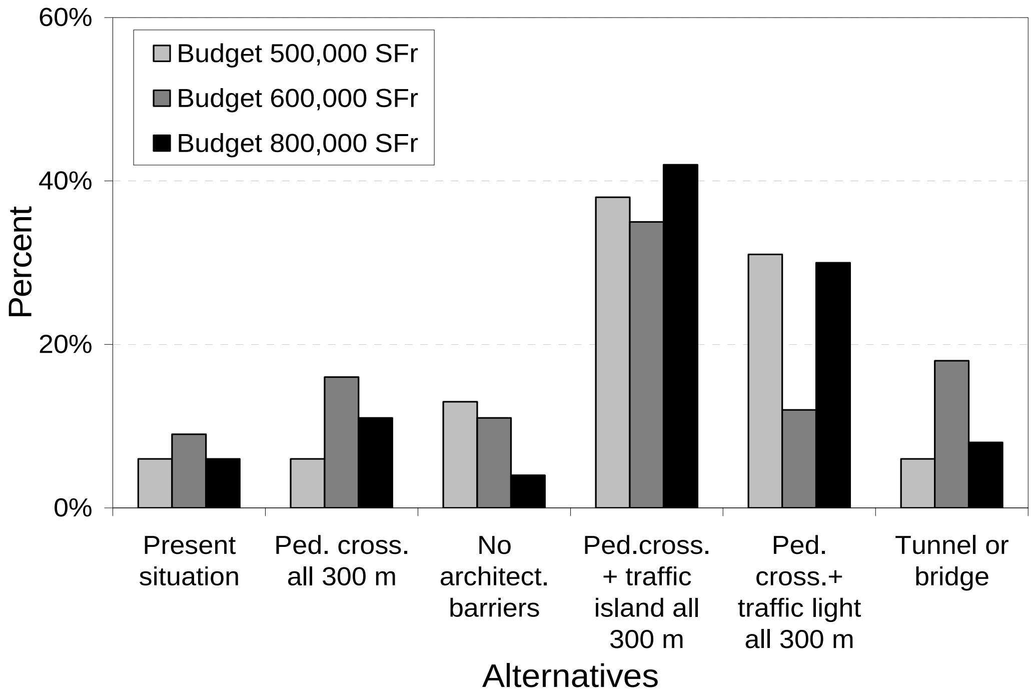
9.8.1 Pedestrians

Figure 9.7 shows for this experiment the alternatives proposed ordered from the cheapest to the most expensive (see Table 9.35).For all three budgets proposed the alternative most selected was 'Pedestrian crossing with traffic islands every 300 m', with a medium price. For this alternative it is noticeable a slight, but not very remarkable, difference between the three budgets. The distribution for the other alternatives does not show a particular trend relative to the budget; i.e. the most expensive one is chosen most by respondents with a budget of 600,000 SFr not by those with 800,000 SFr.

Table 9.35 'Pedestrians' alternatives by cost

Alternatives description	Cost (SFr)
Elimination of architectural barriers	90,000
Pedestrian crossing every 300 m	50,000
Pedestrian crossing with traffic islands every 300 m	150,000
Pedestrian crossing with traffic light every 300 m	200,000
A tunnel or bridge across the road	500,000
Present situation	None

Figure 9.7 Distribution of the choices by budget constraint for the 'Pedestrians' experiment



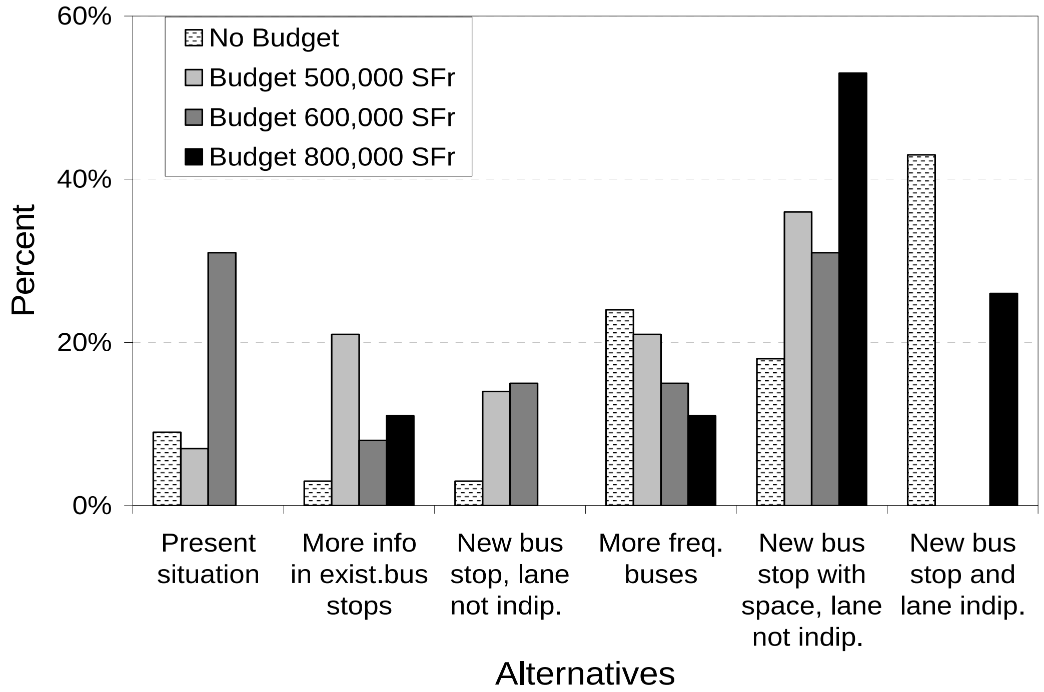
9.8.2 Bus stop and/or bus lane improvement

This experiment, as mentioned previously, is available both in the PE test and in the test without budget constraint. In this case, the influence of different levels of budget is clearer. In fact, when in the previous test a high percentage of respondents selected the alternative 'New bus stop and bus lane independent of the car lane', which is the most expensive, in this case this alternative was selected only by respondents with a budget of 800,000 SFr (see Figure 9.8). It is also noticeable that a very low percentage of respondents with larger available budget selected cheaper solutions and no one for example chose the present situation, a result similar to the previous test without budget constraint. It is, then, clearly demonstrated here how the PE experiment represents, more than a simple multiple choice test, a way to make the respondents trade-off between alternatives in a situation more similar to the reality, where the money is generally a binding constraint.

Table 9.36 'Bus stop and/or bus lane improvement' alternatives by cost

Alternatives description	Cost (SFr)
New bus stop, bus lane not independent	60,000
Space for new bus stop, bus lane not independent	200,000
New bus stop and bus lane independent of the car lane	400,000
All existing bus stops with more information and facilities	20,000
More frequent buses through existing bus stops	70,000
Present situation (8 bus stops, every 600 m)	None

Figure 9.8 Distribution of the choices by budget constraint for the experiment 'Bus stop and/or bus lane improvement'



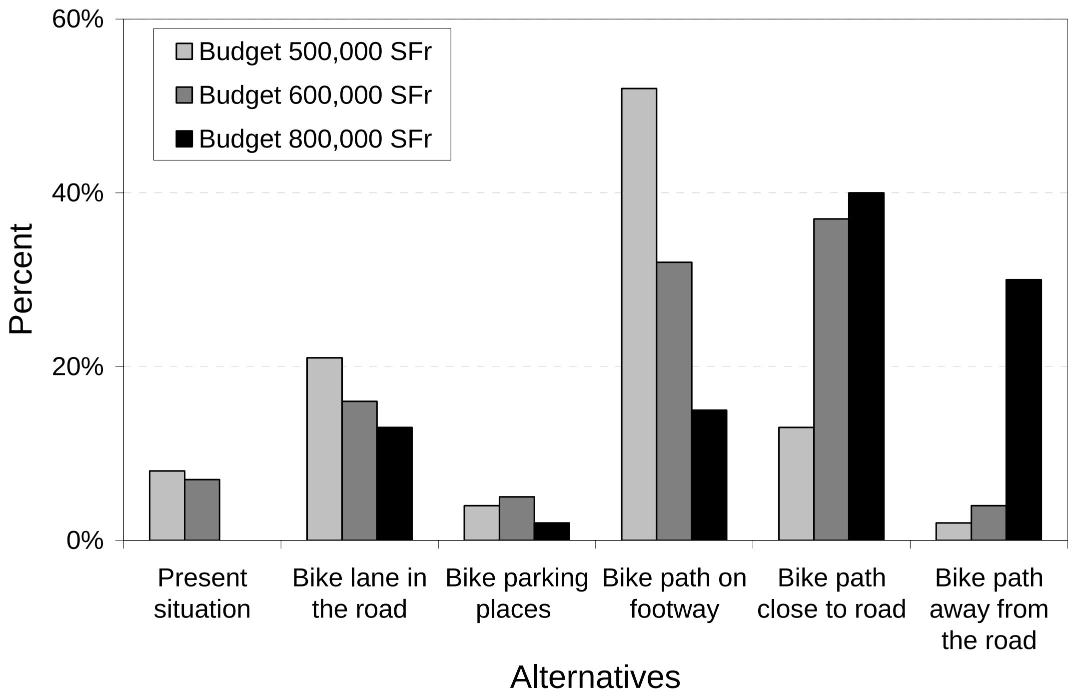
9.8.3 Bike facilities

In this experiment it is possible to make a few observations from the analysis of Figure 9.9. First, it may be seen how the budget influenced the selection, especially for respondents with a high budget available: their choices are concentrated on alternatives with higher prices. Furthermore, it is noticeable that a solution with more impact on comfort than on safety, such as 'Covered parking places for bikes close to bus stops', is not really competitive with all the others, even if the cost is quite low. Finally, the alternatives most preferred are two kinds of bike path, both close to the road. The third kind of bike path, as noticed also during the direct contact with the respondents, is perceived as a too big investment compared with the real usage of this infrastructure.

Table 9.37 'Bike facilities' alternatives by cost

Alternatives description	Cost (SFr)
Bike lane in the road	80,000
Bike path on the footway	100,000
Bike path divided from footway, close to the road	400,000
Bike path faraway from the road	500,000
Covered parking places for bikes close to bus stops	95,000
Present situation	None

Figure 9.9 Distribution of the choices by budget constraint for the experiment 'Bike facilities'



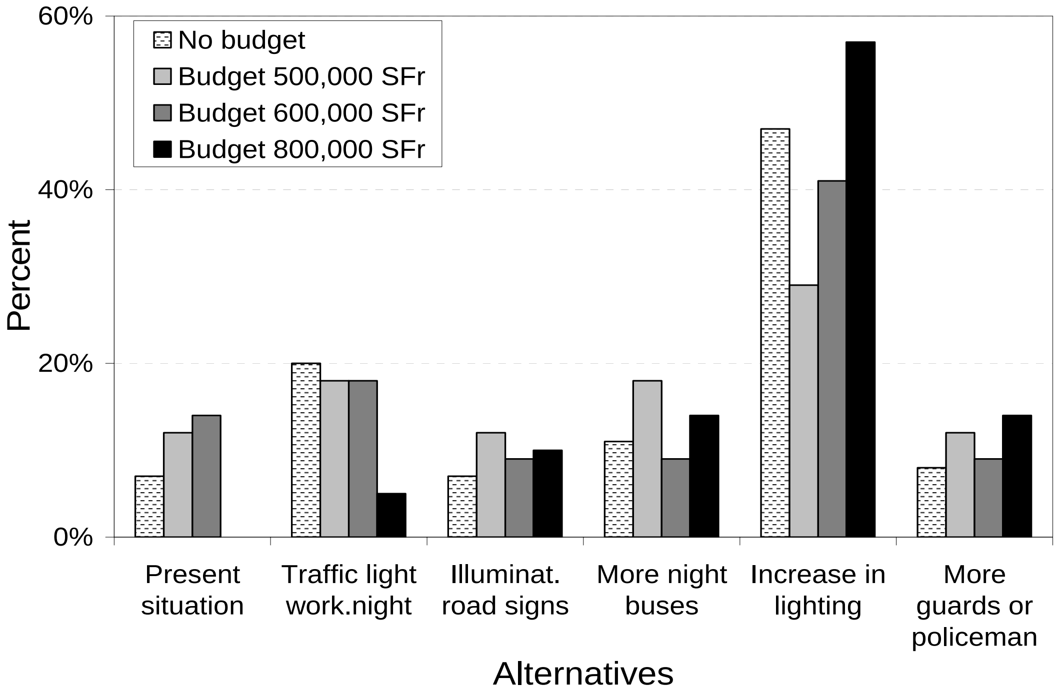
9.8.4 Night security

This experiment, available also from the test without budget constraints, follows a particular trend (see Figure 9.10). The most frequently chosen alternative is the increase in lightning, as in the previous test, for all three budgets, which is the second most expensive but also the one offering the highest value in safety (see survey in Appendix). The choices of the respondents with a high budget available, grows enough regular with the costs of the alternatives; the other respondents do not follow a special trend. In any security case is quite clear that the possibility of more security guards or policemen is not much appreciated; probably it is not seen as an efficient solution to improve security at night, or not convenient for the price offered.

Table 9.38 ‘Night security’ alternatives by cost.

Alternatives description	Cost (SFr)
More night buses	70,000
More security guards or policemen	150,000
Increase in the lighting	100,000
All traffic lights also working at night	5,000
Illuminated road signs	10,000
Present situation	None

Figure 9.10 Distribution of the choices by budget constraint for the experiment 'Night security'



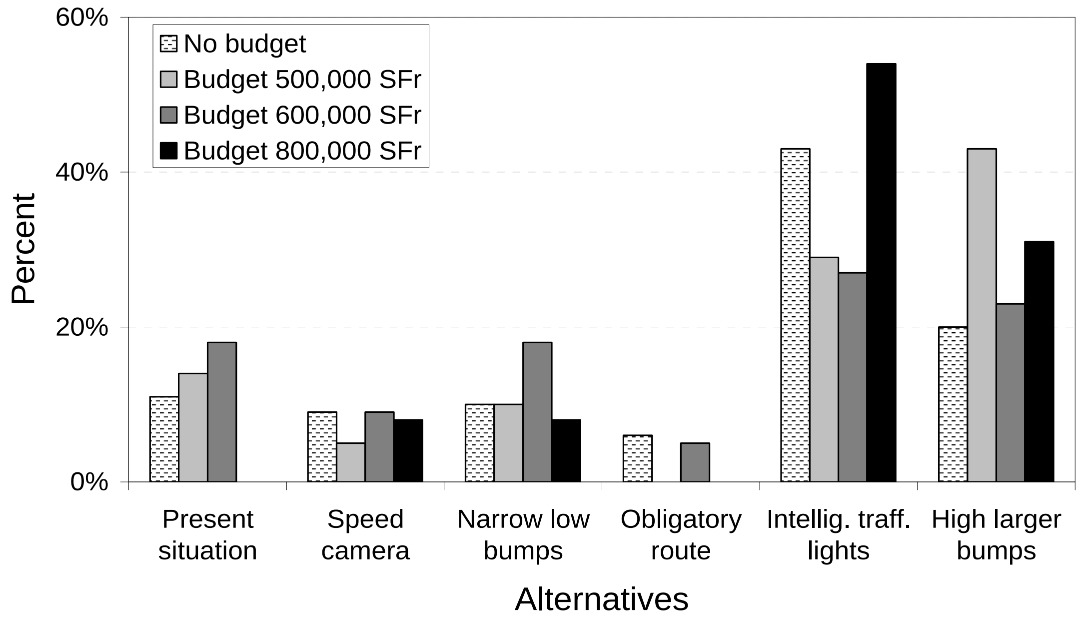
9.8.5 Speed control

In this experiment, comparable once more with a test without budget constraint, is it noticeable from Figure 9.11 that the presence of the budget does not seems to alter the choices very much. The two most frequently chosen alternatives are Two intelligent traffic lights and High and larger bumps every km and the surprising fact is that the most expensive of them is chosen by the respondents with the lowest budget. Other than that, the trend, as before, shows that with a higher available budget or not having a constraint, the preference are for alternatives which are more expensive and make a rather higher contribute to safety.

Table 9.39 ‘Speed control’ alternatives by cost

Alternatives description	Cost (SFr)
Obligatory route with many curves	65,000
Narrow and low bumps every 800 m	60,000
High and larger bumps every km	100,000
Two intelligent traffic lights	70,000
Speed camera every km	5,000
Present situation	None

Figure 9.11 Distribution of the choices by budget constraint for the experiment ‘Speed control’



9.9 Descriptive analysis of the SC approach

The analysis of the stated choice test, the third presented to the respondents, will diverge from the previous two, due mainly to the different structure of the test itself, as described in chapter 7.1.3. The number of usable SC tests returned was 150, which means 900 situations – in each survey six situations were presented. First, all situations will be considered as a whole and it will be analysed how the choices between the two alternatives are distributed. Then, from the total number of usable surveys, those where the respondents did not trade off between the two alternatives proposed at least once, that is, they chose in all six tables the same alternative, will be excluded. Finally, the analysis will separate into the nine different versions and will investigate how much the choices were influenced by this factor.

As previously stated, the number of usable SC tests returned included 900 situations. From these situations the distribution of the different choices can be seen in Table 9.40. The values show that the majority of the respondents chose not to invest. A reason for that could have been the presence of the 'illogical' situations mentioned previously, which moved the most of the respondents not to invest, after having seen some of the variables getting worse levels – i.e. no. of victims increasing or more cars exceeding speed limits by making the investment. A small change is already perceivable when the analysis excludes from the usable SC tests returned those where the respondents did not trade off at least once between the two alternatives. The number of respondents who did not trade off was 28 – 25 (150 situations) selected always 'No investment' and three (18 situations) selected always 'Investment'. These situations were subtracted from the total number of situations received and the distribution of the choice changed slightly: the difference in percentage between those who selected to invest and those who selected not to invest became smaller. This could mean that, those who spent more attention in analysing both alternatives and in trading off between the levels of the variables did not find many situations so illogical as they might look like with just a cursory analysis.

Table 9.40 Distribution of the choices in SC situations returned

	All usable SC test		Test with trade-off	
	Frequency	Percentage	Frequency	Percentage
No investment	544	60.4%	394	54%
Investment	356	39.6%	338	46%
Total	900	100%	732	100%

The last part of the analysis investigates whether the respondent's choices varied also across the nine versions. As previously stated, the situations selected from the choice set to be presented number 54; nine different versions of the survey were created, each of them including six SC test situations. As can be seen from Table 9.41 the distribution of the choices was not constant over the different versions, which means that the choice set had a certain influence on the respondents. It is in any case noticeable that as a result of excluding respondents who did not trade off – most of whom selected the alternative without investment – the distribution of the choices across the alternatives alters slightly (Table 9.42). The tendency is the increase in the situation where respondents selected to make the investment. Only versions three, four and five are exceptions: versions three and four increased the percentage of situations without investment and version five did not vary.

Table 9.41 Distribution of the choices in SC situations returned by version number

Version number	No investment		Investment		Total
	Frequency	Percentage	Frequency	Percentage	
1	64	56%	50	44%	114
2	57	73%	21	27%	78
3	74	65%	40	35%	114
4	57	47.5%	63	52.5%	120
5	51	65%	27	35%	78
6	60	50%	60	50%	120
7	30	50%	30	50%	60
8	65	68%	31	32%	96
9	86	72%	34	28%	120

Table 9.42 Distribution of the choices in SC situations returned by version number for respondents who traded off

Version number	No investment		Investment		Total
	Frequency	Percentage	Frequency	Percentage	
1	46	48%	50	52%	96
2	39	65%	21	35%	60
3	44	52%	40	48%	84
4	51	47%	57	53%	108
5	39	65%	21	35%	60
6	42	41%	60	59%	102
7	24	44%	30	56%	54
8	53	63%	31	37%	84
9	56	67%	28	33%	84

9.10 Estimation of the value of life

The following analysis will start to consider also the Value of life (VOL), implied by the choices of the respondents. Within each kind of approach the VOL is calculated as the amount of money the person is willing to pay to save a statistical life. Practically, in the first two kind of test it is calculated as:

VOL = Cost of the alternative chosen / No. of victims avoided

The number of victims avoided in the first two experiments is connected to the alternative chosen. In the SC approach, since the respondent is given the possibility to choose just between no investment and investment, the VOL is calculated as:

VOL = Investment / No. of victims avoided

The value of victims avoided doing the investment is calculated, for each kind of victim (car and motorbike drivers, bikers, pedestrians) as the difference between the victims in the present situation (no investment) and the victims with the investment. The value to consider in the evaluation of the VOL is the sum of all three kind of victims avoided. Some approximations have been made for the calculations of VOL in all three cases:

- if the value of victims avoided is negative, it is considered as 'No victims avoided'. In this case, as when the number of victims avoided is zero, the VOL, if the investment (or cost) is more than zero, has an infinite value. In the following figures this situation is represented as a VOL with a value much higher then all others available;

- if the investment (or cost) is zero (present situation) the VOL is zero.

It is important to assess that, as will be later specified, the VOL calculated is not only referred to a life saved but to a casualty avoided, which includes also light and heavy injured. For this reason it will not be called VOL, rather VOC.

9.10.1 'Priority Evaluator approach' and 'Traffic and transport improvement test'

The following analysis is divided in two sections. First, the relation between all situations is presented (test without budget constraint and PE test with three amount of budget) for each area of improvement offered. Secondly, the fixed parameter will be the situation and it will be analyzed how the area of improvement influences the choices. Each figure includes the VOC, expressed in Swiss Francs (SFr) and the cumulative distribution of the answers, expressed in per cent. In both sections, for each figure presented, two summary statistics that capture in slightly different ways the central tendency of the distribution of VOC have been calculated: the *sample mean* and the *sample median*. The sample mean is what in common usage is termed the average of the sample. The sample median is the value that divides the sample exactly in half; that is, it is the value at which exactly 50% of the sample has a lower VOC and 50% have a higher VOC. For the calculation of these summary statistics, the following considerations were made:

- the *mean* value is calculated excluding the respondents whose VOC is infinite. In fact, since the infinite is represented as a value with a scale much higher then all others available, and the mean is sensitive to outliers, if these 'infinite' values are included in the calculation, the mean would give them an undue weight and would extremely high. The number of cases considered for the calculation of the mean in shown in every table as N in brackets. If there are no brackets it means that there are no infinite VOC in the experiment considered. It is noticeable that, by discarding the extreme observations, the values of the mean converge to the median;

- the *median* value is calculated considering the total number of cases shown as N in each situation. This number includes all respondents, including those whose VOC is infinite, which is the situations represented in the figures. It is known in fact that the median is a more robust measure of the central tendency since its value is not so greatly influenced by occasional very high values.

It must be remembered that not all areas of improvement were presented in both ‘test without budget constraint’ and ‘PE test’; therefore in some figures it will not be possible to compare both.

Bus stop and/or bus lane

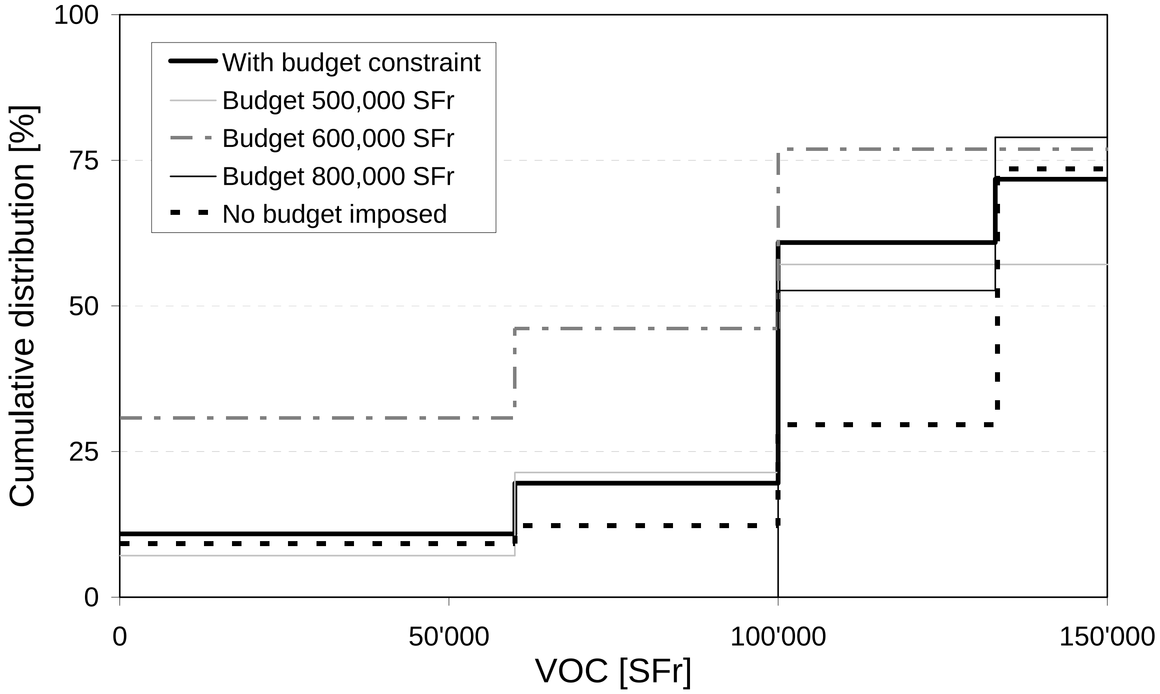
From Figure 9.12 the difference between test without budget constraint and PE test can be noticed: observing the value on the x-axis corresponding to the 50% on the y-axis, which is the median value, it is visible that the line describing the test without budget constraint crosses the 50% threshold more in the right than all other lines describing the PE experiments; that is, without budget constraint the median value is higher than for all other PE tests. Consequently, in the test without budget constraint 50%of the respondents are willing to pay less than 130,000 SFr per victim avoided and 50% more; in all other tests this value is lower. The situation with budget 800,000 SFr shows a distinctive behaviour: the lowest VOC recorded in this case is 100,000 SFr, which means that no one selected the present situation or alternatives which involve a VOC lower than this. Once all three budgets are pooled together, the difference between budget and no budget constraint is again clearly visible, as ‘All budget’ trend, for low VOC, is always above ‘No Budget imposed’: this means that, without constraint, the majority of the respondents have a higher willingness to pay. Since the trend of all situations for values higher than 200,000 SFr becomes the same, it is not shown in the figure.

Table 9.43 Statistics for ‘Bus stop and/or bus lane’ improvement

	With budget constraint	Budget 500,000 SFr	Budget 600,000 SFr	Budget 800,000 SFr	No budget imposed
N*	(33) 46	(8) 14	(10) 13	(15) 19	(72) 98
Mean (SFr.)	85'051	77'500	52'000	111'111	105'741
Median (SFr.)	100'000	100'000	100'000	100'000	133'333

* No. of cases considered. The values in brackets are the no. of cases excluding the infinite values

Figure 9.12 'Bus stop and/or bus lane' improvement for different situations



Night safety

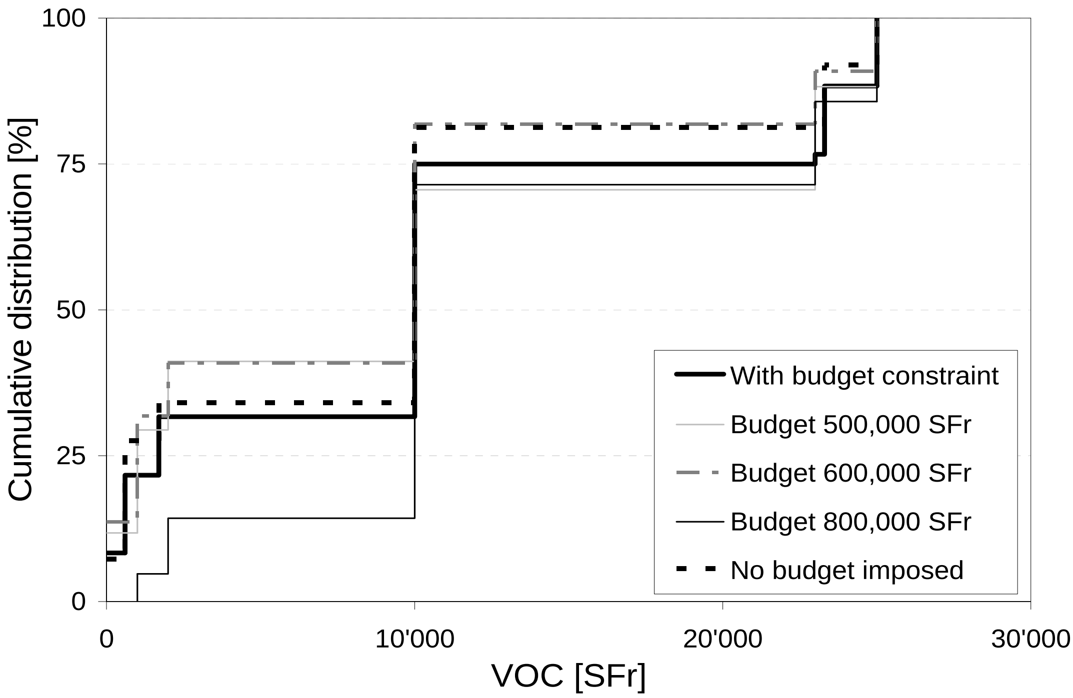
The second experiment (see Table 9.44) shows a different behaviour (see Figure 9.13): in this case all situations have a similar trend, with a median value of 10,000 SFr for a victim avoided in all situations. Although the median is equal for all situations, the mean shows some slight differences: it is not surprising that the highest value associated to the highest budget, but it is remarkable that the situation without budget constraint has a lower mean than the situation with the smallest budget. Another difference from the previous experiment is the lack of infinite VOC; in this case in fact there is no alternative which proposes an improvement with no increase in victims avoided (see example in Appendix A).

Table 9.44 Statistics for 'Night safety' improvement

	With budget constraint	Budget 500,000 SFr	Budget 600,000 SFr	Budget 800,000 SFr	No budget imposed
N*	60	17	22	21	123
Mean (SFr.)	10'606	10'306	8'750	12'792	9'450
Median (SFr.)	10'000	10'000	10'000	10'000	10'000

* No. of cases considered. The values in brackets are the no. of cases excluding the infinite values

Figure 9.13 'Night safety improvement' for different situations



Speed control

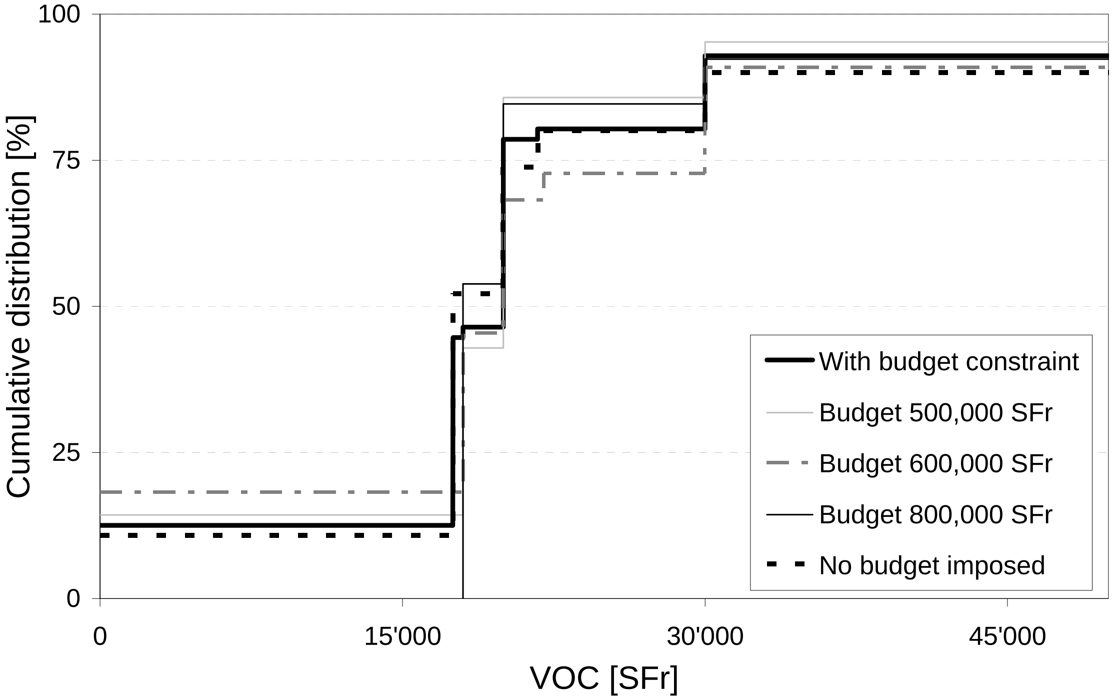
The third experiment, introduced in both kinds of tests – with and without budget constraint – relates to speed control (see Table 9.45). In this case, since one alternative proposed does not change the number of victims avoided, the infinite VOC occurs. As previously, the trend is similar for the majority of situations, with a median willingness to pay for a victim avoided between 17,500 SFr and 20,000 SFr. Once more, in the situation with budget 800,000 SFr no respondent has chosen the present situation or was willing to pay less than 22,000 SFr for a victim avoided.

Table 9.45 Statistics for 'Speed control' improvement

	With budget constraint	Budget 500,000 SFr	Budget 600,000 SFr	Budget 800,000 SFr	No budget imposed
N*	(52) 56	(20) 21	(20) 22	(12) 13	(100) 111
Mean (SFr.)	17'782	17'275	17'333	19'375	17'667
Median (SFr.)	20'000	20'000	20'000	17'500	17'500

* No. of cases considered. The values in brackets are the no. of cases excluding the infinite values

Figure 9.14 'Speed control' improvement for different situations



Pedestrian

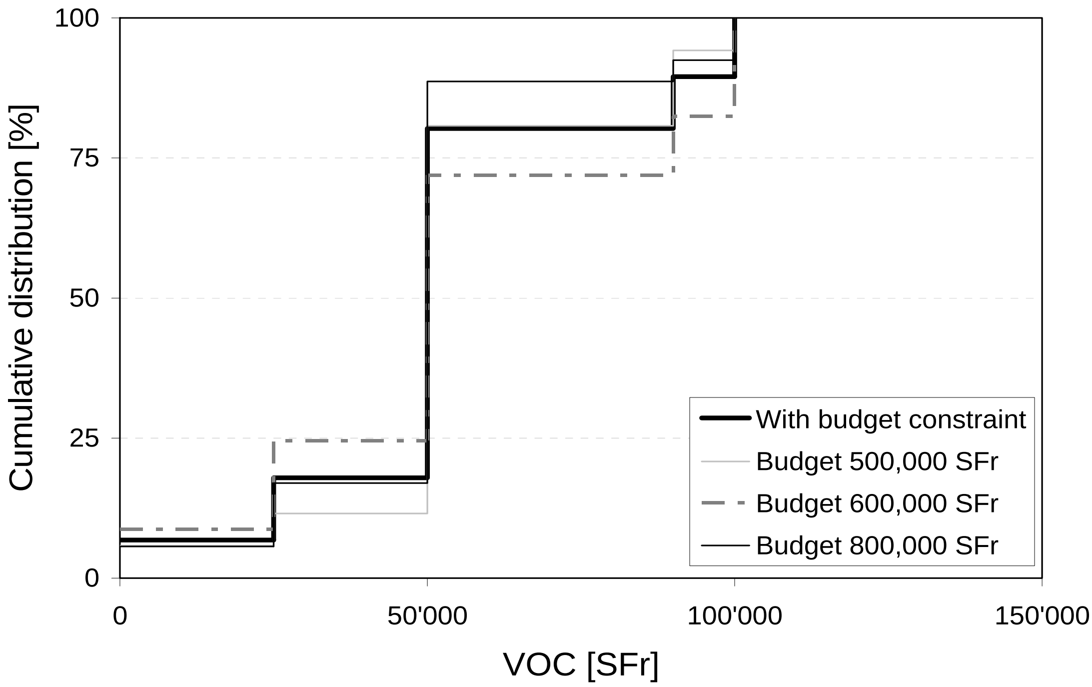
The following experiment, relating to Pedestrians (see Table 9.46), was introduced only in the PE approach. For this reasons the number of trends visible in Figure 9.15 is reduced to four. Another characteristic of this area is that, like 'Night security', it has no infinite VOC. It is then remarkable that the median is the same for all situations, so that the budget imposed seems not to be a factor which has much influence on the choices of respondents. The mean, calculated in this case for all VOC available, has the smallest values for 800,000 SFr and the highest for 600,000 SFr. This fact is understandable when looking at Figure 9.15 the trend of budget 800,000 moves above the trend of budget 600,000 for higher VOL and below it for lower VOC.

Table 9.46 Statistics for 'Pedestrian' improvement

	With budget constraint	Budget 500,000 SFr	Budget 600,000 SFr	Budget 800,000 SFr
N*	162	52	57	53
Mean	52'778	53'942	54'649	49'623
Median	50'000	50'000	50'000	50'000

* No. of cases considered. The values in brackets are the no. of cases excluding the infinite values

Figure 9.15 'Pedestrian' improvement for different situations



Bike facilities

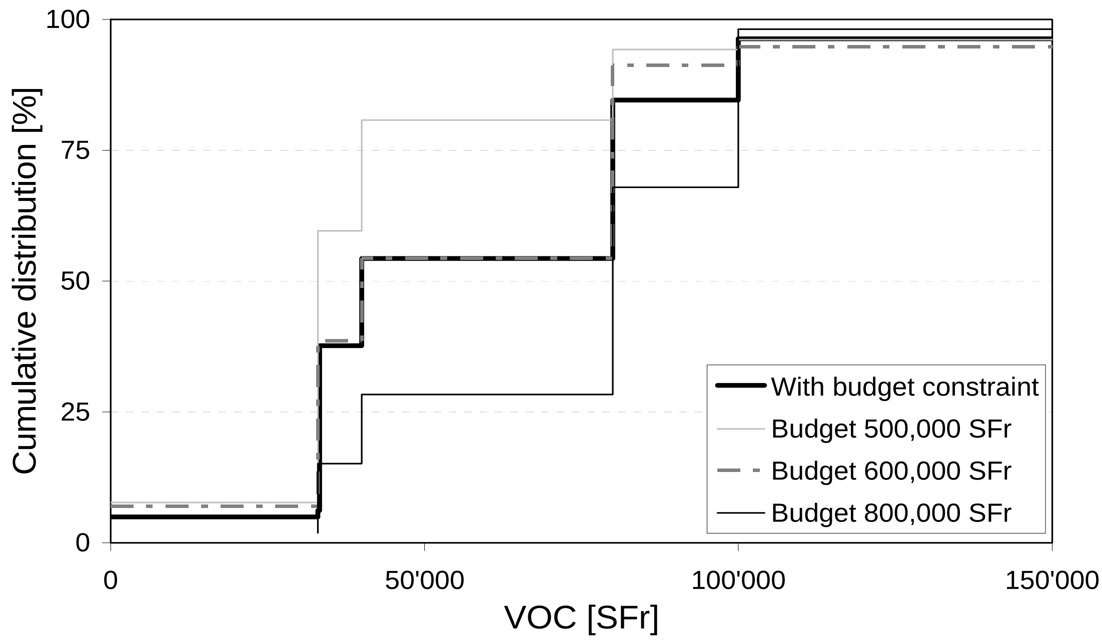
This experiment considers proposals for bike facilities (see Table 9.47) and it was introduced, like the previous one, only in the PE approach. Figure 9.16 shows that, in this case, as in the first experiment described, the budget seems to represent a constraint. The difference in trend between the three budget situations is in fact noticeable: low budgets bring more respondents to invest less for a victim avoided than higher budgets. The median, which also increases with the budget, also clearly shows this divergence. The trend with all budgets pooled together falls in between the high and low budgets.

Table 9.47 Statistics for 'Bike facilities' improvement

	With budget constraint	Budget 500,000 SFr	Budget 600,000 SFr	Budget 800,000 SFr
N*	(156) 162	(50) 52	(54) 57	(52) 53
Mean	55'551	39'993	52'593	73'583
Median	40'000	33'333	40'000	80'000

* No. of cases considered. The values in brackets are the no. of cases excluding the infinite values

Figure 9.16 'Bike facilities' improvement for different situations



Comparing all experiments described it is possible to state that the one with the highest median value is bus stop and/or bus lane; then comes the experiment related to bike facilities and pedestrian. The experiment with lowest median VOC is that related to night safety. The median values obtained are without doubt highly related to the cost and the values of safety of the alternatives proposed; on other hand they can also represent the scale of preference of the respondents for the areas of improvement presented.

Comparison across experiments

This analysis compares the experiments in each of the tests presented. Some experiments include infinite VOC and some not; as before, the mean is calculated excluding the infinite VOC, the median including the infinite. The four situations presented are 'Test without budget constraint' and 'PE approach with budget of 500,000 SFr, 600,000 SFr and 800,000 SFr'.

Test without budget constraint

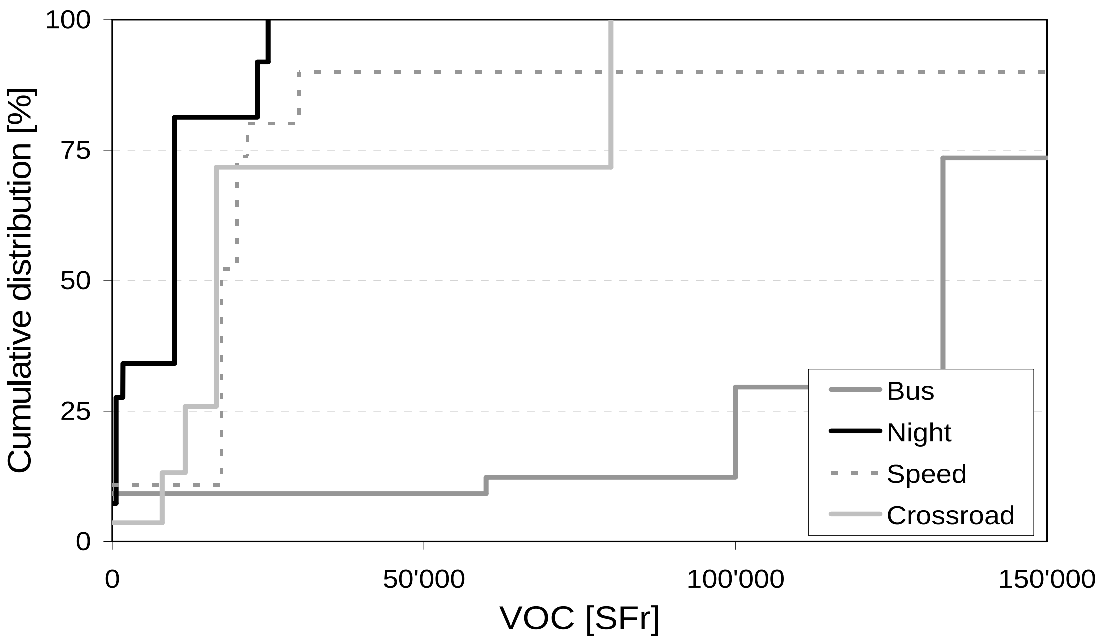
Within the test without budget constraint four experiments are offered. The difference in trend between them is quite remarkable; one of them in particular, the 'bus stop and/or lane improvement' has a completely different trend. In fact, most respondents are willing to pay more for a victim avoided in this experiment than in the others, as has been remarked in the previous analysis. Also the median values demonstrate this difference quite explicitly. One explanation for such a pronounced divergence is that the VOC is strictly related to the values of cost and safety of the alternative, which are quite different for the four experiments proposed. Directly related to that are the choices made from the respondents: by looking at chapter 9.5. it is noticeable how, for example, for 'bus stop and/or lane experiment', a high percentage of respondents were choosing an expensive alternative with a low number of victims avoided, whereas in others experiments such as 'crossroads with bad visibility' the most preferred alternative was quite expensive but with a high number of victims avoided. Since the VOC is the ratio between cost and victims avoided, the values of these two parameters can influence greatly the trend of VOC visible in Figure 9.17.

Table 9.48 Statistics for test without budget constraint

	Bus improvement	Night safety	Speed control	Crossroad with bad visibility
N*	(72) 98	123	(100) 111	166
Mean	105'741	9'450	17'667	31'835
Median	133'333	10'000	17'500	16'667

* No. of cases considered. The values in brackets are the no. of cases excluding the infinite values

Figure 9.17 Different experiments for the test without budget constraint



PE approach with budget 500,000 SFr

The PE approach, as already mentioned, includes five different experiments and three possible budgets. Table 9.49 lists them for the budget situation of 500,000 SFr. As in the test without budget constraint, the dissonance between the trend of the bus experiment and the others is noticeable:

- the ‘bus stop and/or lane’ experiment has the highest median value; consequently, even with this level of budget constraint, respondents direct their investment more toward this are than to others;

- the other experiments have different trends between each other, even if all median values are lower than the experiment ‘bus stop and/or lane’. By comparing these medians with those obtained in the test without budget constraint, for some experiment a modification is noticeable, i.e. the ‘speed control’ whose median is higher than without budget constraint; for other experiments, i.e. ‘night safety ‘, the median is the same in both cases, that is, the budget does not seem to represent a real constraint. Another factor, together with the budget level, that might have influenced the differences in trend can be the combinations of experiments presented, as each respondent received only three of the five shown.

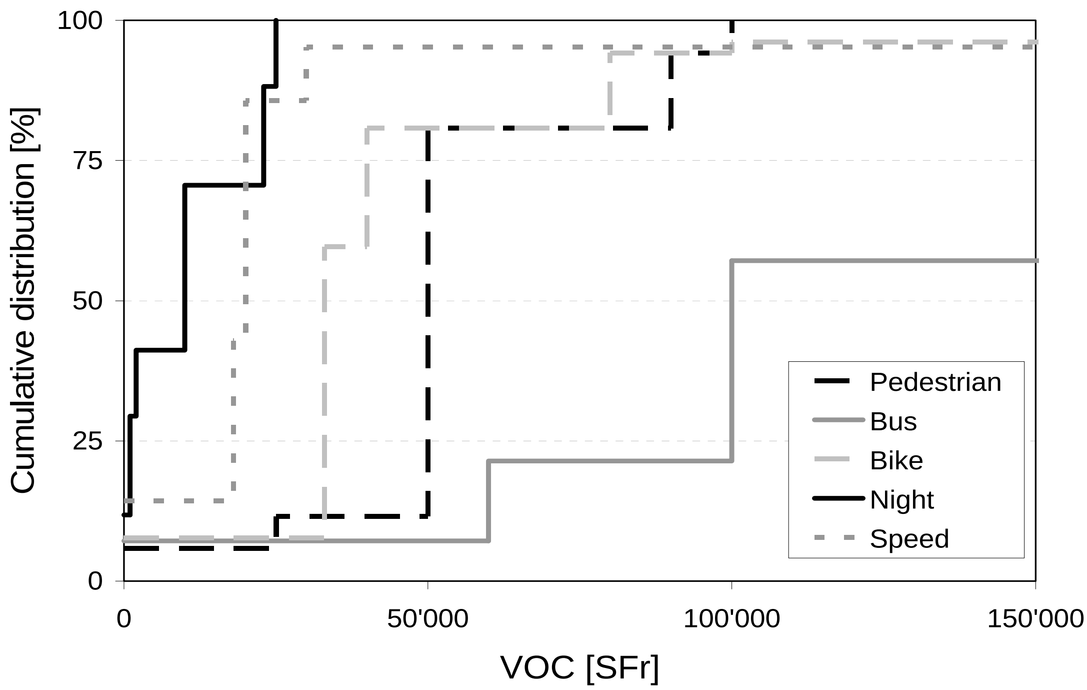
An important difference from the test without budget constraint is also the introduction of two new experiments. This is another factor that could have moved the preferences of the respondents toward alternatives included in different experiments than those presented previously.

Table 9.49 Statistics for PE approach with budget 500,000 SFr

	Pedestrians	Bike facilities	Bus improvement	Night safety	Speed control
N*	52	(50) 52	(8) 14	17	(20) 21
Mean	53'942	39'993	77'500	10'306	17'275
Median	50'000	33'333	100'000	10'000	20'000

* No. of cases considered. The values in brackets are the no. of cases excluding the infinite values

Figure 9.18 Different experiments for the PE approach with budget 500,000 SFr



PE approach with budget 600,000 SFr

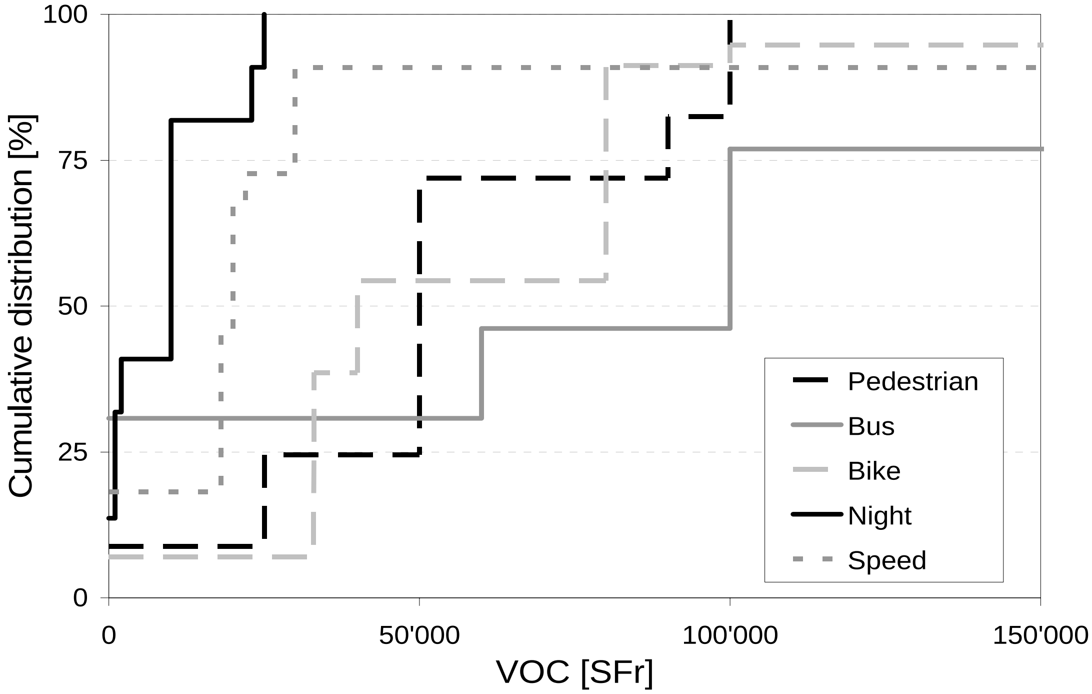
The trends visible in Figure 9.19, represent the cumulative distribution of the VOC with a budget constraint of 600,000 SFr. The mutual positions of the different experiments do not alter very much from budget 500’000 SFr, nor do the median values. The only median which varies is the one relating to ‘bike facilities’, which increases. This means that a higher percentage of respondents are willing to invest more for a victim avoided within this experiment, once they have a greater budget available. Also the ‘bus stop and/or lane’ trend changes slightly, even if the median value does not vary: the percentage of respondents not willing to pay anything for a victim avoided is increasing and all the whole trend seems to be shifted to a higher position. Observing the VOC for the 25% and the 75% of the distribution in both situations, this difference is clearly visible.

Table 9.50 Statistics for PE approach with budget 600,000 SFr

	Pedestrians	Bike facilities	Bus improvement	Night safety	Speed control
N*	57	(54) 57	(10) 13	22	(20) 22
Mean	54'649	52'593	52'000	8'750	17'333
Median	50'000	40'000	100'000	10'000	20'000

* No. of cases considered. The values in brackets are the no. of cases excluding the infinite values

Figure 9.19 Different experiments for the PE approach with budget 600,000 SFr



PE approach with budget 800,000 SFr

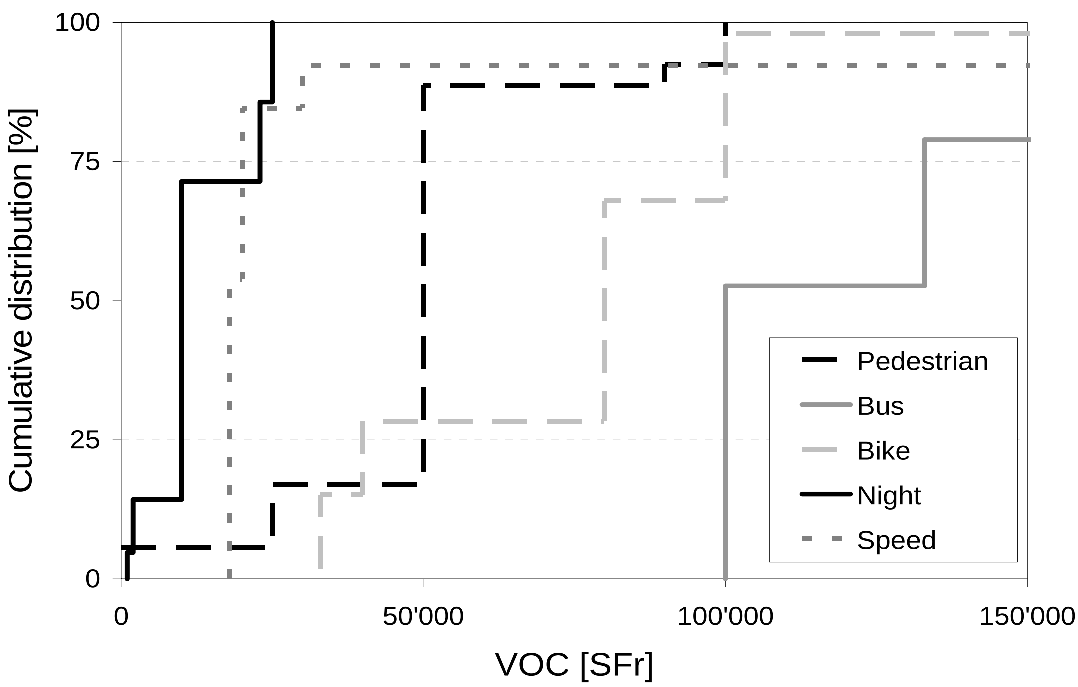
The last situation, visible in Figure 9.20, represents the cumulative distribution of the VOC with a budget constraint of 800,000 SFr. In this case the median still does not vary, except for 'bike facilities', whose median increases again and 'speed control', whose median decreases to the value it had in the test without budget constraint. The growth of the median demonstrates the increased number of respondents willing to pay more for one victim avoided, whereas the decrease demonstrates the opposite. In this situation, the modification of the trend for 'bus stop and/or lane' experiment is once again appreciable: the lowest amount the respondents are willing to pay for a victim avoided is 100,000 SFr; there are no respondents willing to pay less.

Table 9.51 Statistics for PE approach with budget 800,000 SFr

	Pedestrians	Bike facilities	Bus improvement	Night safety	Speed control
N*	53	(52) 53	(15) 19	21	(12) 13
Mean	49'623	73'583	111'111	12'792	19'375
Median	50'000	80'000	100'000	10'000	17'500

* No. of cases considered. The values in brackets are the no. of cases excluding the infinite values

Figure 9.20 Different experiments for the PE approach with budget 800,000 SFr



After comparing the three budget situations and the one without budget constraint it is possible to state that the presence of the budget had different impacts depending on the experiment. This is a sign that once constrained with a certain budget to be invested, the respondents must have changed their mind slightly and traded off more carefully cost and safety among the alternatives proposed in each experiment.

The tendency for the median values across different experiments is:

- the ‘bus stop and/or lane’ experiment has lower median values in the PE test compared with the test without budget constraint. This could mean that, without budget constraints people are willing to invest more in this area; with a constraint they are directing their investments more toward other areas; for different budget levels the situation does not vary significantly;

- the ‘speed control’ experiment has higher median values in the PE test with budget 500,000 SFr and 600,000 SFr and the same median value of the test without budget constraint for the PE tests with highest level of budget;

- concerning the two experiments presented only in the PE test, the median value for the ‘pedestrian’ experiment is constant across different budget levels and that of ‘bike facilities’ increases with the rise in the budget.

These variations demonstrate that respondents, within each experiment proposed, traded off in different ways among the alternatives for different budget levels. In any case, as for the previous analysis, the highest median value for every budget level analysed is the one related to the ‘bus stop and/or lane’ experiment.

9.10.2 Stated choice approach

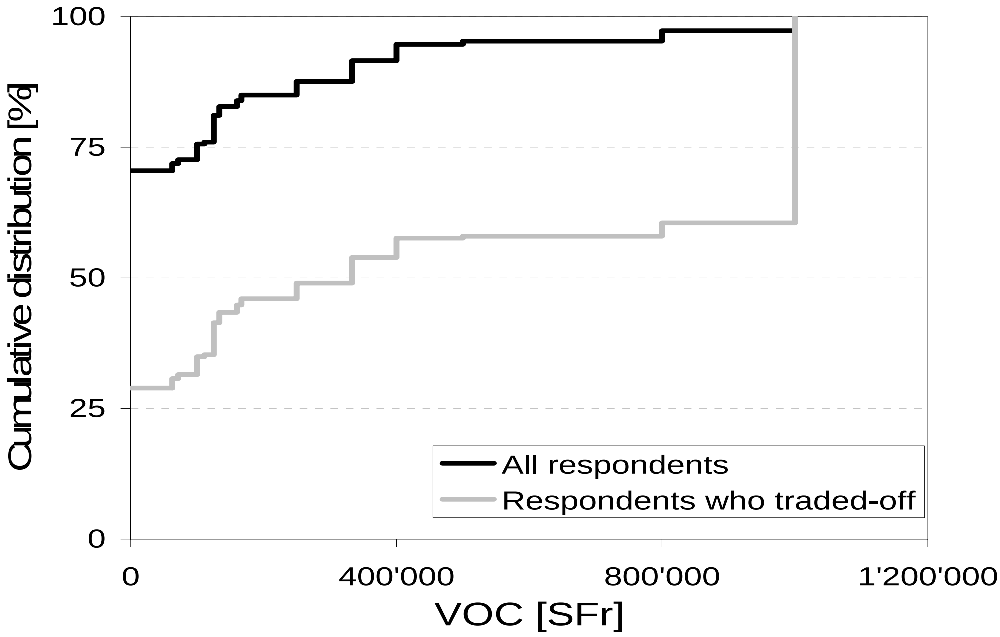
In the stated choice approach, the alternatives presented are not changing, as in the two previous tests. The design of this test, as explained previously, includes 54 independent combinations of values, which made possible the creation of 54 situations, presented to the respondents in groups of six. Since an analysis will not produce clear results if differentiated by situation, it will be performed for all situations pulled together. In Figure 9.21 two different trends are visible: the black one is generated considering all respondent who replied, the grey one is generated excluding the respondents who did not trade off at least one time between the two alternatives proposed, that is, they choose in all six tables the same alternative. There were 28 respondents who did not trade off at least once. Except for the highest values, which represent the infinite VOL, the trends of the two types of respondents in are moving parallel to each other. The median values, as well as the means and the number of cases (N) considered for the evaluation are shown in Table 9.52. Once more, the means are calculated excluding the infinite values and the median with infinite values included.

Table 9.52 Statistics for SC test

	All respondents	Respondents who traded off
N*	(876) 900	(444) 732
Mean	69'923	132'882
Median	0	333'333

* No. of cases considered. The values in brackets are the no. of cases excluding the infinite values

Figure 9.21 VOC/cumulate percentage for the Stated choice approach



10. Modelling

This last section concern the model used for the estimation of the VOL. The first part will briefly introduce how a discrete choice model is developed; then the model employed, as well as the instruments used during the estimation process, will be outlined. The last two sections are an overview of the analysis performed and a description of the results obtained in all three approaches studied.

10.1 How to develop a discrete choice model

To develop a model of individual choice behaviour three factors must be taken into account (Louviere, 2000):

1. objects of choice and sets of alternatives available to decision makers, known as choice set generation;

2. the observed choices of the decision makers (respondents) and a rule for combining them;

3. a model of individual choice and behaviour.

To describe this general model some notation must be introduced (Louviere, 200). Let *G* represent the global set of alternatives available in the choice set and *S* the set of vectors with variables for the decision makers. Each random individual from the sample will be described with some attribute vectors $s \in S$, with the choice made from the set of available alternatives $A \subseteq G$. The individual's alternative set is specified by the analyst. The probability of a generic alternative $x \in A$ to be selected, given the individual socioeconomic background and set of alternatives *A,* for each and every alternative contained in set *A*, can be stated with the following equation:

$$P(x \mid s, A) \quad \forall\, x \in A \qquad (10.1)$$

To evaluate the preceding condition it is necessary to relate the selection probabilities to the utility maximisation assumption, which, assuming that the decision maker has the ability to compare all possible alternatives, expresses mathematically his preferences. Each alternative x∈*A* has associated a utility *U*. Let U_{iq} be the utility of the *i*th alternative for the *q*th individual. Each utility is partitioned into two components, a systematic component, V_{iq}, or representative utility and a random component, ε_{iq}, as may be seen in the following equation:

$$U_{iq} = V_{iq} + \varepsilon_{iq} \tag{10.2}$$

The systematic component is assumed to be that part of utility contributed by variables which can be observed by the analyst, while the random component is the utility contributed by variables unobserved by the analyst, and any measurement and observational errors. That does not mean that individual utility maximisation is a random approach; to the contrary, individuals maximise utility in a deterministic way. Randomness arises because the analyst cannot fully observe the set of these factors and the complete decisions process; only the probability of an event selection can be observed by him. Coming back to equation 10.2, ε_{iq} is typically assumed to be a variable independently and identically distributes with an extreme-value (Gumbel) distribution, which is similar in shape to the normal distribution. This distribution of the random component implies that the probability of any particular alternative being chosen as the most preferred can be expressed in term of the logistic distribution, whose specification is known as the *logit model*, introduced in the next chapter. The systematic component can be expanded as $V_{iq} = \sum_k \beta_{ik} * s_{iqk}$, where β are utility parameters assumed to be constant across all individuals but may vary across alternatives. These variables include the socio-demographic characteristics of the individual and the context of the choices being analysed. At this point one should remember that a basic concept is the assumption that individuals try to choose alternatives which yield the highest utility for them. That is, we assume that individual *q* will choose alternative *i* if and only if

$$U_{iq} > U_{jq} \quad \text{all } j \neq i \in A \tag{10.3}$$

Anyway, the structure of the utility function is a critical point in modelling individual choices, as it represents the process by which alternative variables and individuals' socioeconomic environments combine to influence choice probabilities and, in turn, it delineate the predictive capability of the choice model. Before specifying the structure of the model in more detail it is also constructive to outline the goal of choice modelling. Specifically, the goal of choice modelling is to estimate the significance of the factors which determine V_{iq}. The composition rule assumed is a linear, additive form, which maps the multidimensional attribute vector into a one-dimensional utility (see equation 10.4) where the variables can enter in strictly linear form, as logarithmic, as various powers, as well as various other forms. The term ‘linear’ means linear in the parameters.

$$V_{jq} = \beta_{1j} f(s_{1jq}) + \ldots + c_{kj} f(s_{kjq}) \tag{10.4}$$

It is possible to set one of the *f(s)* equal to one for all *q*; in this case, the utility parameter β is interpreted as an *alternative specific constant*, which represents the net influence of all unobserved, or not explicitly included, characteristics of the individual or alternative in its utility function. At this point, in order to predict whether an alternative will be chosen, the value of its utility must be contrasted with those of alternative options and transformed into a probability value between 0 and 1. For this, a variety of mathematical transformations exist, depending on the model selected. Now it is necessary to specify a probability model and to choose a statistical estimation technique to obtain estimate of the parameters associated with attributes. The next chapter will provide a description of this approach.

10.2 Description of the model

10.2.1 The model employed

The model employed in the evaluation is the *multinomial logit model* (MNL), one of the most popular discrete choice models for cases where the choice set can consist of more than two alternatives. In this model the probability of individual *q* choosing alternative *i* can be expressed as:

$$P_{iq} = \frac{\exp(\beta V_{iq})}{\sum_{A_j \in A} \exp(\beta V_{jq})} \tag{10.5}$$

where the *V* (the dependent variable) are assumed to be linear, additive functions, as shown in the previous section. Other than the alternative specific constant, the rest of the parameters may be one of two kinds:

- *generic,* if they appear in the utility function of every alternative and their values can are assumed to be identical (i.e. x_{jk} may be replaced by x_k);
- *specific,* if the assumption of an equal value is not sustainable.

To decide which variable $x_k \in x$ is introduced in the utility function and whether it is of generic type or specific to a particular alternative, a stepwise process is employed. During the analysis performed all experimental parameters are assumed to be *generic*, as they appear in the utility function of every alternative. It must also be remembered that if some variable share a common value for two or more options (as in the case of variables representing individual attributes, such as income, age, sex), a generic coefficient cannot be estimated as it would always multiply the same value; in this case the variable can only appear in some options or need to enter with different coefficient for each alternative. In the survey developed all alternatives have different variable values; the personal variables, with the same values for different options, were always combined with other variables (as safety or cost), so that the parameters estimated represented the influence of the individual variables on other particular variables. Despite this, the problem posed by personal variables is compounded by the fact that it is not always easy to decide in which utility function the variable should appear. To solve this problem the personal variables appear in all utility functions.

An important implication of the logit model which must be mentioned is that “selections from the choice set must obey the *independence from irrelevant alternatives* property, which states that the relative probabilities of two options being selected are unaffected by the introduction or removal of other alternatives. This property follows from the independence of the Gumbel error terms across the different options contained in the choice set” (Bateman, 2002).

10.2.2 The statistical estimation approach

For the estimation of the utility parameters the *maximum likelihood estimation* (MLE) is used. The software employed is BIOGEME, an object oriented package designed for the maximum likelihood estimation of Generalized Extreme Value (GEV) models. One of the GEV models which can be estimated is the MNL model. The method of maximum likelihood is based on the idea that a given sample could be generated by different populations, and is more likely to come from one population than another. Thus, the maximum likelihood estimates are that set of population parameters which generate the observed sample most often. To illustrate that, let us suppose a random sample of *n* observations of some random variable *Z* denoted by $(z_1, z_2, \ldots z_n)$, drawn from a population characterised by an unknown parameter θ, and the probability function associated to Z written as $f\,(Z/\theta)$ (read as ‘a function of Z given some value for θ’). Maximising the probability function with respect to θ yields an estimate of θ which maximises that function, that is, the value of θ which is mostly likely to have generated the sample of observed Z. The concept of maximum likelihood can be extended also to situations in which a population is characterised by more than a single parameter θ, as in the survey developed. In that case, a vector of parameters θ_i instead of a single θ must be considered. A likelihood function is maximised in the same way as any function is maximised: the MLE estimates of θ are those values at which $\partial L/\partial \theta_i = 0$ (*i* indexes the elements of the parameter vector and L denotes the likelihood function).

10.2.3 Model outputs

In this section some of the outputs which can be obtained from the application of the procedure previously described will be introduced. These include, as cited in Louviere (2000):

- estimated β_{jk};
- asymptotic t-values relative to β;
- measures of goodness-of-fit for the model.

An estimate of β_{jk} can be defined as an estimate of the weight of attribute *k* in the utility expression V_j of alternative *j*. With these β_j, and the values of the variables, it is possible to calculate V_{jq}, interpreted as an estimate of the utility U_{jq} of alternative *j* to individual *q*. A ratio of two coefficients appearing in the same utility function can also provide information about a trade-off, or a marginal rate of substitution, between the two corresponding variables. In the study developed exactly this last function will be employed to evaluate the VOL. The willingness to pay of the respondents to obtain some benefit (in this case one more victim avoided), which express the VOL, is then calculate as the ratio between the 'safety parameter' and the 'cost parameter'. This calculation will be illustrated with details once the utility function employed has been described.

Another important step of the process is the examination of the model estimation output. First, the sign, the relative values of the parameters estimated and the significance of them are examined. The significance can be verified with statistical tests, which test whether a particular β_{jk} estimated is significantly different from zero or some other hypothesised value. The test shown in the analysis is the *t-test*: the ratio of the mean parameter to its standard error is the *t-value.* This, as absolute value, can be compared to the critical value (1.96); if the calculated t-statistic is greater than this value, then is possible to reject the hypothesis that the variable is not significant. The reasons why a variable may not be statistically significant can be the following: the presence of outliers in some samples (i.e. very large or small values of the variable which lie outside the range of most of the observations), missing or erroneous data, as well as the fact that the variable might not influence the choice under study.

Then, with the estimation of more than one model, it is also useful to compare goodness-of-fit measures. Those obtained as output from BIOGEME are the *Log Likelihood Ratio test* and the *Rho-Square.* Before the presentation of these two functions the log-likelihood function must be introduced. The log likelihood function evaluated for the estimated utility parameters is a useful criterion for assessing the goodness-of-fit when the maximum likelihood estimation method is used to estimate the parameters of the MNL model. The function used to test the contribution of particular subset of variables is know as *Log Likelihood Ratio test* and is expressed as $-2(L^0 - L^*)$, which is asymptotically distributed as χ^2 (chi-squared). L^0 is the log-likelihood of the sample for a multinomial logit model when all β parameters are zero, defined in the following equation, and L^* is the log-likelihood of the sample for the estimated model. It can be stated that the L^* is itself a goodness-of-fit measure of a model. A model with a higher value of L^* the model can already considered to be better than the other.

$$L^0 = \sum_{n \in sample} \omega_n \ln \frac{1}{C_n} \tag{10.6}$$

In Equation 10.6 C_n *is* the number of alternatives available to individual n and ω_n is the associated weight of the person. The notions introduced are also used to calculate the second function, known as *Log Likelihood Ratio Index or Rho-Square* that can also be used to measure the goodness-of-fit of the MNL model. This function is expressed as:

$$\rho^2 = 1 - \frac{L^*}{L^0} \tag{10.7}$$

The smaller the ratio in the equation is, the better the statistical fit of the model. The ρ^2 is used as a pseudo-R^2 to measure the goodness-of-fit of the MNL model. Value of ρ^2 between 0.2 and 0.4 are considered to be indicative of extremely good model fits. For the same data set the ρ^2 of a model will increase or at least stay the same whenever new variables are added to the utility functions.

10.3 The analysis

This chapter will describe the steps common to all tests concerned with the specification of the model. Subsequent the analysis will be specific to each of the three tests conducted and will describe step by step the models developed and the results obtained.

10.3.1 Specification of a Multinomial Logit model

The specification of a multinomial logit model consists of a number of distinct steps:

1. define the choice set for the sample;

2. define the choice set for each individual;

3. select the variables which will enter the utility function.

The *first step* has to be different to each test. The first two tests, the one without budget constraint and the PE test, are described with the following variables: safety (no. of victims avoided), journey time change, comfort variation and cost. The universal choice set for each of them depends on the experiment considered: that concerning pedestrians is different from that concerning bikes or night security. Practically, each alternative within the experiment considered has its own values for all variables. For the third test (SC), the variables and their universal choice set can be seen in Table 7.2. The *second step* concerns the choice set for each individual: once more, it is different across the three tests. In the first two, as explained in chapter 7.3, each respondent received a set of three experiments in the first test and three in the PE test. The values of the variables in each experiment do not vary: only the combination of them may change between the two experiments. For the SC test, each respondent received six situations and the combination of values was dependent on which of the nine versions he received. The *third step*, also different from test to test, will be described in chapters 10.3.3., 10.3.4. and 10.3.5., where the model will be developed from a basic model into a more complex one, by adding and combining variables.

Subsequently, in order to estimate the choice model, it is necessary to consider the coded data, relative to chosen and rejected alternatives for each test and experiment faced by respondents. The chosen options and the personal data are coded using the method described in chapter 9.5. Once all data are coded the utility function can be defined: equations 10.8-10.10 show some examples of basic utility functions specified for the test without budget, when just one experiment was considered. In the following equations each alternative is represented with a utility function – three of the six functions are reported below – including:

- the *alternative specific constant* C, which represents, the net influence of all unobserved, or not explicitly included, variables or characteristics of the individual. In the cases analysed this constant was firstly estimated, as a normal parameter. Subsequently, since the estimates of it were never significant, it was fixed and not estimated anymore;

- the *generic variables*, with their parameters to be estimated, SAFETY, JTIME, COMFORT and COST. They are classified as generic because they do appear in the utility functions of every alternative and their coefficients have to be identical. The variable named 'victims1' represents the 'No. of victims avoided' connected with alternative one; 'jtime2', the 'journey time change' connected with alternative 2 and so on. All these variables were coded as explained previously.

$$U_1 = C * one + SAFETY * victims1 + JTIME * jtime1 + COMFORT * comfort1 + COST * cost1 \quad (10.8)$$

$$U_2 = C * one + SAFETY * victims2 + JTIME * jtime2 + COMFORT * comfort2 + COST * cost2 \quad (10.9)$$

……………..

$$U_6 = C * one + SAFETY * victims6 + JTIME * jtime6 + COMFORT * comfort6 + COST * cost6 \quad (10.10)$$

When all experiments are pooled together and no longer treated separately, for all the experiments the utility functions of all alternatives must be specified. To analyse the influence of different experiments in the estimation of the parameters, *scale parameters* are introduced. The scale parameter normally, in a single experiment, cannot be separately identified and it is therefore implicit in the terms estimated. Its relevance is when two models from different experiments are compared. In fact, it is not possible directly to compare parameters estimated from different experiments and in particular, it is not possible to determine whether the observed difference is the result of differences in scale, estimated parameters or both. Indeed, even if the two data sources were generated by the same kind of utility function, but have different scale parameters, the estimated parameters will be different. With two models from different experiments then, since there can be no assumption that the scale parameters are the same in both, the ratio of scale parameters can be measured and used to adjust for differences in error variance to allow models to be compared. Specifically, the scale parameter in MNL is inversely proportional to the standard deviation of the error distribution for all alternatives. Thus, the higher the scale, the smaller the variance; that is, as scale becomes infinitely large, the model discriminates perfectly between two experiments; when scale is zero, choice probabilities are equal.

The basic utility function of the SC model is shown in Equation 10.11, since the variables and the parameters which compose it are quite different from the previous one. In this test in fact the choice situation, as described in Chapter 7.1.3., includes a present situation or 'Alternative zero', and a second alternative, with a given investment.

U_0 = C * zero

U_1 = C * one + SAFCAR * difvcar + SAFBIKE * difvbik + SAFPED * difvped + JTIME * difjtime + SPEED * difspeed + INVEST * invest (10.11)

Since the values of the variables in the present situation do not change across the different combinations included in the design, it was decided to create two utility functions: the first, U_0, represents the present situation, with no parameters except of the constant, which is always fixed. The second, U_1, represents the alternative with the investment, where all variables are calculated as the difference between the Alternative Zero and the alternative with the investment.

Specifically, each of them can be described as follows:

- *difvcar*: represents the difference related to 'no. of victims/year in accidents as car drivers and motorcyclists or passengers';
- *difvbik*: represents the difference related to 'no. of victims /year in accidents as cyclist';
- *difvped*: represents the difference related to 'no. of victims /year in accidents as pedestrian'. For all three kinds of victims, the difference calculated corresponds to the number of victims avoided per year. If the difference is a positive value, by investing is possible to avoid some victims; if negative, the number of victims increases;
- *difjtime*: it represents the difference related to 'journey time for cars along the road (minutes)'. If the difference is positive, by investing is possible to save some time; if negative, the time for the whole distance becomes greater;

- *difspeed*: it represents the difference related to ‘car which exceed speed limit’. In this case, since the value is a percentage, the calculation is made as:

$$\frac{AlternativeWithInvestment - AlternativeZero}{AlternativeZero} \qquad (10.12)$$

  The result will be the percentage of decrease (if negative) or increase (if positive) of the alternative with investment compared with Alternative Zero. For example, if Alternative Zero has 60% of cars exceeding the speed limit and the alternative with investment 30%, the value calculated from Equation 10.12 will be ‘-50%’;

- *invest*: it represents the amount of investment involved for the second alternative.

The following chapter will explain how to evaluate the parameters combined with these values once they are estimate by the model and more generally how to determine the accuracy of the model.

10.3.2 Test of coefficients estimate

The results of the estimation can be inspected by performing a series of tests:

a. the most basic test is the examination of the values of the parameters estimates. Usually there is an a priori expectation, especially with respect to the signs of the parameters. For example, the parameter SAFETY – coefficient of ‘no. of victims avoided’– must have a positive sign, since the utility should increase if the number of victims avoided arises. The opposite is true for COST – coefficient of the cost – which must have a negative sign, since the utility should increase if the cost is lower. In the same way all the other coefficients must be tested. The two coefficients just mentioned are the most important for the estimation performed. In fact, for each utility function, the ratio of SAFETY and COST provides information about the trade-off, or marginal rate of substitution, between the two corresponding variables, that is the WTP of respondents for one victim more avoided;

b. subsequently, the significance of the parameters must be controlled, that is, the *t-value* – as absolute value – in comparison with the critical value –1.96 for a 95% level of confidence. If the calculated t-statistic is greater than this value, then it is possible to reject the null hypothesis that the variable is not significant; otherwise the variable may not influence the choice or may have problems with missing data, outliers, etc.;

c. the last test (but not the least important), concerns the goodness-of-fit of the model. As mentioned previously, the measures of goodness-of-fit obtained as output are *Log Likelihood Ratio test* and *Rho-Square.* Especially when estimating more than one model specification, it is useful to compare goodness-of-fit measures. Everything else being equal, a model specification with a higher value of the final log-likelihood function or of the Rho-Square is considered to be better.

This sequence of tests will be performed for each model estimated and it will also be used to make comparisons between and to analyse the evolution of the models for the three tests.

10.3.3 Use of estimated parameters

Having performed the analysis, the estimated parameters can be used for various purposes, for example:

- to determine values of time, for evaluation purposes;
- to determine equivalent monetary values, such as the WTP for a certain quality of safety improvement;
- to determine demand elasticity, for example for variables which are hard to measure in other contexts;
- to update and/or complement existing demand models.

In this study the purpose will be the second one, as introduced in chapter 10.2.3. Specifically, to obtain the marginal rate of substitution between safety and cost, from Equations 10.8-10.10, an assumption has to be made in the case of either basic models or more complex models: the utility related to safety (no. of victims avoided per year) should correspond to the utility related to cost. Those utilities are calculated as the product of the estimated utility parameters (SAFETY, COST) and the variables. Two examples of the assumption just introduced – one related to the basic model and one related to the model where safety and place of residence are interacted– will clarify the situation (see Equations 10.13 - 10.14). The variable place of residence is introduced as three dummy variables representing the three classes of places of residence – city, village close to the city and village in rural area. One of them, the city, is implicit in the parameter of the variable safety itself.

Assumption for the basic model:

$$SAFETY*victims + COST*cost = 0 \qquad (10.13)$$

Assumption for the model with interaction safety-place of residence:

$$SAFETY*victims + SAFETYvillcity*victims*Village\ close\ to\ the\ city +$$
$$+ SAFETYvillrurarea*victims*\ Village\ in\ rural\ area + COST*cost = 0 \quad (10.14)$$

After this assumption, to calculate the WTP for *one* more victim avoided it is necessary to give the value one to the variable 'victims' and to solve the equation in term of the variable 'cost', which represents the WTP. If other variables are interacted with the variables safety and/or cost – as place of residence in this example – several VOL will be calculated, one for each place of residence. For example, if the VOL for villages close to the city is calculated, the dummy variable 'Village close to the city' will acquire the value one and those connected with other places of residence will acquire the value zero. The VOL can be calculated as

VOL for basic model or for those living in the city: $\cos t = -\dfrac{SAFETY}{COST}$

VOL for villages close to the city: $\cos t = -\dfrac{SAFETY + SAFETYvillcity}{COST}$

VOL for villages in rural areas: $\cos t = -\dfrac{SAFETY + SAFETYvillrurarea}{COST}$

It must be stated that, since in the term victim was not specified if just fatalities were included or also light and heavy injured, the values calculated will refer to Values of a casualty avoided (VOC) instead of Value of life (VOL). In chapter 10.4 will be discussed how the VOL can be obtained.

10.3.4 Analysis Framework

The model described will now be applied to the three data sets obtained from the survey. The framework of the analysis will be the following:

Traffic and transport improvement test

- experiment related to bus stop and/or lane improvement: basic model, three models with the parameter SAFETY related with different persons characteristic;

- all experiments pooled together: basic model, three models with the parameter SAFETY related to different persons characteristic and two models with the parameters COST and SAFETY related to experimental kind and other variables.

PE test

- experiment related to bus stop and/or lane improvement: basic model, one model with the parameter COST/BUDGET related to given budget, one model with the parameters COST/BUDGET and SAFETY related to different variables;

- experiment related to pedestrians: basic model, two models with the parameters COST/BUDGET and SAFETY related to other variables;

- all experiments pooled together: basic model, three models with the parameters COST/BUDGET and SAFETY related to other variables.

SC test

- basic model

During the analysis a large number of models were created; those described in the following chapters are only the most significant or crucial ones. Each model will be accompanied by a table listing the parameters estimated, the *t-values* and the goodness-of-fit values.

Traffic and transport improvement test

The following test will be presented at first for a single experiment, related to 'bus stop and/or lane'; subsequently, all experiments will be pooled together and scale parameters will be defined. In both cases the analysis will start from a basic model and will progress to more elaborate ones. The VOC, intended as the willingness to pay for one more victim avoided, is calculated only for the cases in which the parameters are significant or narrowly insignificant. The significance of the estimated parameters is inspected from the *t-values*: the significant *t-values* – with absolute value greater than 1.96 – will be marked in bold.

Bus stop and/or lane improvement

This experiment consists of the choice of a possible improvement relative to bus stop and/or lane. The sample size is 95 and the alternatives are six, as introduced in chapter 7.1.1. Four variables – safety, journey time change, comfort variation and cost – were used to specify the utility of each alternative; all of them are generic variables, since they appear in the utility function of every alternative. In the basic model no other variables are introduced, that is, the number of estimated parameters is four. The signs of all estimated parameters (see Table 10.1) are correct and unambiguous – we would expect that a negative sign would be associated with cost and time and a positive sign with safety, since an individual's relative utility will increase when time or cost decreases and when the number of victims avoided is greater. The only parameter which looks ambiguous is the comfort parameter – we would expect that a positive, rather than negative, sign would be associated with comfort, since an individual's relative utility will increase when the comfort increases. On the other hand the only significant *t-values* are those relative to safety and journey time, which are greater than 1.96 (95% confidence). The COST parameter is not badly insignificant, whereas the parameter comfort is highly insignificant. Looking at the goodness-of-fit values, which are important especially in comparisons with subsequent models, this model has a Rho-square of 0.1865 and a Likelihood Ratio Test of 63.4989. This last value, which is asymptotically distributed as χ^2, could be compared with the critical value of χ^2 for a significance level $\alpha=0.05$; in this way it is possible to verify if the null hypothesis that the subset of parameters estimated are equal to zero can be rejected or not. In this case the critical value of χ^2 for four parameter estimated is 9.488, which is much lower than the Likelihood Ratio Test value; therefore the null hypothesis can be rejected. The VOC calculated as the ratio between the parameters safety and cost, shows that in this experiment people are willing to pay 181'595 SFr. for one victim avoided per year.

Table 10.1 Bus stop and/or lane - Basic model

Parameters		Value	t-Test
Utility parameters			
COMFORT		-0.09540	-0.4489
COST		-0.00002	-1.8627
JTIME		-1.32410	**-2.9751**
SAFETY		3.83950	**2.3389**
Goodness-of-fit			
Number of estimated parameters:	4		
Sample size:	95		
Null log-likelihood:	-170.217		
Final log-likelihood:	**-138.468**		
Likelihood ratio test:	63.4989		
Rho-square:	**0.1865**		
Value of casualty avoided (SFr per year)		181'595	

The next model presented differs from the basic one for the introduction of the variable age classes interacted with the variable safety. In fact, since age class is not a variable from the choice set and it does not vary across the alternatives, it cannot be included as a separate variable in all utility functions. To enable this and other kinds of variables to be included in all utility functions, they must be interacted with an alternative-specific variable. In this case the age class is interacted with the variable safety, which acquires a different value in every alternative. This interaction should make it clear whether the factor age influences significantly the choice of the respondents. To make possible this interaction the ages of the respondents were divided in four different classes – < 30 years old, 31-30 years old, 51-60 years old, >60 years old – and a dummy variable was created for each of them, represented by 0 – if the respondent does not belong to this age class – and 1 – if the respondent belongs to it. In this way, the influence of each change in variable level for a continuous variable such as the age can be observed. In the utility function of each alternative new parameters and variables are added, which represent the interaction between safety and age classes. Only one age class, that of the elderly in this case, is implicit in the parameter safety itself. The number of estimated parameters increases to seven. Looking at them in Table 10.2 all signs are correct and unambiguous except for comfort, which has a negative sign. On the other hand, from the *t-value* it may be seen that once more the level of significance is much below the critical level. From the other t-values it may also be seen that the only significant parameters are SAFETY and JTIME, whereas COST is still narrowly insignificant, but its significance is improved compared with the previous experiment. Unfortunately the parameters of safety correlated with age classes are not very significant. This means that the age does not significantly influences the estimation of this parameter. Therefore the VOC calculated represent all age classes and it is calculated simply as the ration between the parameter SAFETY itself and the parameter COST; its value is slightly lower than before, but in the same order of magnitude. Looking at the goodness-of-fit values, the Rho-square has a higher value, as does the Final log-likelihood. The Likelihood ratio test has a value which is greater than the critical χ^2 value – it correspond to 14.067 for seven estimated parameters and a significance level α=0.05; the null hypothesis that the subset of parameters estimated are equal to zero can then be rejected. Performing a log-likelihood ratio test between this model and the basic one the value obtained from $-2(L-L_{basic})$ – where L is the Final log-likelihood of this model and L_{basic} the one of the basic one – and asymptotically distributed as χ^2, is 3.82. Considering that the critical χ^2 value for three more parameters, with a significance level α=0.05 is 7.815, this model cannot be considered more significant than the basic one.

Table 10.2 Bus stop and/or lane – Interaction of safety with age classes

Parameters		Value	t-Test
Utility parameters			
COMFORT		-0.08850	-0.4158
COST		-0.00002	-1.9095
JTIME		-1.33310	**-2.9940**
SAFETY		3.71070	**2.2546**
SAFETY (<30 year old)		0.38710	1.3136
SAFETY (31-50 year old)		0.32690	1.5637
SAFETY (51-60 year old)		0.07750	0.3419
Goodness-of-fit			
Number of estimated parameters:	7		
Sample size:	95		
Null log-likelihood:	-170.217		
Final log-likelihood:	**-136.558**		
Likelihood ratio test:	67.3189		
Rho-square:	**0.1977**		
Value of casualty avoided (SFr per year)		170'990	

In the third model, two other variables were added in interaction with safety: place of residence and gross family income per month. For the first one, three dummy variables were created, one for each place of residence – city, village close to the city and village in rural area – already reclassified within the descriptive analysis in chapter 9.4. Monthly income was at first divided into three classes, and a dummy variable subsequently created for each class. The three classes created are: family with income of less than 4,000 SFr. per month, family with a monthly income between 4,001 and 8,000 SFr. and, family with income of more than 8,001 SFr. per month. The variables implicit in the safety parameter are the city, for the places of residence and the class of the lowest income. By adding these two variables, each of which is composed of three classes – with one class for each implicit – the number of parameters estimated becomes eleven. From Table 10.3 it may be seen that the signs and significance of the parameters do not vary from the previous situations. The estimates of the new parameters inserted are correct but not significant. As previously, this means that the variables related to them do not seem to influence significantly the parameter safety. Therefore the VOC calculated is only one and it refers to all age classes, all places of residence and all income classes; its value has the same order of magnitude as in the previous models A small improvement can be seen in the significance of the parameter COST, which compared with the previous models, is closer to the critical value 1.96. This could signify that the introduction of income and place of residence, not influencing very much the variable safety, emphasises the variable cost within the utility function of all alternatives. Regarding the goodness-of-fit values, the Likelihood ratio test has a value which is much greater than the critical χ^2 value for 11 estimated parameters and a significance level α=0.05 (19.675); the null hypothesis that the subset of parameters estimated are equal to zero can be rejected. It is also interesting to analyse the significance of this model in comparison with the previous one, since new variables have been added to it. The Likelihood Ratio test between this model and the previous has a value of 1.96, which is much lower than the critical χ^2 – 9.488 – relative to four more parameters and a significance level α=0.05. The same test related to the basic model has a value of 5.78, still lower than the critical χ^2 – 15.507 – for eight parameters added. Consequently also this model cannot be considered more significant than the basic one, even if the Rho-square also is improved from 0.1977 to 0.2035.

Table 10.3 Bus stop and/or lane – Interaction of safety with age classes, place of residence and gross family income per month

Parameters		Value	t-Test
Utility parameters			
COMFORT		-0.085	-0.398
COST		0.000	-1.936
JTIME		-1.339	**-3.005**
SAFETY		3.728	**2.259**
SAFETY (<30 year old)		0.450	1.465
SAFETY (31-50 year old)		0.308	1.383
SAFETY (51-60 year old)		0.109	0.460
SAFETY (village close to a city)		0.208	0.914
SAFETY (village in rural area)		-0.032	-0.157
SAFETY (4000-8000 SFr/month)		0.056	0.271
SAFETY (>8000 SFr/month)		-0.130	-0.574
Goodness-of-fit			
Number of estimated parameters:	11		
Sample size:	95		
Null log-likelihood:	-170.217		
Final log-likelihood:	**-135.578**		
Likelihood ratio test:	69.2775		
Rho-square:	**0.2035**		
Value of casualty avoided (SFr per year)		169'303	

The last model described for this experiment represents the interaction between a variable already considered, such as the gross family income per month, and a dummy variable related to the kind of intervention proposed in each alternative, which is not a person's variable but it could represent one criterion which respondents followed in making their choices. These variables were respectively: service improvement, small infrastructure and big infrastructure. A table representing the classification of the alternatives offered in each experiment within the kind of intervention categories is available in Appendix B. The number of estimated parameters is eight, which includes the four basics plus four representing the interaction of SAFETY with two classes for each of the two new variables. The variables implicit in safety are those relating to small infrastructure and with the lowest income. The estimations obtained with this model are quite particular. Regarding the signs of the estimated parameters, all seem correct and unambiguous, including the parameter comfort. The problem in this model is the significance: the *t-value* for all parameters is in fact very low, far below the critical value 1.96. The surprising values are those relating to the goodness-of-fit: the final log likelihood increases from -138.468 of the basic model to -69.4863, which gives a value of Likelihood ratio test – between this model and the basic model – of 137.963, much higher than the critical χ^2 for four parameters added and a significance level α=0.05, which is 9.488. The model in this case is much more significant than the basic one. Rho-square reaches a value of 0.5918 and the Likelihood ratio test has a much higher value than the critical χ^2, for eight parameters estimated and a significance level α=0.05. It might be suggested that the variable causing these improvements is that related to the kind of intervention, which was introduced just in this model. That could be interpreted in the following ways: by introducing this last variable the model could reflect better the reality and how respondents made their choices. On the other hand, when this variable is interacted with SAFETY, the estimated parameters are not significant. As a test (results not shown here) this variable was interacted with other variables such as COST and COMFORT and with other person variables, and the results did not improve. This could mean that the respondents were making their choices considering mostly the kind of alternative presented, but not weighting very much the values of the variables associated with them. Because of the very low significance values, the VOC obtained from this model are not sufficiently meaningful to be shown.

Table 10.4 Bus stop and/or lane – Interaction of safety with kind of intervention and gross family income

Parameters		Value	t-Test
Utility parameters			
COMFORT		20.4214	0.0403
COST		-0.0021	-0.0414
JTIME		-43.2122	-0.0426
SAFETY		235.0605	0.0422
SAFETY (service improvement)		-255.2744	0.0000
SAFETY (big infrastructure)		121.5846	0.0400
SAFETY (4000-8000 SFr/month)		-0.2728	-0.4118
SAFETY (>8000 SFr/month)		0.7607	0.9524
Goodness-of-fit			
Number of estimated parameters:	8		
Sample size:	95		
Null log-likelihood:	-170.217		
Final log-likelihood:	**-69.4863**		
Likelihood ratio test:	201.462		
Rho-square:	**0.5918**		

To conclude this section, the models which gave the best results can be considered the second and the third presented. It should be reiterated that the models shown are already a result of a previous selection made from several calculated models and they represent the best results obtained. A few general remarks can be made, after those already made in each table description:

- this experiment represents just one of the four included in the first test, so that it is not possible to generalize the results of this experiments to all of them. Different models were estimated for each of them and the main difference or peculiarity can be listed as follows:

    - for all experiments the introduction of the variable related to ‘kind of intervention’ influenced appreciably the significance and the goodness-of-fit of the model;

  - specifically for the experiment related to 'crossroad' in all models performed the estimated parameter signs of SAFETY and COST are the opposite of what would be expected – SAFETY negative and COST positive. Only when the variable 'intervention kind' was introduced the parameter COST acquired a negative sign. One possible explanation for that can be related to the values of the variables within this experiment and to the choice which respondents made, as may be seen in chapter 9.6.4. The values of the variables in fact are particular for having high values of safety related to alternatives with also high cost; so that, the safety seems to increase with the cost. Additionally, the most chosen alternatives from the respondents were exactly two of those, precisely 'Traffic light with photocell' and 'Roundabout'. Therefore, the model perhaps translated that as if the utility was increasing with the cost (because the number of victims avoided is higher for more expensive alternatives) or decreasing with the safety (because the cost is lower for alternatives with less victims avoided;

  - the order of magnitude of the VOL calculated for other single experiments is mostly lower than these derived from 'bus stop and/or lane'. This reflects also the median VOL values trend, analysed in chapter 9.9.1.

- this experiment was selected because of its quite appreciable evolution in the results obtained, even with simple modifications of the models;

- we must be conscious that the possible combinations and interactions of variables to create new models are very large. This is just a small fragment of this number;

- concerning the VOC, which was the aim of the calculation, it is already interesting to observe that even if the values vary slightly across the models, the magnitude of the value does not change substantially.

All experiments pooled together

The second group of models for the test without budget constraint, analyses the estimations of utility parameters for all experiments pooled together. For this reason, as introduced previously, scale parameters were associated with each experiment, which have been estimated in the same way as the other parameters in every model. There are 483 observations available per estimation.

The first model, as for the single experiment, is the basic model (see Table 10.5). Four variables – safety, journey time change, comfort variation and cost – were used to specify the utility of each alternative; all of them are generic variables, since they appear in the utility function of every alternative. The number of estimated parameters is seven, which is the sum of the four parameters related to the variables mentioned and three scale parameters, since one of them must be fixed. Looking at the signs of the estimated parameters, all of them are correct and unambiguous: the utility decreases with cost and journey time and increases with comfort and safety. Concerning the significance of them, the only parameters which is very insignificant is COST, with a *t-value* much lower than the critical one; SAFETY and COMFORT are significant and JTIME narrowly insignificant. The scale parameter estimates are mostly significant or narrowly insignificant and all their values are lower than one. This means that their variance is substantially different from the fixed one. The goodness-of-fit values show a Likelihood ratio test with a value much higher than the critical χ^2, for seven parameters estimated and a significance level $\alpha=0.05$, which is 14.067; consequently the null hypothesis that the subset of parameters estimated are equal to zero can be rejected. Although the estimated parameter relative to cost is not significant, the VOC has been calculated, and it shows a value with a higher order of magnitude than that calculated in the previous experiment. Comparing this value with the median and mean VOC, analysed in chapter 9.9.1, it can be seen that the magnitude of it is about 10^2 times bigger than median and mean VOC for all experiments pooled together. Remembering the assumption that, for the calculation of the mean, the ‘infinite’ VOC were excluded, it has been shown that, with the reintroduction of these values, the mean VOC could reach a magnitude closer to this model, with a value of 934,191 SFr. per year.

Table 10.5 Basic model

Parameters		Value	t-Test
Utility parameters			t-Test against zero
COMFORT		0.3476000	**2.8674**
COST		-0.0000004	-0.4497
JTIME		-0.2215000	-1.9235
SAFETY		0.6275000	**3.6247**
Scale parameters			t-Test against one
Scale BUS		1.0000000	fixed
Scale NIGHT		0.3195000	**-7.2248**
Scale SPEED		0.5907000	-1.8202
Scale CROSSROAD		0.4521000	**-5.6197**
Goodness-of-fit			
Number of estimated parameters:	7		
Sample size:	483		
Null log-likelihood:	-865.42		
Final log-likelihood:	**-745.519**		
Likelihood ratio test:	239.802		
Rho-square:	**0.1385**		
Value of casualty avoided (SFr per year)		(1'746'403) [8]	

In the second model presented the variable safety is interacted with the variables representing the age classes of the respondents. As previously, a variable of this kind, which is not a part of the choice set and it does not vary across the alternatives, can be introduced only in interaction with an alternative specific variable such as safety in this case. The signs of the parameters (see Table 10.6) are correct and the *t-values*, except for COST and SAFETY for respondents younger than 30 year old, are significant. Also the scale parameters, all of them still smaller than one, have t-values higher than the critical 1.96, that is, all of them are significant. The goodness-of-fit values show a Rho-square higher than the basic model, a

8 This value is in brackets because of the low significance level of the parameter COST.

Likelihood ratio test still higher than the critical χ^2, for ten parameters estimated and a significance level α=0.05, which is 18.307. A Likelihood ratio test between this model and the basic model has a value of 9.394, which is higher than the critical χ^2 for three parameters added and a significance level α=0.05, which is 7.815. Consequently is possible to assess that this model is more significant than the basic model. Concerning the VOC, in this case it is distinguished for different age classes; For the younger class, whose estimated parameter is not significant, the VOC is the same as for the age class implicit in SAFETY itself – that of the elderly. Specifically, the different VOC are calculated as shown in Equations 10.15-10.17, which are similar to those introduced in Chapter 10.3.3.

$$VOL(31-50YearOld) = -\frac{SAFETY + SAFETY(31-50YearOld)}{COST} \tag{10.15}$$

$$VOL(51-60YearOld) = -\frac{SAFETY + SAFETY(51-60YearOld)}{COST} \tag{10.16}$$

$$VOL(<30/>60YearOld) = -\frac{SAFETY}{COST} \tag{10.17}$$

The VOC calculated in all three cases has a magnitude similar to the basic model and it seems to decrease with the age: the younger, except of the youngest, are willing to pay more than the elderly. That could be generated from the progressive lack of interest of older people towards problems related to traffic safety, since they do not consider it as something very important any more or as a problem which their opinions cannot influence very much.

Table 10.6 Interaction of safety with age classes

Parameters		Value		t-Test
Utility parameters				t-Test against zero
COMFORT		0.3335000		**2.7969**
COST		-0.0000003		-0.4592
JTIME		-0.2224000		**-2.0526**
SAFETY		0.4050000		**2.7026**
SAFETY (<30 year old)		0.1132000		0.7451
SAFETY (31-50 year old)		0.3265000		**2.6976**
SAFETY (51-60 year old)		0.2398000		1.9519
Scale parameters				t-Test against one
Scale BUS		1.0000		fixed
Scale NIGHT		0.3217		**-7.5012**
Scale SPEED		0.5802		**-2.0349**
Scale CROSSROAD		0.4817		**-5.0477**
Goodness-of-fit				
Number of estimated parameters:	10			
Sample size:	483			
Null log-likelihood:	-865.42			
Final log-likelihood:	**-740.822**			
Likelihood ratio test:	249.195			
Rho-square:	**0.1440**			
Value of casualty avoided (SFr per year)	<30 years	31-50 years	51-60 years	>60 years
	1,190,540	2,150,449	1,895,377	1,190,540

In the third model the variable safety is interacted with the variables – already introduced in the previous set of models – gross family income per month and kind of intervention proposed in each alternative (service improvement, small infrastructure or big infrastructure). The number of estimated parameters becomes eleven (see Table 10.7). Looking at the signs of the parameters, they are all correct and unambiguous, except of that of SAFETY related to service improvement which is negative. Normally, if the difference between the parameter SAFETY itself and SAFETY interacted with service becomes positive, then also the variable 'service improvement' has a significant influence. If the difference is negative, as in this case, the influence of 'service improvement' is negligible. Secondly, all parameters have significant *t-value* – except of cost, whose level of significance anyhow increases from before, getting closer to the critical value. Another point in favour of this model is given from the goodness-of-fit values: Rho square, in comparisons with the previous models, increases considerably; the likelihood test has a value much higher than the critical χ^2 for eleven parameters estimated and a significance level α=0.05, which is 19.675. A likelihood test between this model and the basic model shows as well a value of 239.802, much greater than the critical χ^2 for four parameters added and a significance level α=0.05, which is 9.488. Consequently, it seems that the model is more significant than the previous ones and the variables associates with safety, in this case, influence substantially the choices of the respondents. The VOC calculated are differentiated for classes of gross family income and kind of improvement; the service improvement class is excluded because of its estimated value. Looking at them it may be seen that their magnitude is lower than in the previous two models and that they are moving closer to the median and mean VOC analysed previously. It is also noticeable that the VOC is increasing with income level; for the same levels of income, the value is greater for big infrastructures than for small infrastructures.

Table 10.7 Interaction of safety with intervention kind and class of gross family income

Parameters		Value		t-Test
Utility function parameters				t-Test against zero
COMFORT		0.238000		0.9918
COST		-0.000003		-1.6053
JTIME		-0.496100		**-2.3903**
SAFETY		0.679200		**2.2018**
SAFETY (service improvement)		*-0.725400*		**-2.8098**
SAFETY (big infrastructure)		0.828300		**4.2451**
SAFETY (4000-8000 SFr/month)		0.336100		**2.0694**
SAFETY (>8000 SFr/month)		0.440000		**2.3193**
Scale parameters				t-Test against one
Scale BUS		1.000000		fixed
Scale NIGHT		0.161600		**-18.5386**
Scale SPEED		0.357100		**-4.2157**
Scale CROSSROAD		0.254800		**-10.2806**
Goodness-of-fit				
Number of estimated parameters:	11			
Sample size:	483			
Null log-likelihood:	-865.42			
Final log-likelihood:	**-706.451**			
Likelihood ratio test:	317.937			
Rho-square:	**0.1837**			
Value of casualty avoided (SFr per year)	<4000 SFr/month		4000-8000 SFr/month	>8000 SFr/month
Small infrastructure	217'500		325'127	358'378
Big infrastructure	482'720		590'347	623'598

Since the previous model showed a great improvement, the next model was performed by including in the previous the variable 'place of residence', to analyse whether that may have some influence. The values in Table 10.8 show that all estimated parameters have a correct sign and for SAFETY interacted with 'service improvement' the situation is the same as before. Also the *t-values* are significant for the majority of them: the insignificant t-values are those relative to cost and to safety interacted with 'village close to the city'. Among the goodness-of-fit values is visible that Rho square increases as the Likelihood ratio test does, remaining with a value much higher than the critical χ^2 for 13 parameters estimated and a significance level α=0.05, which is 22,362. A comparison can be made with the Log-likelihood function of the previous one: the likelihood ratio test has a value of 5.56, which is slightly lower than the critical χ^2 for two more parameters estimated and a significance level α=0.05 which is 5.991. Consequently, the introduction of the place of residence is not improving the significance of the model. The VOC were calculated considering all variables except service improvement; the VOC referred to village close to the city, because of the low significance level, is the same as that for city, which is implicit in the parameter SAFETY itself. The tendency is, as before, for VOL to increase with higher gross family income per month and big infrastructures. The place of residence influences in that those who live in the city, in every situation, are willing to pay more than those who live in villages close to the city. One reason could be that the inhabitants of the city feel, more than others, traffic safety as an all day problem, with which they are more directly involved.

Table 10.8 Interaction of safety with intervention kind, class of gross family income and place of residence

Parameters	Value	t-Test
Utility parameters		t-Test against zero
COMFORT	0.308000	1.4851085
COST	-0.000002	-1.5301602
JTIME	-0.415500	**-2.3702723**
SAFETY	0.656000	**2.5684893**
SAFETY (service improvement)	*-0.661006*	**-2.8318824**
SAFETY (big infrastructure)	0.785800	**4.4409000**
SAFETY (4000-8000 SFr/month)	0.348200	**2.3135906**
SAFETY (>8000 SFr/month)	0.382000	**2.2060473**
SAFETY (village close to the city)	-0.223000	-1.4666871
SAFETY (village in rural area)	-0.351900	**-2.2129310**
Scale parameters		t-Test against one
Scale BUS	1.000000	fixed
Scale NIGHT	0.183200	**-16.932081**
Scale SPEED	0.432400	**-3.3693309**
Scale CROSSROAD	0.292100	**-9.6773087**
Goodness-of-fit		
Number of estimated parameters:	13	
Sample size:	483	
Null log-likelihood:	-865.42	
Final log-likelihood:	**-703.671**	
Likelihood ratio test:	323.498	
Rho-square:	**0.1869**	

Value of casualty avoided (SFr per year)		<4000 SFr/month	4000-8000 SFr/month	>8000 SFr/month
Small infrastructure	City	284'239	435'135	449'757
	Village close to city	284'239	435'135	449'757
	Village in rural area	131'745	282'642	297'263
Big infrastructure	City	624'731	775'627	790'249

Village close to city	624'731	775'627	790'249
Village in rural area	472'237	623'133	637'755

The following model (see Table 10.9) does not represent improvement in values from the previous ones; rather it approaches the analysis in a different way. In fact, coming back to the variables considered in the basic model, four new dummy variables were created, related to the single experiments, which are the four available for the test without budget. The aim was to understand whether the interaction between cost of the alternative and the experiment where this alternative was proposed influenced respondent's choices. The number of estimated parameters is ten; three new parameters were added to the basic model and the variable implicit in the parameter cost itself is that related to the experiment 'bus stop and/or lane'. The signs of all of them are correct and unambiguous, except COST, which has a positive sign. The problem relates to their significance: all *t-values*, in fact, except two of them – highlighted in bold – are below the critical value. This means that they are not significant, that is, the probability that their estimated values are those shown is very low. Among the goodness-of-fit values Rho-square slightly increases from the basic model and the Likelihood ratio test has a value much higher than the critical χ^2 for ten parameters estimated and a significance level α=0.05, which is 18.307. A Likelihood test, to compare this model with the basic one, shows a value – 4.28 – which is slightly lower than the critical χ^2 for three more parameters estimated and a significance level α=0.05. Owing to the insignificant t-values the VOC for this model have not been calculated.

Table 10.9 Interaction of cost with experiment

Parameters		Value	t-Test
Utility parameters			t-Test against zero
COMFORT		0.358200	**2.5409**
COST		0.000001	0.4469
COST (crossroad)		-0.000001	-0.3402
COST (night)		-0.000009	**-2.2169**
COST (speed)		-0.000004	-0.5514
JTIME		-0.099000	-0.9953
SAFETY		0.407200	1.3159
Scale parameters			t-Test against one
Scale BUS		1.000000	fixed
Scale NIGHT		0.587900	-0.8765
Scale SPEED		1.155000	0.2294
Scale CROSSROAD		0.595300	-0.9599
Goodness-of-fit			
Number of estimated parameters:	10		
Sample size:	483		
Null log-likelihood:	-865.42		
Final log-likelihood:	**-743.379**		
Likelihood ratio test:	244.083		
Rho-square:	**0.1410**		

To conclude the analysis of this second group of models related to the test without budget constraint it can be stated that the best fitting models, whit best and most significant parameter estimates, are represented by those shown in Table 10.8. Similarly to the single experiment models, the introduction of the variable ‘intervention kind’ seems to affect the model significantly; this is again a sign that, apart from the experiment considered, an important criterion followed by respondents in making their choice was the kind of alternative proposed. This fact therefore gives much more importance to the description of the alternative presented in the survey than to the variable values related to it. A possibility could have been the introduction of the variables related to intervention kind not in interaction with SAFETY but as separate variables in all utility functions. To do that it should have been necessary to define different intervention kind variables for each alternative – there would have been 16 instead of four different variables related to it – so that, the variable could became alternative specific. A difference which can be detected from the single experiment models is that, generally, parameter estimates – for the same kind of variable interactions – in models with all experiments pooled together are more significant. The reason for that could be related to the interaction between different experiments. As stated at the end of the single experiment analysis, the results from different single experiments modelling, each of them considered separately, were not all similar to each other. So that, once all experiments had been pulled together, the different outputs compensated one another and produced an overall better result. The VOL detected with this group of models, as mentioned during the models description, varies from values with magnitude 10^6 to values with magnitude 10^5. The VOL for the most significant model vary between 131,745 SFr per year and 790,249 SFr per year.

Priority Evaluator test

The following test will be presented, initially for two experiments singly, related to 'bus stop and/or lane' and 'pedestrian'; subsequently all experiments will be pooled together and scale parameters will be defined. In both cases, as for the previous test, the analysis will start from a basic model and will progress to more elaborate ones. The VOC is calculated again just for the cases in which the parameters are significant or narrowly insignificant. One of the main differences from the previous test is, as already mentioned, the presence of a budget constraint. To introduce that into the models, in each of them the variable and the parameter cost were replaced with a variable and a parameter representing the ratio between cost of the alternative and budget available. In this way the VOC, calculated in the basic model as simply the ratio between SAFETY parameter and COST/BUDGET parameter, no longer expresses the amount of money the respondents are willing to pay for one more casualty avoided; rather, this ratio symbolised the percentage of the budget respondents were willing to invest for this aim. Even if the interpretation differs, the name VOC will be maintained.

Bus stop and/or lane improvement

In the following experiment, as mentioned in the previous test, respondents are asked to select a possible improvement relative to bus stop and/or lane between the six proposed – included the possibility of not modifying anything. The data consist of 46 observations. Four variables are employed in the basic model (see Table 10.10) are four: safety, journey time change, comfort variation and cost over budget: consequently there are also four estimated parameters. Looking at the sign of the estimated utility parameters, they are all correct and unambiguous –

we would expect that a negative sign would be associated with cost and time and a positive sign with safety and comfort, since an individual's relative utility will increase when time and cost decrease and will increase if the number of victims avoided and the comfort are higher. The *t-values* are mostly significant, except of that relating to comfort. The Likelihood ratio test, has a value higher than the critical χ^2 for four parameters estimated and a significance level α=0.05, which is 9.488, consequently the null hypothesis that the subset of parameters estimated are equal to zero can be rejected. Finally, the percentage of budget which respondents are willing to invest for one more casualty avoided is about the 21%, as shown at the end of the table. For the levels of budget given the VOC would correspond to 106,250 SFr per year if the budget was 500,000 SFr., 127,500 SFr, per year if the budget was 600,000 SFr. and 170,000 SFr. per year if the budget was 800,000 SFr. These values have the same order of magnitude as the median and mean VOC calculated in chapter 9.9. and also do not differ much also from the VOC found during the first test analysis.

Table 10.10 PE bus - Basic model

Parameters		Value	t-Test
Utility parameters			
COMFORT		0.2138	0.8830
COST/BUDGET		-16.6944	**-3.2139**
JTIME		-0.6518	**-2.7825**
SAFETY		3.5472	**3.5029**
Goodness-of-fit			
Number of estimated parameters:	4		
Sample size:	46		
Null log-likelihood:	-82.4209		
Final log-likelihood:	**-72.8058**		
Likelihood ratio test:	19.2304		
Rho-square:	**0.1167**		
Value of casualty avoided		0.2125	

The second model differs from the basic model in the interaction of the variable cost over budget with three dummy variables created to represent the three levels of budget offered. In this way it should be possible to understand how much these different levels of budget influenced the people's choices. The dummy variable implicit in the cost over budget variable is that related to budget 800,000 SFr, which is the highest level. The results of the estimations may be seen in Table 10.11. The signs of the estimated parameters are all correct and unambiguous; regarding the significance, the only parameter not significant is the cost over budget related to the variable 'budget 600,000 SFr.' Among the goodness -of-fit values Rho square increases from the basic model and the Likelihood ratio test has a value higher than the critical χ^2 for six parameters estimated and a significance level α=0.05, which is 12.592. The Likelihood ratio test between this model and the basic one is 10.8, a value higher than the critical χ^2 for two more parameters estimated and a significance level α=0.05, which is 5.991. These results show that this model is more significant than the basic one. The VOC calculated vary slightly from the basic model: it seems that respondents higher budget available would spend a lower percentage of their budget to avoid one more casualty than respondents with lower budget. Despite this difference, the VOC calculated for each budget have all the same order of magnitude. Consequently, the VOC does not depend significantly from the level of budget given.

Table 10.11 PE bus - Interaction of cost with the budget given

Parameters		Value	t-Test
Utility parameters			
COMFORT		0.6086	**2.0220**
COST/BUDGET		-48.1374	**-3.8102**
COST/BUDGET (budget 500,000 SFr)		12.9050	**3.0076**
COST/BUDGET (budget 600,000 SFr)		4.1853	1.3547
JTIME		-1.7691	**-3.7066**
SAFETY		8.8796	**4.0390**
Goodness-of-fit			
Number of estimated parameters:	6		
Sample size:	46		
Null log-likelihood:	-82.4209		
Final log-likelihood:	**-67.4009**		
Likelihood ratio test:	30.0401		
Rho-square:	**0.1822**		
Value of casualty avoided	budget 500,000 SFr	budget 600,000 SFr	budget 800,000 SFr
	0.2520 (126,000 SFr/year)	0.2020 (121,000 SFr/year)	0.1845 (147,000 SFr/year)

The third and last model related to this experiment introduces to the previous models also the interaction between the parameter safety and the three dummy variables related to kind of intervention – service improvement, small infrastructure and big infrastructure (see Table 10.12). The variable implicit in the safety itself is ‘small infrastructure’. Regarding the estimated parameters signs, they are all correct except that of SAFETY related to service improvement; even the sum of this estimated parameter with the parameter SAFETY itself has still a wrong sign – negative. Looking at its *t-value*, it shows a value much lower than the critical one; that is, the kind of intervention classified as service improvements influences in the same way the parameter SAFETY in the utility function as small infrastructures, the variable implicit in the parameter SAFETY itself. Another aspect is that, as before, the parameter of cost related to the middle budget is, narrowly, not significant, although its *t-*

value improves in comparison with the previous one. Within goodness-of-fit values, Rho-square increases from 0.1822 to 0.5516 and the Likelihood ratio test has still a value higher than the critical χ^2 for eight parameters estimated and a significance level α=0.05, which is 15.507. To compare this model with the previous one, the Likelihood ratio test between them has a value of 60.8962, which is much higher than the critical χ^2 for two more parameters estimated and a significance level α=0.05, which is 5.991. Once more the introduction of the kind of improvement influenced significantly the results of the model. The VOC are calculated for the three levels of budget and for different intervention kind. The results show that, firstly, as in the last model, respondents with lower budget are willing to invest a bigger percentage of their budget, independently of the intervention kind, to avoid one more victim. Secondly, respondents are willing to invest a bigger percentage in big infrastructures than in small infrastructures and service improvement; this result was also found in the previous test. The values calculated for the different combinations are visible in brackets and do not greatly differ between each other. The order of magnitude is the same as for the basic model.

Table 10.12 PE bus - Interaction of cost with the budget given and of safety with the kind of intervention

Parameters		Value	t-Test
Utility parameters			
COMFORT		1.9397	**2.91680**
COST/BUDGET		-126.8235	**-2.71640**
COST/BUDGET (budget 500,000 SFr)		39.9304	**2.44460**
COST/BUDGET (budget 600,000 SFr)		16.8215	1.53340
JTIME		-3.3383	**-2.46670**
SAFETY		19.5631	**2.65410**
SAFETY (service improvement)		*-30.8283*	-0.00002
SAFETY (big infrastructure)		6.1770	**2.08620**
Goodness-of-fit			
Number of estimated parameters:	8		
Sample size:	46		
Null log-likelihood:	-82.4209		
Final log-likelihood:	**-36.9546**		
Likelihood ratio test:	90.9327		
Rho-square:	**0.5516**		
Value of casualty avoided	budget 500,000 SFr	budget 600,000 SFr	budget 800,000 SFr
Big infrastructure	0.2962 (148,000 SFr/year)	0.2340 (140,000 SFr/year)	0,2030 (162,000 SFr/year)
Small infrastructure and service improvement	0,2251 (113,000 SFr/year)	0.1778 (106,000 SFr/year)	0.1543 (123,000 SFr/year)

Pedestrian improvement

In the next single experiment described, respondents are asked to select a possible improvement relative to 'pedestrian' from among the six proposed– including the possibility of not modifying anything. The data consist of 161 observations and the basic model has the same shape as the previous experiment. All parameters signs are correct and all parameters, except COMFORT, are significant. Among the goodness-of-fit measures the Likelihood ratio test has a value greater than the critical χ^2 for four parameters estimated and a significance level α=0.05, which is 9.488. The VOC calculated as ratio between SAFETY and COST/BUDGET shows that respondents in this experiment are willing to invest about 17% of the budget given for one casualty avoided, a lower percentage than in the previous experiment.

Table 10.13 PE pedestrian - Basic model

Parameters		Value	t-Test
Utility parameters			
COMFORT		0.1663	1.1946
COST/BUDGET		-6.5384	**-4.5370**
JTIME		-0.0789	**-2.5467**
SAFETY		1.1222	**4.7795**
Goodness-of-fit			
Number of estimated parameters:	4		
Sample size:	161		
Null log-likelihood:	-288.473		
Final log-likelihood:	**-265.477**		
Likelihood ratio test:	45.9918		
Rho-square:	**0.0797**		
Value of casualty avoided		0.1716	

The second model for this experiment (see Table 10.14) introduces the three dummy variables related to the levels of budget offered in relation to the parameter COST/BUDGET, and two dummy variables related to the kind of intervention related to the parameter SAFETY. In this case the intervention ‘service improvement’ was excluded, since no alternative proposed was related to it. With these interactions, the parameter estimates are still correct and unambiguous and all of them, except COMFORT, are significant. The parameter COMFORT, in any case, improves its significance. Looking at the goodness-of-fit values, Rho square increases from 0.0797 to 0.1462; the Likelihood ratio test is still greater than the critical χ^2 for seven parameters estimated and a significance level α=0.05, which is 14.067. A Likelihood ratio test with the basic model has a value of 38.366, which is much higher than the critical χ^2 for two more parameters estimated and a significance level α=0.05, corresponding to 7.815. This means that the model tested is much more significant than the basic one. Since all parameters are significant, the VOC for all combinations are calculated. As in the previous experiment, the percentage of budget which respondents are willing to invest for a casualty avoided decreases with the growth of the budget available. Another similarity is the preference for investing higher percentages of the budget, within each budget category, in big rather than small infrastructures. The values in brackets, calculated for each budget level, make possible the comparison with median and mean VOC, evaluated in chapter 9.9.: the magnitude for small infrastructures is similar to them, whether for big infrastructures it is one order of magnitude bigger.

Table 10.14 PE pedestrian - Interaction of cost with the budget given and of safety with the kind of intervention

Parameters	Value	t-Test
Utility parameters		
COMFORT	0.1888	1.2578
COST/BUDGET	-15.4934	**-6.6512**
COST/BUDGET (budget 500,000 SFr)	5.5991	**4.1869**
COST/BUDGET (budget 600,000 SFr)	4.1865	**3.4456**
JTIME	-0.1847	**-4.9279**
SAFETY	1.7195	**6.3026**
SAFETY (big infrastructure)	0.6329	**4.2219**
Goodness-of-fit		
Number of estimated parameters:	7	
Sample size:	161	
Null log-likelihood:	-288.473	
Final log-likelihood:	**-246.309**	
Likelihood ratio test:	84.329	
Rho-square:	**0.1462**	

Value of casualty avoided	budget 500,000 SFr	budget 600,000 SFr	budget 800,000 SFr
Small infrastructure	0.1738 (86,900 SFr/year)	0.1521 (91,260 SFr/year)	0.1110 (88,800 SFr/year)
Big infrastructure	0.2377 (118,850 SFr/year)	0.2080 (124,800 SFr/year)	0.1518 (121,440 SFr/year)

The third and last model associated with this experiment includes three more variables – those related to gross family income per month – interacted with the variable safety (see Table 10.15). The variable implicit in the safety parameter itself is that related to the lowest gross family income (<4000 SFr per month). In this case the only parameters which are not significant are comfort and safety interacted with the highest gross family income per month. Despite this, all signs are correct and unambiguous. Concerning the goodness-of-fit values, Rho square increases slightly and the Likelihood ratio test is still higher than the critical χ^2 for nine parameters estimated and a significance level α=0.05, which is 16.919. A Likelihood ratio test with the previous model gives a value – 5.202 – which is slightly lower than the critical χ^2 for two more parameters estimated and a significance level α=0.05, which is 5.991. The same test, but with the basic model, gives a value of 43.538, which is much higher than the critical χ^2 for five more parameters estimated and a significance level α=0.05, corresponding to 11.070. These results imply that this model is more significant than the basic one, but less significant than the previous one introduced; that is, the two parameter added related to family gross income do not improve the significance of the model. The VOC were calculated for all variables classes; that related to the highest family income, since the parameter related to it is not significant, is the same as that related to the lowest family income, which is implicit in the parameter SAFETY itself. The trend is still showing a willingness to invest higher percentages of the budget acquired when this is lower and the improvement is classified as big infrastructure. Including the factor income, all other factors being equal, the percentage of budget which respondents are willing to invest is greater for respondents with income between 4,000 and 8,000 SFr/month.

Table 10.15 PE pedestrian - Interaction of cost with the budget given and of safety with the kind of intervention and the income

Parameters		Value	t-Test
Utility parameters			
COMFORT		0.1997	1.3306
COST/BUDGET		-15.7049	**-6.6933**
COST/BUDGET (budget 500,000 SFr)		5.4418	**4.0434**
COST/BUDGET (budget 600,000 SFr)		3.9726	**3.2496**
JTIME		-0.1889	**-5.0208**
SAFETY		1.5346	**5.4336**
SAFETY (big infrastructure)		0.6160	**4.0595**
SAFETY (4000-8000 SFr/month)		0.3795	**2.2529**
SAFETY (>8000 SFr/month)		0.2427	1.3238
Goodness-of-fit			
Number of estimated parameters:	9		
Sample size:	161		
Null log-likelihood:	-288.473		
Final log-likelihood:	**-243.708**		
Likelihood ratio test:	89.5314		
Rho-square:	**0.1552**		
Value of casualty avoided	budget 500,000 SFr	budget 600,000 SFr	budget 800,000 SFr
Small infrastructure <4000 and >8000 SFr/month	0.1495	0.1308	0.0977
Big infrastructure <4000 and >8000 SFr/month	0.2095	0.1833	0.1369
Small infrastructure -4000-8000 SFr/month	0.1865	0.1632	0.1219
Big infrastructure 4000-8000 SFr/month	0.2465	0.2157	0.1611

With this model the analyses of the single experiments are concluded. Once more, the models selected from both the experiments were chosen among a larger group of models, being those more significant and having the best levels of improvement. The similarity between these two experiments can be related to few aspects. One of them is the reaction after the introduction of the variable ‘improvement kind’: in both cases the model is improved substantially. Another one is the variation of VOC across the combination of variables: as remarked, in both cases, for example, respondents are willing to invest a bigger percentage of their budget in big infrastructures; additionally, lower is the level of budget available, greater is the percentage of it that respondents are willing to invest. In any case, the order of magnitude of the VOC across all cases does not vary consistently.

All experiments pooled together

The third group of models for the PE test concerns the estimations of the utility function parameters for all experiments pulled together. Therefore, scale parameters were introduced in every model. For all models 483 observations are available.

The first model is a basic model (Table 10.16), rather similar to that presented for the single experiments; eight parameters are estimated, of which four are scale parameters – one scale parameter must be always fixed. All the parameter estimates are correct and significant – except COMFORT, as before. The scale parameters too are mostly significant and three of them have values bigger than one: this is a sign that the variance of the experiments does not vary much from the fixed one. The likelihood ratio test, among the goodness-of-fit values, is greater than the critical χ^2 for eight parameters estimated and a significance level α=0.05, corresponding to 16.919; consequently, the null hypothesis that the subset of parameters estimated are equal to zero can be rejected. The VOC calculated shows that respondents are willing to invest about 19% of the budget given for one more casualty avoided, a result which does not differ much from the previous ones.

Table 10.16 PE Basic model

Parameters		Value	t-Test
Utility parameters			t-Test against zero
COMFORT		0.000004	0.0104
COST/BUDGET		-1.935700	**-3.6715**
JTIME		-0.027100	**-2.9871**
SAFETY		0.365300	**3.7673**
Scale parameters			t-Test against one
Scale PEDESTRIAN		3.116700	**2.0888**
Scale BUS		3.913000	1.6204
Scale BIKE		2.499000	**2.0250**
Scale NIGHT		0.508100	**-2.5884**
Scale SPEED		1.000000	fixed
Goodness-of-fit			
Number of estimated parameters:	8		
Sample size:	483		
Null log-likelihood:	-865.42		
Final log-likelihood:	**-771.031**		
Likelihood ratio test:	188.778		
Rho-square:	**0.109**		
Value of casualty avoided		0.1887	

The first step from the basic model consists of the integration of the variable cost/budget with the dummy variables (already introduced for single experiments) relating to the level of budget given, and of the variable safety with the dummy variables relating to the intervention kind (see Table 10.17). The variables implicit in the safety and cost/budget parameter itself are the highest budget level (800,000 SFr) and the intervention related to small infrastructures. Although the estimated parameter signs are all correct, some of them are not fully significant: the parameters cost/budget related to budget 500,000 and 600,000 SFr. and the journey time parameters have *t-values* below the critical value 1.96. Regarding the estimated scale parameters, most of them decrease, although the *t-values* do not vary very much. This is a sign that the variance of the experiments comparing with the fixed one start to be larger. Looking at the goodness-of-fit measures, the Likelihood ratio test is still much greater than the critical χ^2 for 12 parameters estimated and a significance level α=0.05, corresponding to 21.026. A Likelihood ratio test between this model and the basic one has a value of 316.266, which is also much higher than the critical χ^2 for four more parameters estimated and a significance level α=0.05, which is 9.488. This means that the model created is considerably more significant than the basic one. Once more it is noticeable how the kind of intervention influenced the respondent's choices. Concerning the amount of budget given, from the low significance of the estimated parameters related to it, it can be assumed that, the percentage which respondents are willing to pay for one more casualty avoided is not strongly influenced from the level of budget given. The VOC shown is calculated with the parameter COST/BUDGET itself and includes all three budget levels. The values obtained show very low percentage in intervention related to service improvement and small infrastructure. Those related to big infrastructures account for, as previously, the highest percentage. This result could be caused by either of two factors: first, the service improvement is an intervention kind which is not proposed in all experiments; therefore, in some cases it could not even be chosen. Secondly, most of the alternatives related to service improvement do not greatly influence the level of safety, but mostly other parameters such as comfort or journey time.

After the results obtained from this model, a slightly different model, without the interaction of the budget levels, was performed. This model is not shown, since the values are very similar to this one just presented; however, it was a useful test to sustain the hypothesis that budget levels do not greatly influence the choices of the respondents once the experiments are analysed all together . The same cannot be said of models with experiments analysed singly, as may be seen in the first two groups of models.

Table 10.17 PE Interaction of cost/budget with the budget given and of safety with the kind of intervention

Parameters		Value		t-Test
Utility parameters				t-Test against zero
COMFORT		0.0015		**2.6766**
COST/BUDGET		-5.4186		**-3.5160**
COST/BUDGET (budget 500,000 SFr)		1.2693		1.5302
COST/BUDGET (budget 600,000 SFr)		0.0972		0.1222
JTIME		-0.0152		-0.7892
SAFETY		0.3771		**4.3093**
SAFETY (service improvement)		-0.3616		**-2.7996**
SAFETY (big infrastructure)		1.4161		**3.9108**
Scale parameters				t-Test against one
Scale PEDESTRIAN		0.4430		**-3.9447**
Scale BUS		1.7423		1.0463
Scale BIKE		3.2163		**2.5318**
Scale NIGHT		0.6069		**-2.1001**
Scale SPEED		1.0000		fixed
Goodness-of-fit				
Number of estimated parameters:	12			
Sample size:	483			
Null log-likelihood:	-865.42			
Final log-likelihood:	**-612.898**			
Likelihood ratio test:	505.044			
Rho-square:	**0.292**			
Value of casualty avoided		Service improvement	Small infrastructure	Big infrastructure
		0.0029	0.0696	0.3309

In the third model with all experiments pooled together an interaction was searched between the variable cost/budget and the experiments proposed. Five dummy variables were created, related to the five experiments, and one of them – that related to pedestrians – was implicit in cost/budget. The signs of the estimated parameters are correct, except for the parameter COST/BUDGET related to the night experiment – the sum of its estimated value and the COST/BUDGET estimated value is still positive. Despite that, the *t-values* of most parameters where COST/BUDGET was interacted with the experiments are not significant; the same is true of most of the scale parameters. Additionally, despite the same number of estimated parameters, Rho-square and Final log-likelihood have values much lower than the previous model. Therefore it can be stated that this model is less significant than the previous ones and the variable experiment kind does not influence respondent choices Regarding the Likelihood ratio test, its value is still higher than the critical χ^2 for 12 parameters estimated and a significance level α=0.05, which is 21.026 The VOC calculated refer to the only COST/BUDGET estimated parameter which is significant and includes all the experiments.

Table 10.18 PE Interaction of cost/budget with the experiments

Parameters		Value	t-Test
Utility parameters			t-Test against zero
COMFORT		0.0002	0.2748
COST/BUDGET		-4.4870	**-2.7500**
COST/BUDGET (bike)		0.0115	0.0291
COST/BUDGET (bus)		0.7760	1.4869
COST/BUDGET (night)		*9.9033*	1.2212
COST/BUDGET (speed)		-11.5004	-1.6528
JTIME		-0.0657	**-2.5122**
SAFETY		0.8131	**2.7865**
Scale parameters			t-Test against one
Scale PEDESTRIAN		1.4902	0.8207
Scale BUS		2.0733	1.0742
Scale BIKE		1.1276	0.2958
Scale NIGHT		0.2187	-7.8969
Scale SPEED		1.0000	fixed
Goodness-of-fit			
Number of estimated parameters:	12		
Sample size:	483		
Null log-likelihood:	-865.42		
Final log-likelihood:	**-767.026**		
Likelihood ratio test:	196.788		
Rho-square:	**0.114**		
Value of casualty avoided		0.1812	

The last model performed combines the last two models presented (see Table 10.19), to investigate whether this integration can produce better results. The variable implicit with variable safety is that relating to small infrastructure and those implicit with cost/budget are the experiment related to ‘pedestrian’ and the highest budget level. The parameter signs are all correct and unambiguous except one – the sum of the estimated parameter SAFETY related to service improvement with the estimated parameter SAFETY itself is in fact negative, not positive. On the other hand the *t-values* related to them are in most cases not significant, so that this combination does not seem to influence the parameters’ estimates very much. Regarding the goodness-of-fit values, in comparison with the previous model presented, Rho-square is improving and the final log-likelihood increases. A Likelihood ratio test between this and the previous model has a value of 332.808, which is much higher than the critical χ^2 for four more parameters estimated and a significance level α=0.05, corresponding to 9.488. That represents, despite the low significance of the model, a small improvement from the previous one. The VOC are calculated represent all experiments and all income classes, being the estimated parameters COST/BUDGET the only one significant. A differentiation is made between big and small infrastructures. The results are rather similar to those obtained in the second model, with a higher percentage invested for big infrastructures and a low percentage for small infrastructure. The VOC for service improvement interventions, which was previously the lowest, in this case was not considered, since the parameter related to it is not significant.

Table 10.19 PE Interaction of cost with the experiments and the budget given and of safety with the kind of intervention

Parameters		Value	t-Test
Utility parameters			t-Test against zero
COMFORT		0.0013	1.2433
COST/BUDGET		-11.0573	**-2.7176**
COST/BUDGET (bike)		4.2124	1.5813
COST/BUDGET (bus)		-1.8945	-0.8718
COST/BUDGET (night)		8.9717	1.3204
COST/BUDGET (speed)		-9.4350	-1.1972
COST/BUDGET (budget 500,000 SFr)		1.5968	1.0137
COST/BUDGET (budget 600,000 SFr)		-0.5709	-0.4561
JTIME		0.0266	0.7247
SAFETY		0.6175	1.9334
SAFETY (service improvement)		*-0.6340*	-1.5919
SAFETY (big infrastructure)		3.1290	**3.5626**
Scale parameters			t-Test against one
Scale PEDESTRIAN		0.1943	**-12.3916**
Scale BUS		0.9627	-0.1051
Scale BIKE		1.9217	0.9049
Scale NIGHT		0.3266	**-4.6976**
Scale SPEED		1.0000	fixed
Goodness-of-fit			
Number of estimated parameters:	16		
Sample size:	483		
Null log-likelihood:	-865.42		
Final log-likelihood:	**-600.622**		
Likelihood ratio test:	529.596		
Rho-square:	**0.3060**		

Value of casualty avoided	Big infrastructure	Small infrastructure
	0.3388	0.0558

As conclusion for this third group of models related to the PE test, the best fitting model found – with parameter estimates mostly significant and acceptable goodness-of-fit values – is the second one performed, although the influence of variables such as budget levels, as mentioned during the analysis, is negligible. Some common features across the models are once again the big influence of the intervention kind, and particularly the tendency of the respondents to invest a higher percentage of the given budget in interventions related to big infrastructures. Comparing these results with those found during the two single experiment analyses the apparent big difference is the influence of budget levels. In this case – all experiments pooled together – one reason to justify its low influence could be that the budget constraint, whatever its level, did not influence the total utility of the respondents, obtained as a sum of marginal utilities from single experiments. This influence seems more visible within single experiments, since the respondents are obliged, in each of them, to weight their choices, towards the attainment of the maximum marginal utility; that is, the respondents normally try not to exclude any experiment from their utility maximisation, rather they try to distribute their choices so that from each experiment they can obtain the maximum marginal utility, which added to the others gives them the maximum total utility. If it is assumed that the total utility normally does not vary substantially, the fact that different budget levels do not influence considerably the choices of the respondents can be explained.

Stated choice test

The last test analysed relates to the stated choice experiment, substantially different from the previous ones for the variables presented, the situation and the choice set. For the basic model, also in this case, the variables used to specify the utility function are those available in the situations presented to the respondents. Each variable is related to one of the parameters shown in Table 10.20. 901 observations are available for this test. As may be seen, only one model related to this test is presented; the values obtained are neither correct nor interpretable. The first ambiguous features of this model are the signs of the estimated parameters – those marked in italic – mostly the opposite of what would be expected, and their level of significance. In fact, utility is expected to increase with a larger investment available, with more journey time saved, with higher number of victims avoided and with fewer cars exceeding the speed limits; not all these criteria seem to have been respected from the estimates obtained. Additionally, those parameters with an unambiguous sign have a *t-value*, below the critical threshold 1.96 for a level of confidence of 95%.

Table 10.20 SC Basic model

Parameters		Value	t-Test
Utility parameters			
INVESTEMENT		0.00003	0.14965
JOURNEY TIME SAVED		*-0.22686*	**-4.42026**
SAFETY BY BIKE		*-0.03632*	-0.54081
SAFETY BY CAR		*-0.21231*	**-4.51166**
SAFETY PEDESTRIAN		0.06620	1.20231
CAR EXCEEDING SPEED LIMIT		*0.03918*	**9.90046**
Goodness-of-fit			
Number of estimated parameters:	6		
Sample size:	901		
Null log-likelihood:	-624.526		
Final log-likelihood:	-280.018		
Likelihood ratio test:	689.015		
Rho-square:	**0.551631**		

Since this situation was difficult to understand, some more models were performed by introducing the following modifications: at first, as in chapter 9.9.2, the same analysis was performed excluding respondents who did not trade-off at least one time within the six tables given to them. The number of observations available for the test became 744 but the results did not change much from those shown, except that the significance level decreased for all estimated parameters. Subsequent models performed, which did not give any better results, were the following: all three kinds of victims have been pulled together in a variable ‘total no. of victims avoided’; a utility function for each kind of victim was created; personal variables as age, place of residence or income were correlated with the variables safety or investment. None of them could improve the critical points of the first one; some of them were even impossible to run. This result leads to the conclusion that there could have been problems or mistakes in some part of the analysis performed before the construction of the model or even in the test framework, such as the following:

- the choice set of the variables or the variables themselves did not reflect the reality;
- the way this approach was presented was not clear enough to the respondent, so their choices were not really consistent and therefore the data not interpretable;
- the respondents were tired after the first two tests and did not pay much attention on this last test.

These are some of the possible reasons which could be the background to the negative results obtained. It is also clear that, because of that, it was not possible to calculate any VOC related to it. This experiment can however be taken into consideration for future applications of the SC approach.

10.4 Final results

After the analysis performed for each test developed in the survey, in this final section the most significant results (VOC) obtained will be summarised and compared with each other. Unfortunately, because of the negative results obtained from the SC test, this approach must be excluded from the analysis. Subsequently, these results will be compared with those obtained from previous studies in the literature. From both ‘test without budget constraint’ and ‘PE test’ the VOC selected are those related to the models with better parameter estimates, level of significance and goodness-of-fit values. Table 10.21 shows those related to the test without budget constraint, when all experiments have been pulled together. The lowest and highest VOC are highlighted in bold. Significant VOC, found during the single experiment analyses, and not all reported in the previous chapter, for most of the experiments had lower orders of magnitude, except for that relative to ‘bus stop and/or lane’, which was between 160,000 SFr and 180,000 SFr. The same situation can be seen among the median VOC reported in Table 10.22 – only the median has been reported, being the median valuation closer to the ‘majority wish’ than will the mean. All median VOC are considerably lower than the VOC calculated from the model; then, as previously mentioned, a difference in magnitude is visible between the experiment ‘bus stop and/lane’ and all others.

Table 10.21 Best VOC results from 'test without budget constraint'

Intervention kind	Place of residence	<4000 SFr/month	4000-8000 SFr/month	>8000 SFr/month
Small infrastructure	City	284'239	435'135	449'757
	Village in rural area	**131'745**	282'642	297'263
Big infrastructure	City	624'731	775'627	**790'249**
	Village in rural area	472'237	623'133	637'755

Table 10.22 Median VOC results from 'test without budget constraint' (SFr per year)

Bus stop and/or lane	Night safety	Speed control	Crossroad
133'333	10'000	17'500	16'667

The VOC calculated in the PE test, as explained during the analysis, were calculated as the percentage of budget given which the respondents were willing to invest. The results from the best fitting model are reported in Table 10.23: they are related to the model with all experiments pulled together and they refer to all three budget levels, as these levels do not influence significantly respondents choices.. For big infrastructure, for example, the intervention in which respondents were willing to invest the highest percentage of their budget, the values shown in Table 10.23 represent about 165,000 SFr with the lowest budget and about 265,000 SFr with the highest.

Table 10.23 Best VOC results from 'PE test'

Service improvement	Small infrastructure	Big infrastructure
0.0029	0.0696	**0.3309**

As in the previous test, also here the difference between the experiment 'bus stop and/or lane' and the other experiments was perceivable. The percentages related to this experiment are always, all conditions being equal, higher than in other experiments; this situation is noticeable also in the analysis of the median VOC, performed in chapter 9.9.1. for all levels of budget given.

To summarise, among all best descriptive results obtained, the VOC calculated mostly had orders of magnitude not greater than 10^5; the only exceptions can be found in the basic model of 'test without budget constraint' with all experiments pooled together and subsequently, with the introduction of the age class variable. In these cases the VOC reached a magnitude of 10^6. The values obtained in empirical studies developed in the past and reported in Jones-Lee (1990) – which refer just to avoided fatalities, therefore named VOL – based on mean and median marginal rate of substitution, are shown in Table 10.24. A short review about them will allow to understand what the values presented refer to. The empirical study reported in Blomquist (1979) was a revealed preference exercise for the USA focused upon people's willingness to pay to trade time and inconvenience for safety in their decision to wear or not car seat-belts in the absence of a compulsory legislation, cited in Jones-Lee (1990). The next empirical estimate, conducted in Great Britain and reported in Jones-Lee *at al.* (1985) was a questionnaire with three categories of questions: valuation questions to provide estimates of relevant marginal rate of substitution, relative valuation of reduction in risk of fatal and non-fatal accidents; perception questions, to test the quality of respondents' perceptions of transport risk; factual questions concerning person's features. The Persson's study methodology, conducted in Sweden during 1986-1987 had also an approach similar to Jones-Lee, whether his survey instrument embodied some important modifications: for example questions asking directly about willingness to pay for reduction in the risk of non-fatal injuries were also included. At last, Mayer *et al.* study employed also a questionnaire based on Jones-Lee *et al.* with a small non random sample in Austria in 1988. The values related to these studies are in British pounds (1989 prices); to calculate the corresponding values in SFr the prevailing exchange rate was used (1 Pound = 2.3 SFr). Even if these evaluations are related to 1989 prices – therefore lower than actual prices – and the range of possible values of statistical life implied by these results is already quite large, it is possible to perceive the difference in magnitude compared with the values calculated in the experiment performed.

Table 10.24 Values of statistical life from previous studies (1989 £-sterling converted a current exchange rate)

	Based on mean marginal rate of substitution		Based on median marginal rate of substitution	
Blomquist (1979)	1,012,000 SFr	440,000 £		—
Jones-Lee (1985)	4,600,000 SFr	2,000,000 £	1,564,000 SFr	680,000 £
Persson (1989)	3,795,000 SFr	1,650,000 £	1,449,000 SFr	630,000 £
Maier (1989)	4,370,000 SFr	1,900,000 £		—

Source: Jones-Lee (1990)

On one side, this could be the result of the considerable difficulty associated with empirical work in this area. Another possible explanation to justify the low values obtained, more related to the experiment performed itself, can be found in the background of the survey and in particular in the definition of 'victims', as shortly introduces during the analysis. The VOL, which is the aim of the experiment, should be the marginal rate of substitution between the cost of the improvement and one victim avoided, in the sense of fatality. The problem is raised from the definition of 'victim': what in the meaning is included of this term and what is excluded. This was also exacerbated by the fact that in using two languages – English and Italian – this term could have been evaluated differently. In Italian, in fact, this term can include both fatalities and serious or light injures. Because of that, respondents might have interpreted the variable 'number of victims avoided' including not only the fatalities avoided, but also different kinds of injured; therefore the values obtained do not represent the 'Value of a statistical LIFE saved' (VOL), rather the 'Value of a statistical CASUALTY avoided' (VOC). For this reason all the values shown within the analyses are named VOC instead of VOL. To obtain the VOL the VOC should be multiplied by a factor, representing, within the victims avoided, the different percentages of fatalities, of seriously injured and of slightly injured. This factor can be obtained considering, at first, the distribution of the accidents in the year 2002 between different injures and fatalities, from the accident statistics for Switzerland 2003 by Bfu, Bern (see Table 10.25). Since the costs associated with different kinds of casualties are weighted differently and the experiment conducted is concerned only with values related to fatalities, some conversion factors have to be found to express all casualties in terms of fatalities. These conversion factors are calculated in Table 10.26, where also the social costs distinguished for different damage types – from VSS Norm 640 009 – are reported.

The final factor F, obtained from Equation 10.15., which must be multiplied by the victim avoided, corresponds to **0.0584**.

$$F = 0.017 * 1 + 0.196 * 0.1666 + 0.786 * 0.0111 \quad (10.15)$$

Table 10.25 Distribution of accident intensity

	Accidents with injures to people	Light injured	Heavy injured	Fatalities
Number of accidents in 2003	30,305	23,843	5,931	513
Shares	1	0.786	0.196	0.017

Source: Bfu 2003, USV T.02

Table 10.26 Social costs of accidents and conversion factors

Type of damage	Social costs of accidents (SFr)	Conversion factor
Damages pro person light injured	20,000	0.0111
Damages to person heavy injured	300,000	0.1666
Damages pro persons dead	1,800,000	1

Source: VSS Norm 640 009 -Table 7

The final VOC from the analysis will then be multiplied by 1/F, which corresponds to **17.12.** Taking for example the lowest and highest VOC from Table 10.21 they will become:

$$131{,}745 * 17.12 = 2{,}255{,}474 \quad (10.16)$$

$$790{,}249 * 17.12 = 13{,}529{,}062 \quad (10.17)$$

These values represent the VOL searched and have an order of magnitude which is more similar to those calculated in other studies, therefore more convincing and more representative. Despite this modification, which enabled the correction of the slight mistake, this fact should be taken into consideration for later experiments.

Another study, developed from Jud and Frei in February 2004 concerning the VOL obtained from the analysis of different real projects related to traffic safety in Switzerland, shows a median VOL of 955,562 SFr/year and a mean VOL of 1,455,362 SFr/year with a discount rate of 3.25% for the next 15 years; instead, with a discount rate of 7%, the mean VOL becomes 1,886,541 SFr/year and the median 1,239,676 SFr/year (Frei and Jud, 2004). The order of magnitude of these values is approximately the same as the final VOL obtained in this study.

Another point that should be taken into consideration is related to the *costs* defined in the experiments presented within test without budget and PE test. As explained previously, all of them represented only the costs of realisation, but how these costs will be distributed across time, or for how long this cost will be sustained, was not defined. Some alternatives proposed could have in fact costs which will be distributed across several years, such as the realisation of a bicycle path or of a new bus stop; some others could have costs which must be sustained every year, such as increasing the number of buses or of night security guards. In view of this, it is assumed that all costs refer to one year only. Consequently, the VOL refers as well to one year only and no discount rate must be applied.

11. Conclusions and outlook

At the conclusion of this experiment it can be stated that the results obtained are quite satisfactory, although the size of the survey developed was limited and the returned surveys were representative of small areas with slightly different features from one another. This is also demonstrated by the consistency of the results obtained with previous studies. It must be clearly stated that the analysis also made it possible to find many problems relating to the survey itself, including the construction, the values of the variables proposed, the description of the alternatives, the explanations, etc. The most significant will be listed below, so that following experiments of this kind will have the chance to avoid repeating them:

- respondents are making their choices mainly on the basis of their personal experience with the context considered: therefore, the description of the alternative proposed must be as realistic as possible. It might be in fact better to refer to an existing area instead of an imaginary situation, as assumed in this experiment. This might offer to respondents a more familiar context, so that they can feel more involved with the experiment proposed. This aspect will also bring the need for an appropriate exploratory study of the area involved and of the territory, to give to the variables proposed consistent values;

- care should be taken over the definition of what the term ‘victim’ does and does not include, as mentioned during the examination of the final results. Even if there remains the possibility to scale the values obtained with appropriate factors, a pertinent definition, clarified from the beginning, might be convenient;

- concerning the pilot survey, in this experiment it was carried out with the help of people from different territorial and age contexts compared with those who were later to be the sample. It might be convenient and constructive to have also the pilot survey tested by people with the same characteristics as the main sample. That might, in fact, bring more information about possible problems. In the experiment developed this omission was redeemed with the later telephone contact with the respondents;

- many other analyses could be performed with the data collected, more related, for example, to the influence of the budget on the respondents’ choices – i.e. how the choices varied, all conditions being equal, when the budget level changed – and to their effect on the VOL. The experiment then cannot be considered concluded, as many other ways to approach it exist. On the other hand, it is open to further development, which might bring results similar to or different from those found here;

- it may be assumed that the negative results of the stated choice survey are mostly generated from the form of the approach in the survey. The variables presented are general and do not refer to any real improvement proposed, so that the respondents might not have the feeling of making an investment in something not clearly specified, of which they know only the effects. The results obtained from this approach are not interpretable, as may be seen from the analysis, probably for the reasons stated above: most of the respondents made their choices randomly, not finding a uniform criterion to evaluate whether investment or no investment was the best solution;

- lastly, as already mentioned in the final results, for all cost variables associated with the alternatives proposed, it was not specified how these costs are distributed over time. This factor, which in reality is fundamental, to drawing a comparison of the costs of alternative improvements (projects or policies) over different space of time, should be also introduced.

To conclude, it might be restated that, the range of possible VOL, can be very large. This is caused, mainly by measurement errors, which are errors associated with inaccuracy in responses to the survey. These errors can come from inability of respondents to answer, from weaknesses in the survey itself or from effects of the mode of collection (Bateman,2002). It must however be born in mind that, working with empirical data, these errors will be always present, since the reality can not easily be made uniform. The estimation of the VOL is an attempt to include the complex pattern of community preferences into the planning process and we must be conscious that all possible models used to describe these patterns and to estimate the VOL can never represent the full complexity of the choices.

As Dawn et al.(1993) declared: “ It is recognised that many problems and limitations are involved in the measurement of an explicit VOL. However, despite its weaknesses and shortcomings, it is considered that the application of an explicit value of life should help make safety investment policies more rational, more consistent and more accountable”

12. Literature

Bateman, I.J., T.C. Carson, B. Day, M. Hanemann, N. Hanley, T. Hett, M. Jones-Lee, G. Loomes, S.Mourato, E. Özdemiroglu, D.W. Pearce, R. Sudgen and J. Swanson (2002) *Econometric valuation with stated preference techniques*, Edward Elgar, Cheltenham, UK.

Ben-Akiva and M., S.R. Lerman (1985) *Discrete Choice Analysis*: *Theory and Application to travel demand,* MIT Press, Cambridge.

Dawn I., R. Kemp and M. Thieme (1993) The statistical value of life and safety investment*, Research report*, **13**, School of Environmental Sciences, University of East Anglia, Norwich.

De Blaeij A., R.J.G.M. Florax, P. Rietveld and E. Verhoef (2000) *The Value of Statistical Life: A Meta-Analysis,* Tinbergen Institute Discussion Paper, Rotterdam.

De Gottardi , R. (2003) *Sviluppo territoriale e mobilità: problemi e prospettive,* Divisione della pianificazione territoriale, DT, www.ti.ch/dt, Bellinzona.

Frei, A.and R. Jud (2004) *Was ist ein verhinderter Verkehrstoter den Schweizer Gemeinden Wert?*, Semesterarbeit Verkehrsplanung, IVT, ETH Zürich, Zürich.

Glantz, S. and B. K. Slinker (2001) *Primer of applied regression & analysis of variance*, McGraw-Hill, New York.

Hauer, E. (1994) Can one estimate the value of life or is it better to be dead than stuck in traffic, *Transportation Research*, **28A** (2) 109-118.

Hoinville, G. (1971) Evaluating community preferences, *Environment and Planning*, **3** (1) 33-50.

Jones-Lee, M.W., M. Hammerton and P.R. Philips (1985) The value of transport safety: Results of a national sample survey, *Economic Journal*, **95** 49-72.

Jones-Lee, M.W. (1990) The value of transport safety, *Oxford Review of Economic Policy*, **6** 39-60.

Jones-Lee, M.W., G. Loomes, D. O'Reilly and P. Phillips (1993) The value of preventing non-fatal road injuries: findings of a willingness-to-pay national sample survey, *Contractor Report*, **330**, Transport Research Laboratory, Crowthorne.

Johnson, B. (1996) Perl Tutorial, http://www.ncsa.uiuc.edu/General/Training/PerlIntro/, University of Illinois, Urbana-Champagne, Juni 1996.

Louviere, J.J., D.A. Hensher and J.D. Swait (2000) *Stated Choice Methods: Anaylsis and Application*, Cambridge University Press, Cambridge.

Moreni, G.and R. Hürlimann (2003) *I ticinesi e la mobilità*, Rapp Trans AG, Dipartimento del territorio, www.ti.ch/dt, Bellinzona .

Mugo Fridah W., http://trochim.human.cornell.edu/tutorial/mugo/tutorial.htm.

Ortuzar, J.de Dios and L.G. Willumsen (1994) *Modelling Transport*, John Wiley & Sons, Chichester.

Pearmain, D. (1989) *The measurement of passenger valuations towards rail station facilities: an application of the "Priority Evaluator Method"*, presentation at the 17th PTRC Summer Annual Meeting, Brighton, September 1989.

Pearmain, D., J. Swanson, E. Kroes and M. Bradley (1991) *Stated Preference Techniques: A Guide to Practice*, Steer Davies and Gleave, London.

Schwab Christe, N.and N.C. Soguel (1995) Contingent valuation, transport safety and the value of life, *Kluwer Academic Publishers*, Boston.

Willeke, R. and S. Beyhoff (1990) Economic Cost of Road Accidents, Report of COST-Aktion 313, Köln.

Appendix A

In this appendix the following versions of the survey will be available in the format they have been ended in to the respondents:

- pilot survey version in English and in Italian – only one version was created in both languages;

- final survey in English (version eight) and Italian (version one).

All other versions of the final survey will be included on the CD ROM digitally, together with the data related to the analyses.

Gloria Locatelli
Institut für Verkehrsplanung und Transportsysteme IVT
HIL-ETH Hönggerberg
CH-8093 Zürich

Zürich,. .....November 2003
Fam. ....
Via ....
..............., ...

OBJECT: Presentation attached survey

Dear Family ....,

With the agreement of the Institute IVT (Institut für Verkehrsplanung und Transportsysteme), of the ETH Zürich and the Prof. Kay W. Axhausen, by whom I work for my diploma thesis, with theme “Traffic safety”, I send you as attachment the survey which I’m developing.

The following survey is composed with three different parts, which require distinct approaches and a personal questionnaire in the end.
I would ask you kindly to read with attention the introduction to each of them and to follow the instructions.
It would be extremely helpful that the survey will be compiled, individually, from the member of your family, above 16 years old, which will have the next birthday at first.

Once compiled, I would ask you to send all back in the prepaid envelop included.

The collected data will be then processed for my thesis and kept at the Institut for research intents.

I thank you in advance for the attention.

Sincerely

Gloria Locatelli

....

Prof. Kay W. Axhausen

....

1. Traffic and transport improvement test

Here below are presented six possibilities of improvement concerning transport and traffic along *one road in the city,* ***5 km long***.
For every possibility, different alternatives are specified. Each alternative has a defined cost and involves different changes in safety, journey time and comfort.

- ***Safety change:*** it shows how the value of safety along the road considered changes, with the alternative chosen, for the road users involved in the variable. It is expressed in *number of victims avoided in one year*.

- ***Journey time change:*** it shows the variation of the journey time to go all over the road, for the road user specified .
  The average time needed for a road of 5 km inside the city is:
  - *By car* with a speed of 50 km/h, 6 minutes
  - *By bike* with 18 km/h, about 20 minutes
  - *By bus* with a speed of 50 km/h and 8 bus stop (every 600 m), 14 minutes

  If the journey time variation is positive, you will need more time to go all over the road; if negative, less time.

- ***Comfort change:*** it represents, if positive, an increase in comfort for the road user involved in the variable presented. If negative, it represent a reduction.

- ***Cost:*** it represent the amount needed to realise the alternative considered. It can be provided as a certain percentage of the public taxes which everyone has to pay, or eventually a new tax.

➔In each of the six point just **one choice is possible,** by making a cross under the alternative selected. The decision is taken by trading off the values of cost, security, journey time and comfort**.**

1. Pedestrian in the road

	Elimination of architectonic barriers	***Zebra crossing every 300 m***	***Zebra crossing with traffic islands every 300 m***	***Zebra crossing with traffic light every 300 m***	***A tunnel or bridge across the road***	***Present situation***
Safety (n° victims avoided)	1	2	4	5	7	0
Journey time change for car driver	0	+ 10 min	+ 6 min	+ 15 min	0	0
Comfort variation	+++	+	++	++	+++	0
Cost (CHF)	90.000	50.000	150.000	200.000	500.000	0
YOUR CHOICE ⌧		□	□	□	□	□

2. Velocity control along the road

	Obligatory route with many curves	***Narrow and low bumps every 800 m***	***High and larger bumps every km***	***Two intelligent traffic light***	***Speed camera every km***	***Present situation***
Safety (n° victims avoided)	3	2	5	4	0	0
Journey time change for car drivers	+ 3.5 min	+ 2.5 min	+ 3 min	+ 4 min	+ 2 min	0
Comfort variation	- -	- - -	- -	-	0	0
Cost (CHF)	65.000	60.000	100.000	70.000	5.000	0
YOUR CHOICE ⌧	□	□	□	□	□	□

3. Bike facilities along the road

	Bike lane in the road	***Bike path in the walking path***	***Bike path divided from walking path, close to the road***	***Bike path faraway from the road***	***Covered parking places for bikes close to bus stops***	***Present situation***
Safety (n° victims avoided)	2	3	5	5	0	0
Journey time change for bikers	- 5 min	- 3 min	- 8 min	- 6 min	0	0
Comfort variation	+	+	++	+++	+++	0
Cost (CHF)	80.000	100.000	400.000	500.000	95.000	0
YOUR CHOICE ⌧	□	□	□	□	□	□

4. Bus stop and/or bus lane improvement along the road

	New Bus stop, Bus lane not independent	***Space for bus stop, Bus lane not independent***	***Bus stop and bus lane independent from the car lane***	***All existing bus stops with more information and facilities***	***More frequent bus trough existing bus stops***	***Present situation***
Safety (n° victims avoided)	1	2	3	0	0	0
Journey time change for passengers	+ 3 min	+ 2 min	+ 1 min	0	-2 min	0
Comfort variation	+	+	++	++	+++	0
Cost (CHF)	60.000	200.000	400.000	20.000	70.000	0
YOUR CHOICE ⌧	□	□	□	□	□	□

5. Night security along the road

	Major number of night bus	***Major number of night guard or police-man***	***Increase in the lightning***	***All traffic light working also in the night***	***Indication signs provided with light***	***Present situation***
Safety (n° victims avoided)	3	6	10	8	6	0
Journey time change for car driver	+ 5 min	0	0	+ 3 min	0	0
Comfort variation	+++	+++	++	-	+	0
Cost (CHF)	70.000	150.000	100.000	5.000	10.000	0
YOUR CHOICE ⌧	□	□	□	□	□	□

6. Crossroad with bad visibility

	Present situation	***Mirrors just in corner with breadth =< 90°***	***Mirrors in every corner with bad visibility***	***Traffic light with photocell***	***Traffic light regulated "a priori"***	***Roundabout***
Safety (n° victims avoided)	0	4	6	12	12	10
Journey time change for car driver	0	- 2 min	- 3 min	+ 2 min	+ 5 min	- 3 min
Comfort variation	0	+	++	+++	++	+++
Cost (CHF)	0	3.000	5.000	200.000	140.000	800.000
YOUR CHOICE ⌧	□	□	□	□	□	□

Priority Evaluator approach, concerning improvement in transport and traffic safety

Imagine that your municipality decide, for the next year, to invest **500.000 CHF**, coming from public taxes, toward improvements in traffic and transport along a street in your city, 5 km long.
You are the person charged of selecting in what and how much to invest of this budget.
Here you have presented three possibilities of improvement, concerning transport and traffic, each with different alternatives. Each alternative has a defined *cost* and involves different variations in *safety, journey time* and *comfort*, parameters described previously.

The rules are:

- ✓ **You must be able to allocate the entire (or as much as possible) budget available**
- ✓ **You must choose one alternative from each variable**, by making a cross under the selected one.

Budget: **500.000 CHF**

1. Pedestrian in the road

	Elimination of architectonic barriers	Zebra crossing every 300 m	Zebra crossing with traffic islands every 300 m	Zebra crossing with traffic light every 300 m	A tunnel or bridge across the road	Present situation
Safety (n° victims avoided)	1	2	4	5	7	0
Journey time change for car driver	0	+ 10 min	+ 6 min	+ 15 min	0	0
Comfort variation	+++	+	++	++	+++	0
Cost (CHF)	90.000	50.000	150.000	200.000	500.000	0
YOUR CHOICE ⌧	□	□	□	□	□	□

2. Velocity control along the road

	Obligatory route with many curves	Narrow and low bumps every 800 m	High and larger bumps every km	Two intelligent traffic light	Speed camera every km	Present situation
Safety (n° victims avoided)	3	2	5	4	0	0
Journey time change for car drivers	+ 3.5 min	+ 2.5 min	+ 3 min	+ 4 min	+ 2 min	0
Comfort variation	- -	- - -	- -	-	0	0
Cost (CHF)	65.000	60.000	100.000	70.000	5.000	0
YOUR CHOICE ⌧	□	□	□	□	□	□

3. Bike facilities along the road

	Bike lane in the road	Bike path in the walking path	Bike path divided from walking path, close to the road	Bike path faraway from the road	Covered parking places for bikes close to bus stops	Present situation
Safety (n° victims avoided)	2	3	5	5	0	0
Journey time change for bikers	- 5 min	- 3 min	- 8 min	- 6 min	0	0
Comfort variation	+	+	++	+++	+++	0
Cost (CHF)	80.000	100.000	400.000	500.000	95.000	0
YOUR CHOICE ⌧	□	□	□	□	□	□

3. Stated choice approach

Here below are presented 10 possible combinations of five variables, which are parameters connected with traffic and transport, along a road in your city, **5 km long**.
For each of them, the choice is between the possibility to don't invest anything for the next year and to invest a certain amount of money, coming from public taxes.
By trading off the values of the variables presented, make a choice, in each of the 10 combinations, with a cross under the alternative selected.

1.

Investment (CHFx1000)	No investment	500
n° of victims/year in accidents as car and motorbike driver or passenger	4	5
n° of victims/year in accidents as biker	2	4
n° of victims/year in accidents as pedestrian	3	0
Journey time for cars along the road (minutes)	9	10
Cars which exceed speed limits (in %)	60	65
YOUR CHOICE ⌧	□	□

2.

Investment (CHFx1000)	No investment	800
n° of victims/year in accidents as car and motorbike driver or passenger	4	6
n° of victims/year in accidents as biker	2	0
n° of victims/year in accidents as pedestrian	3	2
Journey time for cars along the road (minutes)	9	10
Cars which exceed speed limits (in %)	60	30
YOUR CHOICE ⌧	□	□

3.

Investment (CHFx1000)	No investment	800
n° of victims/year in accidents as car and motorbike driver or passenger	4	2
n° of victims/year in accidents as biker	2	1
n° of victims/year in accidents as pedestrian	3	0
Journey time for cars along the road (minutes)	9	10
Cars which exceed speed limits (in %)	60	30
YOUR CHOICE ⌧	□	□

4.

Investment (CHFx1000)	No investment	500
n° of victims/year in accidents as car and motorbike driver or passenger	4	6
n° of victims/year in accidents as biker	2	0
n° of victims/year in accidents as pedestrian	3	5
Journey time for cars along the road (minutes)	9	10
Cars which exceed speed limits (in %)	60	65
YOUR CHOICE ⌧	□	□

5.

Investment (CHFx1000)	No investment	1000
n° of victims/year in accidents as car and motorbike driver or passenger	4	0
n° of victims/year in accidents as biker	2	4
n° of victims/year in accidents as pedestrian	3	2
Journey time for cars along the road (minutes)	9	7
Cars which exceed speed limits (in %)	60	30
YOUR CHOICE ⌧	□	□

6.

Investment (CHFx1000)	No investment	500
n° of victims/year in accidents as car and motorbike driver or passenger	4	0
n° of victims/year in accidents as biker	2	1
n° of victims/year in accidents as pedestrian	3	4
Journey time for cars along the road (minutes)	9	6
Cars which exceed speed limits (in %)	60	30
YOUR CHOICE ⌧	□	□

7.

Investment (CHFx1000)	No investment	800
n° of victims/year in accidents as car and motorbike driver or passenger	4	2
n° of victims/year in accidents as biker	2	3
n° of victims/year in accidents as pedestrian	3	5
Journey time for cars along the road (minutes)	9	6
Cars which exceed speed limits (in %)	60	65
YOUR CHOICE ⌧	□	□

8.

Investment (CHFx1000)	No investment	500
n° of victims/year in accidents as car and motorbike driver or passenger	4	2
n° of victims/year in accidents as biker	2	3
n° of victims/year in accidents as pedestrian	3	4
Journey time for cars along the road (minutes)	9	6
Cars which exceed speed limits (in %)	60	70
YOUR CHOICE ⌧	□	□

9.

Investment (CHFx1000)	No investment	1000
n° of victims/year in accidents as car and motorbike driver or passenger	4	0
n° of victims/year in accidents as biker	2	3
n° of victims/year in accidents as pedestrian	3	0
Journey time for cars along the road (minutes)	9	10
Cars which exceed speed limits (in %)	60	70
YOUR CHOICE ⌧	□	□

10.

Investment (CHFx1000)	No investment	800
n° of victims/year in accidents as car and motorbike driver or passenger	4	0
n° of victims/year in accidents as biker	2	4
n° of victims/year in accidents as pedestrian	3	4
Journey time for cars along the road (minutes)	9	7
Cars which exceed speed limits (in %)	60	70
YOUR CHOICE ⌧	□	□

4. Personal questionnaire

- *What is your sex?*

  Male ☐

  Female ☐

- *In which year are you born?* __/__/__/__

- *Where do you live at the moment?*

  Downtown a city (>100.000 inhabitants) ☐

  In the periphery of a big city ☐

  In a medium city (30.000 until 100.000 inhabitants) ☐

  In a small city (10.000 until 30.000 inhabitants) ☐

  In a village close to a city ☐

  In a village in a rural region ☐

- *Do you have a driving licence?*

  Yes ☐ No ☐

- *In which year did you acquire it?* __/__/__/__

- *Do you have a car available:*

  Always ☐ Often ☐ Seldom ☐ Never ☐

- *In which way you dispose of the car?*

  I own the car ☐

  Someone in my home owns the car ☐

  A friend of me owns the car ☐

  I have access to a company car, which I can also use for private trips ☐

  I have access to a company car, which I can not use for private trips ☐

  I use the possibility of car- sharing ☐

  Other forms ☐

  From my parents

- *How many <u>km</u> did you drive a car last year ?* __/__/__/__/__/__/

- *Do you have a* ***General Abonnement*** *(GA)?*

  Yes ☐ No ☐

➢ *Do you have a **Halbtax-Abo**?*

Yes ☐ No ☐

➢ *Do you have a **monthly-annual ticket** for your city or municipality?*

Yes ☐ No ☐

➢ *How many <u>days</u> you were travelling by **bus, tram or train,** the last week?*

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐

➢ *How many <u>trips</u> did you make the last week with bus, tram or train?*
(If you change public transport within the same journey, it counts as just one trip.
Go and return count as two trips)

__/__/__/

➢ *How many <u>days</u> you were travelling by **bike** the last week?*

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐

➢ *How many <u>days</u> you were travelling by **car** the last week?*

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐

➢ *How much safe do you feel, if you walk alone <u>after 10 o'clock p.m.</u> in your residential area?*

Very safe ☐

Enough safe ☐

A bit safe ☐

Very unsafe ☐

I'm not around after 10 o'clock p.m., for safety reasons ☐

I'm not around after 10 o'clock p.m., but not for safety reasons ☐

➢ *How do you feel <u>after 10 o'clock</u> in the public transport?*

Very safe ☐

Enough safe ☐

A bit unsafe ☐

Very unsafe ☐

I never use public transport after 10 o'clock p.m., for safety reasons ☐

I never use public transport after 10 o'clock p.m., but not for safety reasons ☐

- *Did you ever had an accident on the road?*

  Yes ☐ No ☐

- *If yes, how many did you have...?*

While driving a car	__/__/
While a car passenger	__/__/
While driving a motorbike	__/__/
While a motorbike passenger	__/__/
While driving a bike	__/__/
While walking	__/__/
While bus/tram/train passengers	__/__/

- *Which monthly income does your family has?*

<2000	CHF	☐
2000-4000	CHF	☐
4000-6000	CHF	☐
6000-8000	CHF	☐
8000-10.000	CHF	☐
10.000-12.000	CHF	☐
>12.000	CHF	☐

- *How many persons contribute to the family budget?* /__/

Thank you very much for taking part at the survey.

Any other comment :

....

....

....

....

Gloria Locatelli
Institut für Verkehrsplanung und Transportsysteme IVT
HIL-ETH Hönggerberg
CH-8093 Zurigo

Zurigo,. ....Novembre 2003
Fam. ....
Via ....
..............., ...

OGGETTO: Presentazione inchiesta allegata

Gentile Famiglia ....,

Con il consenso dell'Istituto IVT (Institut für Verkehrsplanung und Transportsysteme), dell'università ETH di Zurigo e del Prof Kay W. Axhausen, presso il quale lavoro per la mia tesi di laurea, dal tema "Sicurezza nel traffico", Vi invio in allegato l'inchiesta che sto sviluppando.

La seguente inchiesta è composta da tre diverse parti e da un questionario finale, le quali richiedono approci differenti.
Vi chiedo cordialmente di leggere con attenzione l'introduzione ad ognuna di esse e di seguire le istruzioni per la compilazione.
Sarebbe inoltre estremamente utile che l'inchiesta venga compilata, in tutte le sue parti, dal membro della vostra famiglia, di età superiore a 16 anni, che compie gli anni più a breve termine.

Una volta compilata Vi prego di rispedire il tutto, al più presto, nella busta prepagata che trovate allegata.

I dati raccolti verranno poi elaborati nell'ambito della mia tesi e mantenuti all'interno dell'istituto a scopo di ricerca.

Pregandovi di prendere parte all'inchiesta, Vi ringraziamo anticipatamente.

Cordiali Saluti

Gloria Locatelli

....

Prof. Kay W. Axhausen

....

Test: miglioramenti nel settore del traffico e dei trasporti

Qui di seguito Le sono presentate sei possibili variabili riguardanti il miglioramento nel settore dei trasporti e del traffico, *lungo una strada nella sua città,* ***lunga 5 km***.
Per ogni variabile sono specificate diverse alternative. Ogni alternativa è contraddistinta da un costo e da diverse variazioni di “sicurezza”, “tempo di percorrenza della strada” e “comfort”.

- ***Sicurezza:*** mostra come la sicurezza lungo la strada considerata vari, per l’utente coinvolto nella variabile, a seconda dell’alternativa scelta. È rappresentato dal numero di vittime da incidenti evitate in un anno.

- ***Variazione del tempo di percorrenza:*** rappresenta il mutamento del tempo impiegato per percorrere la strada, dall’utente considerato.
  Il tempo medio di percorrenza per una strada di 5 km, in città, è:
  - *In automobile* a 50 km/h, circa 6 minuti
  - *In bicicletta* a 18 km/h, circa 20 minuti
  - *In autobus* a 50 km/h e 8 fermate (ogni 600 m), circa 14 minuti

  Se la variazione è positiva, significa che per percorrere tutta la strada impiegherà più tempo; se negativa, meno tempo.

- ***Variazione del comfort:*** rappresenta, se positivo, un aumento del comfort e se negativo, una diminuzione del comfort, per l’utente della strada coinvolto nella variabile presentata.

- ***Costo:*** rappresenta l’importo necessario per l’attuazione dell’alternativa considerata. Questa cifra può provenire dalle tasse attualmente pagate dai cittadini o eventualmente da una nuova tassa.

➔Per ognuno dei sei punti **una sola scelta è possibile**, mettendo una croce sotto l’alternativa prescelta. La decisione deve essere presa trattando tra i valori di sicurezza, comfort, tempo di percorrenza e costo.

1. Pedoni lungo la strada

	Eliminazione barriere architetton.	*Strisce pedonali ogni 300 m*	*Strisce pedonali con salvagente ogni 300 m*	*Strisce pedonali con semaforo ogni 300m*	*Un ponte o sottopass.*	*Nessuna modifica*
Sicurezza (n°vittime evitate)	1	2	4	5	7	0
Variazione tempo di percorrenza (per automobilisti)	0	+ 10 min	+ 6 min	+ 15 min	0	0
Variazione del comfort	+++	+	++	++	+++	0
Costo (CHF)	90.000	50.000	150.000	200.000	500.000	0
LA SUA SCELTA ⌧	□	□	□	□	□	□

2. Controllo della velocità lungo la strada

	Percorso obbligatorio con molte curve	*Cunette basse e strette ogni 800 m*	*Dossi larghi ogni km*	*Due semafori intelligenti (onda verde)*	*Auto velox ogni km*	*Nessuna modifica*
Sicurezza (n°vittime evitate)	3	2	5	4	0	0
Variazione tempo di percorrenza (per automobilisti)	+ 3.5 min	+ 2.5 min	+ 3 min	+ 4 min	+ 2 min	0
Variazione del comfort	- -	- - -	- -	-	0	0
Costo (CHF)	65.000	60.000	100.000	70.000	5.000	0
LA SUA SCELTA ⌧	□	□	□	□	□	□

3. Agevolazioni per ciclisti lungo la strada

	Pista ciclabile sulla carreggiata, divise da una linea	*Pista ciclabile sul marciapiede*	*Pista ciclabile divisa dal marciapiede, vicino alla strada*	*Pista ciclabile lontana dalla strada*	*Parcheggio coperto per bici, alla fermata dell'autobus*	*Nessuna modifica*
Sicurezza (n°vittime evitate)	2	3	5	5	0	0
Variazione tempo di percorrenza (per ciclisti)	- 5 min	- 3 min	- 8 min	- 6 min	0	0
Variazione del comfort	+	+	++	+++	+++	0
Costo (CHF)	80.000	100.000	400.000	500.000	95.000	0
LA SUA SCELTA ⌧	□	□	□	□	□	□

4. Fermate e corsie degli autobus lungo la strada

	Nuova fermata lungo la strada, corsia non indipend.	*Spazio per la fermata, corsia non indipend.*	*Fermata e corsia indipend. dalla carreggiata*	*Più informazioni e attrezzature nelle fermate esistenti*	*Corse autobus più frequenti lungo le fermate esistenti*	*Nessuna modifica*
Sicurezza (n°vittime evitate)	1	2	3	0	0	0
Variazione tempo di percorrenza (per passeggeri)	+ 3 min	+ 2 min	+ 1 min	0	-2 min	0
Variazione del comfort	+	+	++	++	+++	0
Costo (CHF)	60.000	200.000	400.000	20.000	70.000	0
LA SUA SCELTA ⌧	□	□	□	□	□	□

5. Sicurezza di notte lungo la strada

	Maggior numero di autobus notturni	*Maggior numero di guardie nottune*	*Aumento illuminazione stradale*	*Tutti i semafori funzionanti anche di notte*	*Cartelli stradali provvisti di luci*	*Nessuna modifica*
Sicurezza (n°vittime evitate)	3	6	10	8	6	0
Variazione tempo di percorrenza (per automobilisti)	+ 5 min	0	0	+ 3 min	0	0
Variazione del comfort	+++	+++	++	-	+	0
Costo (CHF)	70.000	150.000	100.000	5.000	10.000	0
LA SUA SCELTA ⌧	□	□	□	□	□	□

6. Incrocio con scarsa visibilità

	Rotatoria	*Specchi solo in angoli =< 90°*	*Specchi in ogni angolo con scarsa visibilità*	*Semaforo con fotocell.*	*Semaforo regolato "a priori"*	*Nessuna modifica*
Sicurezza (n°vittime evitate)	0	4	6	12	12	10
Variazione tempo di percorrenza (per automobilisti)	- 3 min	- 2 min	- 3 min	+ 2 min	+ 5 min	0
Variazione del comfort	+++	+	++	+++	++	0
Costo (CHF)	800.000	3.000	5.000	200.000	140.000	0
LA SUA SCELTA ⌧	□	□	□	□	□	□

Approccio "Stima delle Priorità", riguardante miglioramenti nel settore dei trasporti e del traffico

Immagini che la sua amministrazione comunale, per il prossimo anno, stanzi **500.000 CHF**, proveniente dalle imposte comunali, da investire in progetti di miglioramento nel settore dei trasporti e del traffico, lungo una strada di 5 km, nella sua città.
Immagini di fare le veci dell'incaricato nella scelta di quanto e in quali progetti investire questo stanziamento.
Di seguito sono presentate tre possibilità di miglioramento, ognuna caratterizzata da diverse alternative. Ogni alternativa è contraddistinta da un determinato *costo* e da un livello di *sicurezza*, *tempo di percorrenza della strada* e *comfort*, parametri descritti in precedenza.

Le regole sono:

- ✓ **Tutto lo stanziamento (o la maggior parte) disponibile deve essere utilizzato**
- ✓ **E' obbligatorio scegliere un'alternativa per ogni variabile**, mettendo una croce sotto la prescelta.

Stanziamento **: 500.000 CHF**

1. Pedoni lungo la strada

		Eliminazion e barriere architetton.	***Strisce pedonali ogni 300 m***	***Strisce pedonali con salvagente ogni 300 m***	***Strisce pedonali con semaforo ogni 300m***	***Un ponte o sottopass.***	***Nessuna modifica***
Sicurezza (n°vittime evitate)		1	2	4	5	7	0
Variazione tempo di percorrenza (per automobilisti)		0	+ 10 min	+ 6 min	+ 15 min	0	0
Variazione del comfort		+++	+	++	++	+++	0
Costo (CHF)		90.000	50.000	150.000	200.000	500.000	0
LA SUA SCELTA	⌦	□	□	□	□	□	□

2. Controllo della velocità lungo la strada

		Percorso obbligatorio con molte curve	***Cunette basse e strette ogni 800 m***	***Dossi larghi ogni km***	***Due semafori intelligenti (onda verde)***	***Auto velox ogni km***	***Nessuna modifica***
Sicurezza (n°vittime evitate)		3	2	5	4	0	0
Variazione tempo di percorrenza (per automobilisti)		+ 3.5 min	+ 2.5 min	+ 3 min	+ 4 min	+ 2 min	0
Variazione del comfort		- -	- - -	- -	-	0	0
Costo (CHF)		65.000	60.000	100.000	70.000	5.000	0
LA SUA SCELTA	⌦	□	□	□	□	□	□

3. Agevolazioni per ciclisti lungo la strada

		Pista ciclabile sulla carreggiata, divise da una linea	***Pista ciclabile sul marciapiede***	***Pista ciclabile divisa dal marciapiede, vicino alla strada***	***Pista ciclabile lontana dalla strada***	***Parcheggio coperto per bici, alla fermata dell'autobus***	***Nessuna modifica***
Sicurezza (n°vittime evitate)		2	3	5	5	0	0
Variazione tempo di percorrenza (per ciclisti)		- 5 min	- 3 min	- 8 min	- 6 min	0	0
Variazione del comfort		+	+	++	+++	+++	0
Costo (CHF)		80.000	100.000	400.000	500.000	95.000	0
LA SUA SCELTA	⌦	□	□	□	□	□	□

Approccio "Scelte fissate"

Qui di seguito Le sono presentate 10 combinazioni di cinque variabili riguardanti possibili conseguenze legate al traffico, lungo una strada nella sua città, **lunga 5 km**.
Per ognuna di esse la scelta viene fatta tra due possibilità: non fare nessuno stanziamento per il prossimo anno e stanziare una certa quantità di denaro, proveniente dalle tasse pagate dai cittadini.
Osservando i valori delle variabili, scelga, in ognuna delle 10 combinazioni, quale alternativa preferisce tra le due, mettendo una croce nello spazio sottostante.

1.

Stanziamento (CHFx1000)	Nessuno stanziamento	500
n° di vittime/anno in incidenti come autista o passeggero di auto e moto	4	5
n° di vittime/anno in incidenti come ciclista	2	4
n° di vittime/anno in incidenti come pedone	3	0
Tempo di percorrenza della strada per automobilisti(min)	9	10
% Automobili che superano i limiti di velocità	60	65
LA SUA SCELTA ⌧	□	□

2.

Stanziamento (CHFx1000)	Nessuno stanziamento	800
n° di vittime/anno in incidenti come autista o passeggero di auto e moto	4	6
n° di vittime/anno in incidenti come ciclista	2	0
n° di vittime/anno in incidenti come pedone	3	2
Tempo di percorrenza della strada per automobilisti(min)	9	10
% Automobili che superano i limiti di velocità	60	30
LA SUA SCELTA ⌧	□	□

3.

Stanziamento (CHFx1000)	Nessuno stanziamento	800
n° di vittime/anno in incidenti come autista o passeggero di auto e moto	4	2
n° di vittime/anno in incidenti come ciclista	2	1
n° di vittime/anno in incidenti come pedone	3	0
Tempo di percorrenza della strada per automobilisti(min)	9	10
% Automobili che superano i limiti di velocità	60	30
LA SUA SCELTA ⌧	□	□

4.

Stanziamento (CHFx1000)	Nessuno stanziamento	500
n° di vittime/anno in incidenti come autista o passeggero di auto e moto	4	6
n° di vittime/anno in incidenti come ciclista	2	0
n° di vittime/anno in incidenti come pedone	3	5
Tempo di percorrenza della strada per automobilisti(min)	9	10
% Automobili che superano i limiti di velocità	60	65
LA SUA SCELTA ⌧	□	□

5.

Stanziamento (CHFx1000)	Nessuno stanziamento	1000
n° di vittime/anno in incidenti come autista o passeggero di auto e moto	4	0
n° di vittime/anno in incidenti come ciclista	2	4
n° di vittime/anno in incidenti come pedone	3	2
Tempo di percorrenza della strada per automobilisti(min)	9	7
% Automobili che superano i limiti di velocità	60	30
LA SUA SCELTA ⌧	□	□

6.

Stanziamento (CHFx1000)	Nessuno stanziamento	500
n° di vittime/anno in incidenti come autista o passeggero di auto e moto	4	0
n° di vittime/anno in incidenti come ciclista	2	1
n° di vittime/anno in incidenti come pedone	3	4
Tempo di percorrenza della strada per automobilisti(min)	9	6
% Automobili che superano i limiti di velocità	60	30
LA SUA SCELTA ⌦	□	□

7.

Stanziamento (CHFx1000)	Nessuno stanziamento	800
n° di vittime/anno in incidenti come autista o passeggero di auto e moto	4	2
n° di vittime/anno in incidenti come ciclista	2	3
n° di vittime/anno in incidenti come pedone	3	5
Tempo di percorrenza della strada per automobilisti(min)	9	6
% Automobili che superano i limiti di velocità	60	65
LA SUA SCELTA ⌦	□	□

8.

Stanziamento (CHFx1000)	Nessuno stanziamento	500
n° di vittime/anno in incidenti come autista o passeggero di auto e moto	4	2
n° di vittime/anno in incidenti come ciclista	2	3
n° di vittime/anno in incidenti come pedone	3	4
Tempo di percorrenza della strada per automobilisti(min)	9	6
% Automobili che superano i limiti di velocità	60	70
LA SUA SCELTA ⌦	□	□

9.

Stanziamento (CHFx1000)	Nessuno stanziamento	1000
n° di vittime/anno in incidenti come autista o passeggero di auto e moto	4	0
n° di vittime/anno in incidenti come ciclista	2	3
n° di vittime/anno in incidenti come pedone	3	0
Tempo di percorrenza della strada per automobilisti(min)	9	10
% Automobili che superano i limiti di velocità	6	70
LA SUA SCELTA ⌦	□	□

10.

Stanziamento (CHFx1000)	Nessuno stanziamento	800
n° di vittime/anno in incidenti come autista o passeggero di auto e moto	4	0
n° di vittime/anno in incidenti come ciclista	2	4
n° di vittime/anno in incidenti come pedone	3	4
Tempo di percorrenza della strada per automobilisti(min)	9	7
% Automobili che superano i limiti di velocità	60	70
LA SUA SCELTA ⌦	□	□

Questionario

- *Di che sesso è ?*

  Maschio ☐

  Femmina ☐

- *In che anno è nato/a ?* __/__/__/__

- *Dove abita al momento ?*

  In una grande città (>100.000 abitanti) ☐

  Nella periferia di una grande città ☐

  In una piccola città (tra 30.000 e100.000 abitanti) ☐

  In una cittadina (tra 10.000 e 30.000 abitanti) ☐

  In un paese vicino ad una città ☐

  In un paese in zona rurale ☐

- *Ha la patente di guida ?*

  Si ☐ No ☐

- *In che anno l'ha ottenuta?* __/__/__/__

- *Ha un automobile disponibile:*

  Sempre ☐ Spesso ☐ Raramente ☐ Mai ☐

- *In che modo dispone dell'automobile?*

  Possiedo un'automobile ☐

  Nella mia famiglia qualcuno possiede un'automobile ☐

  Un amico possiede un'automobile ☐

  Utilizzo un'auto aziendale, anche per usi privati ☐

  Utilizzo un'auto aziendale, ma non per usi privati ☐

  Utilizzo il „car-sharing" ☐

  Altre forme ☐

- *Quanti km ha fatto lo scorso anno in automobile ?* __/__/__/__/__/__/__

➢ *Ha un* **Abbonamento Generale** *(GA) ?*

Si ☐ No ☐

➢ *Ha un* **Abbonamento Metà-Prezzo** *(Halbtax-Abo)?*

Si ☐ No ☐

➢ *Ha un* **abbonamento mensile/annuale** *per la sua città o comune?*
Si ☐ No ☐

➢ *Quanti giorni ha viaggiato con* **autobus, tram, o treno** *la scorsa settimana?*

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐

➢ *Quanti viaggi ha fatto con autobus, tram, o treno, la scorsa settimana?*
(se ha fatto dei cambi durante lo stesso tragitto, conta solo uno.
Andata e ritorno conta doppio)

__/__/

➢ *Quanti giorni ha viaggiato in* **bicicletta,** *la scorsa settimana?*

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐

➢ *Quanti giorni ha viaggiato in* **automobile** *la scorsa settimana?*

0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐

➢ *Quanto si sente sicuro/a, a camminare da solo/a nel suo quartiere dopo le 10 di sera?*

Molto sicuro	☐
Abbastanza sicuro	☐
Un po' insicuro	☐
Molto insicuro	☐
Non vado in giro dopo le 10 di sera, per ragioni di sicurezza	☐
Non vado in giro dopo le 10 di sera, ma non per ragioni di sicurezza	☐

➢ *Quanto si sente sicuro/a, dopo le 10 di sera, nei mezzi pubblici?*

Molto sicuro ☐

Abbastanza sicuro ☐

Un po‘ insicuro ☐

Molto insicuro ☐

Non uso i mezzi pubblici dopo le 10 di sera, per ragioni di sicurezza ☐

Non uso i mezzi pubblici dopo le 10 di sera, ma non per ragioni di sicurezza ☐

....

➢ *Ha mai avuto un <u>incidente stradale</u>?*

Si ☐ No ☐

....

➢ *Se si, quanti ne ha avuti...?*

Guidando un’automobile __/__/
Da passeggero di un‘automobile __/__/
Guidando una moto __/__/
Da passeggero di una moto __/__/
Andando in bicicletta __/__/
Camminando __/__/
Da passeggero di autobus/tram/treno __/__/

....

➢ *Che reddito <u>mensile</u> ha la sua famiglia?*

<2000	CHF	☐
2000-4000	CHF	☐
4000-6000	CHF	☐
6000-8000	CHF	☐
8000-10.000	CHF	☐
10.000-12.000	CHF	☐
>12.000	CHF	☐

....

➢ *Quante persone contribuiscono al reddito famigliare?* /__/

....

Grazie per la partecipazione all’inchiesta.

Commenti :

....

....

....

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Surname Name

Street

CH-Postcode, Town

Zürich, 3 December 2003

Dear Family Surname,

Last year *2120* road users were *victims of a road accident* (2096 injured and 24 dead) in Ticino. The total number of *road accidents,* was *7645*, and just within the cities 5608 (73%). During the last seven years these values have decreased (by 10%), but they are still too high to be acceptable. Although the individual road user is responsible for approximately 90% of the incidents, also the vehicle and the road also have a strong influence on security matters.
Moreover, statistics show that the majority of accidents happen *within the city*, where the number of vehicles is larger, and speed limits and the Rules of the Road are not always respected.

Do you think, existing roads are safe enough?
If not, do you think that there is a need for more safety measures?

In cooperation with the Institute IVT (Institut für Verkehrsplanung und Transportsysteme) of the Swiss Federal Institute of Technology Zurich (ETH) and Prof. Kay W. Axhausen, with whom I am working for my diploma thesis on the theme “Traffic safety”, I enclose *the survey*, which is *intended to answer the above questions* and find a way to minimise the alarming number of road fatalities.

The survey is composed of three different parts, each with a distinct approach and a personal questionnaire at the end.

It would be extremely helpful if the survey could be filled out, *individually*, by that member of your family, *over 17 years old,* whose birthday is the next to come up.
Once completed, please *send it back in the prepaid envelope* enclosed as soon as possible, and *before the 31 December 2003.*

The collected data will then be processed for my thesis and your identity and data will be kept in strict confidence.
I thank you in advance for your assistance.

Yours sincerely

Gloria Locatelli Prof. Kay W. Axhausen

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1. Traffic and transport improvement test

Below are presented six possible improvements in transport and traffic on *one street in the city, **5 km long***.
For each of them, different alternatives are specified. For every alternative a defined cost and different changes in safety, journey time and comfort are listed.

- ***Safety change:*** it shows how the safety on the street considered is different for each alternative. It is expressed in *number of victims avoided / year*.
- ***Journey time change:*** it shows the variation of the journey time it takes for the whole distance, specified for different road users.
- ***Comfort change:*** it represents, if positive, an increase in comfort for the road user involved in the variable presented. If negative, it represents a decrease.
- ***Cost:*** it represents the amount needed to realise the alternative considered. It can be thought of as a certain percentage of public taxes which everyone has to pay, or possibly a new tax.

Instructions:

1. Read the alternatives and the values of *safety, journey time, comfort* and *cost*.
2. Compare them, thinking which is more important for you
3. Choose the most suitable alternative **,** by putting *a cross in the space below*
   In every table just **one choice is possible**.

Example:

Bus stop and/or bus lane improvement on the road

	New bus stop, bus lane not independent	*Space for new bus stop, bus lane not independent*	*New bus stop and bus lane independent of the car lane*	*All existing bus stops with more information and facilities*	*More frequent buses through existing bus stops*	*Present situation (8 bus stops, every 600 m)*
Safety (no. victims avoided)	1	2	3	0	0	0
Journey time change for passengers	+ 3 min	+ 2 min	+ 1 min	0	-2 min	0
Comfort variation	+	+	++	++	+++	0
Cost (SFr)	60,000	200,000	400,000	20,000	70,000	0
YOUR CHOICE ☒	□	□	X	□	□	□

In the above table I have chosen the third alternative, because to me personally, the most important things when I use the bus are the journey time and the safety.
In the alternative chosen the journey time is shorter, and the *bus stop*, independent of the car lane, is *safer to reach*. Naturally, that will have a higher cost than the other alternatives.

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1. Night security along the road

	More night buses	More night security guards or policemen	Increase in the lighting	All traffic lights also working at night	Illuminated road signs	Present situation
Safety (no. victims avoided)	3	6	10	8	6	0
Journey time change for car driver	+ 5 min	0	0	+ 3 min	0	0
Comfort variation	+++	+++	++	-	+	0
Cost (SFr.)	70,000	150,000	100,000	5,000	10,000	0
YOUR CHOICE ☒	☐	☐	☐	☐	☐	☐

2. Speed control on the road

	Obligatory route with many curves	Narrow and low bumps every 800 m	High and larger bumps every km	Two intelligent traffic lights	Speed camera every km	Present situation
Safety (no. victims avoided)	3	2	5	4	0	0
Journey time change for car drivers	+ 3.5 min	+ 2.5 min	+ 3 min	+ 4 min	+ 2 min	0
Comfort variation	- -	- - -	- -	-	0	0
Cost (SFr)	65,000	60,000	10,.000	70,000	5,000	0
YOUR CHOICE ☒	☐	☐	☐	☐	☐	☐

3. Crossroad with bad visibility

	Roundabout	Mirrors just in corner with angle =< 90°	Mirrors in every corner with bad visibility	Traffic light with photocell	Traffic light regulated "a priori"	Present situation
Safety (no. victims avoided)	10	4	6	12	12	0
Journey time change for car driver	- 3 min	- 2 min	- 3 min	+ 2 min	+ 5 min	0
Comfort variation	+++	+	++	+++	++	0
Cost (SFr.)	800,000	3,000	5,000	200,000	140,000	0
YOUR CHOICE ☒	☐	☐	☐	☐	☐	☐

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2. **Priority Evaluator approach**, concerning improvement in transport and traffic safety

Imagine that your municipality decides, next year, to invest **800,000 CHF**, drawn from public taxes, in improvements in traffic and transport on a *street in your city, **5 km long***.
You are the person in charge of deciding how to invest this budget.
Below, *three possibilities of improvement* are presented, concerning transport and traffic, each with different alternatives. Each alternative has a defined *cost* and involves different variations in *safety, journey time* and *comfort*, parameters described previously.

The rules are:

- ✓ **You should allocate the entire (or as much as possible) budget available.** The sum of the costs of the three choices made must not exceed 800.000 SFr.
- ✓ **You should choose one alternative from each table**, by making a cross below the selected one.

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Budget: **800,000 CHF**
N.B. The *sum of the costs* of the choices made in the three tables must not exceed this amount.

1. Pedestrians on the road

	Elimination of architectural barriers	*Pedestrian crossing every 300 m*	*Pedestrian crossing with traffic islands every 300 m*	*Pedestrian crossing with traffic light every 300 m*	*A tunnel or bridge across the road*	*Present situation*
Safety (no. victims avoided)	1	2	3	4	5	0
Journey time change for car driver	0	+ 10 min	+ 6 min	+ 15 min	0	0
Comfort variation	+++	+	++	++	+++	0
Cost (SFr.)	90,000	50,000	150,000	200,000	500,000	0
YOUR CHOICE ⌧	□	□	□	□	□	□

2. Bus stop and/or bus lane improvement on the road

	New bus stop, *bus lane not independent*	*Space for new bus stop, bus lane not independent*	*New bus stop and bus lane independent from the car lane*	*All existing bus stops with more information and facilities*	*More frequent buses through existing bus stops*	*Present situation (8 bus stops, every 600 m)*
Safety (no. victims avoided)	1	2	3	0	0	0
Journey time change for passengers	+ 3 min	+ 2 min	+ 1 min	0	-2 min	0
Comfort variation	+	+	++	++	+++	0
Cost (SFr.)	60,000	200,000	400,000	20,000	70,000	0
YOUR CHOICE ⌧	□	□	□	□	□	□

3. Bike facilities on the road

	Bike lane in the road	*Bike path on the footway*	*Bike path divided from footway, close to the road*	*Bike path faraway from the road*	*Covered parking places for bikes close to bus stops*	*Present situation*
Safety (no. victims avoided)	2	3	5	5	0	0
Journey time change for cyclists	- 5 min	- 3 min	- 8 min	- 6 min	0	0
Comfort variation	+	+	++	+++	+++	0
Cost (SFr.)	80,000	100,000	400,000	500,000	95,000	0
YOUR CHOICE ⌧	□	□	□	□	□	□

2. Stated choice approach

Here below I propose you six combinations of five variables regarding improvements concerning traffic and transport, *on a road in your city,* ***5 km long***.

You have to choose between *2 possibilities*:
I. Do not invest anything for the next year
II. Invest a certain amount of money, drawn from public taxes

In each table:

1. Compare the values of the variables between the column "no investment" and the column with the investment
2. Choose the column which more satisfies you, by making a cross below the selected one.

Example:

Investment (SFr.)	No investment	500,000
No. of victims/year in accidents as car drivers and motorcyclists or passengers	4	2
No. of victims/year in accidents as cyclist	2	3
No. of victims/year in accidents as pedestrians	3	4
Journey time for cars along the road (minutes)	9	6
Cars which exceed speed limits (in %)	60	70
YOUR CHOICE ⌧	X	□

In this case I have used the following reasoning.
If the investment is made:
- The number of victims as car drivers and motorbike or passengers decrease
- The number of victims as cyclists or pedestrians increase
- By car the journey time will be longer
- More cars will exceed speed limits

⇒ Since I am mainly a cyclist, and not a car user, it is more important for me to decrease the victims as cyclist or pedestrian and not so much to decrease the journey time for cars. Therefore, to make the investment is in this case not beneficial for me and I've chosen to NOT TO INVEST ANYTHING (cross under "No investment").

N.B.

⇒ In this approach, *the values of the variables in the third column* have been created to *simulate reality*, where it can happen, contrary to logic, that investment may not improve every variable. Rather, a variable can sometimes improve, but it may also worsen or stay the same. Don't be surprised if *a situation looks illogical*, and repeat the reasoning as in the example.
⇒ It is useless to compare the tables with each other, because they have all different values.

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1. Investment (SFr.)	No investment	1,000,000
No. of victims/year in accidents as car drivers and motorcyclists or passengers	4	2
No. of victims/year in accidents as cyclist	2	1
No. of victims/year in accidents as pedestrians	3	5
Journey time for cars along the road (minutes)	9	10
Cars which exceed speed limits (in %)	60	70
YOUR CHOICE ⌧	□	□

2. Investment (SFr.)	No investment	800,000
No. of victims/year in accidents as car drivers and motorcyclists or passengers	4	2
No. of victims/year in accidents as cyclist	2	4
No. of victims/year in accidents as pedestrians	3	4
Journey time for cars along the road (minutes)	9	11
Cars which exceed speed limits (in %)	60	40
YOUR CHOICE ⌧	□	□

3. Investment (SFr.)	No investment	500,000
No. of victims/year in accidents as car drivers and motorcyclists or passengers	4	2
No. of victims/year in accidents as cyclist	2	1
No. of victims/year in accidents as pedestrians	3	4
Journey time for cars along the road (minutes)	9	10
Cars which exceed speed limits (in %)	60	65
YOUR CHOICE ⌧	□	□

4.Investment (SFr.)	No investment	500,000
No. of victims/year in accidents as car drivers and motorcyclists or passengers	4	2
No. of victims/year in accidents as cyclist	2	3
No. of victims/year in accidents as pedestrians	3	2
Journey time for cars along the road (minutes)	9	6
Cars which exceed speed limits (in %)	60	30
YOUR CHOICE ⌧	□	□

5.Investment (SFr.)	No investment	1,000,000
No. of victims/year in accidents as car drivers and motorcyclists or passengers	4	5
No. of victims/year in accidents as cyclist	2	0
No. of victims/year in accidents as pedestrians	3	4
Journey time for cars along the road (minutes)	9	6
Cars which exceed speed limits (in %)	60	40
YOUR CHOICE ⌧	□	□

6.Investment (SFr.)	No investment	1,000,000
No. of victims/year in accidents as car drivers and motorcyclists or passengers	4	5
No. of victims/year in accidents as cyclist	2	1
No. of victims/year in accidents as pedestrians	3	5
Journey time for cars along the road (minutes)	9	11
Cars which exceed speed limits (in %)	60	65
YOUR CHOICE ⌧	□	□

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4. Personal questionnaire

- *What sex are you?*
  Male □
  Female □

- *In which year were you born?* __/__/__/__

- *Where do you live at the moment?*
  In a big city a city (>80.000 inhabitants) □
  In a medium-sized city (20.000 until 80.000 inhabitants) □
  In a village close to a city □
  In a village in a rural area □

- *Do you have a driving licence?*
  Yes □ No □

- *If yes, in which year did you acquire it?* __/__/__/__

- *Do you have a car available:*
  Always □ Often □ Seldom □ Never □

- *In which way do you have access to the car?*
  I own the car □
  Someone in my home owns the car □
  A friend of mine owns the car □
  I have access to a company car, which I can also use for private trips □
  I have access to a company car, which I can not use for private trips □
  I use the option of car- sharing □
  Other way □
  I do not have access to a car □

- *How many km did you drive a car last year ?* __/__/__/__/__/__/__/

- *Do you have a **General Abonnement** (GA)?*
  Yes □ No □

- *Do you have a **Halbtax-Abo**?*
  Yes □ No □

- *Do you have a **monthly-annual ticket** for your city or a particular route?*
  Yes □ No □

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➢ *On how many days did you travel by **bus, tram or train,** the last week?*
0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□

➢ *How many trips did you make in the last week by bus, tram or train?*
(If you change public transport within the same journey, it counts as just one trip. Departure and return count as two trips)

__/__/__/

➢ *On how many days did you travel by **bike** the last week?*
0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□

➢ *On how many days did you travel by **car** the last week?*
0□ 1□ 2□ 3□ 4□ 5□ 6□ 7□

➢ *How safe do you feel, if you walk alone after 10 pm in your residential area?*
Very safe □
Safe enough □
Rather unsafe □
Very unsafe □
I'm not around after 10 o'clock p.m., for safety reasons □
I'm not around after 10 o'clock p.m., but not for safety reasons □

➢ *How do you feel after 10pm in public transport?*
Very safe □
Safe enough □
Rather unsafe □
Very unsafe □
I never use public transport after 10 o'clock p.m., for safety reasons □
I never use public transport after 10 o'clock p.m., but not for safety reasons □

➢ *Have you ever had an accident on the road?*
Yes □ No □

➢ *If yes, how many did you have...?*

While driving a car __/__/
While a car passenger __/__/
While driving a motorbike __/__/
While a motorbike passenger __/__/
While riding a bike __/__/
While walking __/__/
While a bus/tram/train passenger __/__/

- *What is your gross family income per month?*

<2000	SFr.	□
2000-4000	SFr.	□
4001-6000	SFr.	□
6001-8000	SFr.	□
8001-10.000	SFr.	□
10.001-12.000	SFr.	□
>12.000	SFr.	□

....

- *How many persons contribute to the family budget?* /__/

....

Thank you very much for taking part in the survey.

Any other comments:

....

....

....

....

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Surname Name

Street

CH-ZipCode, Town

Zurigo, 5 dicembre 2003

Gentile Famiglia Surname,

Lo scorso anno *2120* utenti delle strade in Ticino sono stati *vittime di incidenti stradali* (2096 feriti e 24 morti). Il totale degli *incidenti stradali*, è stato di *7645* e solo nei centri abitati 5608, il 73%.
Negli ultimi sette anni questi valori sono andati leggermente diminuendo (-10%), ma in assoluto si tratta in ogni caso di cifre ancora troppo elevate per considerarsi accettabili. Circa il 90% degli incidenti sono da attribuire all'utente stesso, tuttavia anche il veicolo e la strada possono influire molto sulla sicurezza.
La *maggioranza degli incidenti* inoltre, come rilevato dalle statistiche, *avvengono in ambito urbano*, dove il numero di veicoli è più elevato, e i limiti di velocità e le norme del Codice della strada non sempre sono rispettati.

Secondo lei le strade al giorno d'oggi, sono abbastanza sicure?
Altrimenti, pensa che sia necessario rafforzare le misure di sicurezza?

In collaborazione con l'Istituto IVT (Istituto per la Pianificazione del traffico e le Tecniche dei trasporti), del Politecnico federale di Zurigo (ETH) e del Prof. Kay W. Axhausen, presso il quale lavoro per la mia tesi di laurea dal tema "Sicurezza nel traffico", Vi invio in allegato *l'inchiesta che servirà a rispondere alle precedenti domande* e a trovare un modo per ridurre al minimo questo numero impressionante di incidenti.

La seguente inchiesta è composta da tre diverse parti, ognuna delle quali richiede un differente approccio, e da un questionario finale.

Sarebbe molto utile che l'inchiesta fosse compilata, *individualmente*, dal membro della vostra famiglia, *maggiorenne*, che, alla data del ricevimento, ha il compleanno più vicino. Una volta compilata Vi prego di *rispedire il tutto*, al più presto, possibilmente *entro il 31 dicembre 2003, nella busta prepagata* che trovate allegata.

I dati raccolti saranno poi elaborati nell'ambito della mia tesi e la vostra identità e dati saranno mantenuti strettamente riservati.
Pregandovi di prendere parte all'inchiesta, Vi ringraziamo anticipatamente.

Cordiali Saluti

Gloria Locatelli   Prof. K. W. Axhausen

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1. Test: miglioramenti nel settore del traffico e dei trasporti

Qui di seguito Le propongo tre possibili miglioramenti nel settore dei trasporti e del traffico, *lungo una strada nella sua città,* ***lunga 5 km***.
Per ognuno sono specificate diverse alternative. Ogni alternativa è contraddistinta da un costo e da diverse variazioni di "sicurezza", "tempo di percorrenza della strada" e "comfort".

- ***Sicurezza:*** mostra come la sicurezza lungo la strada considerata vari, secondo l'alternativa scelta. È rappresentato dal numero di vittime evitate / anno.
- ***Variazione del tempo di percorrenza:*** rappresenta il mutamento del tempo impiegato per percorrere la strada, dall'utente specificato.
- ***Variazione del comfort:*** rappresenta, se positivo, un aumento del comfort, se negativo, una diminuzione del comfort.
- ***Costo:*** importo necessario per l'attuazione dell'alternativa considerata. Questa cifra può provenire dalle tasse attualmente pagate dai cittadini o eventualmente da una nuova tassa.

Istruzioni:

1. Leggere le alternative e i valori di *sicurezza, tempo di percorrenza, comfort* e *costo.*
2. Confrontarli pensando a quale di questi si da più importanza
3. Scegliere l'alternativa piu opportuna mettendo una croce nello spazio sottostante.
   In ogni tabella **è possibile una sola scelta.**

Esempio:

Fermate e corsie degli autobus lungo la strada

	Nuova fermata lungo la strada, corsia non indipend.	*Spazio per la nuova fermata, corsia non indipend.*	*Nuova fermata e corsia indipend. dalla carreggiata*	*Più informaz. e attrezzature nelle fermate esistenti*	*Corse autobus più frequenti lungo le fermate esistenti*	*Nessuna modifica (8 fermate, ogni 600 m)*
Sicurezza (no.vittime evitate)	1	2	3	0	0	0
Variazione tempo di percorrenza (per passeggeri)	+ 3 min	+ 2 min	+ 1 min	0	-2 min	0
Variazione del comfort	+	+	++	++	+++	0
Costo (SFr.)	60,000	200,000	400,000	20,000	70,000	0
LA SUA SCELTA ☒	□	□	X	□	□	□

Nella tabella sovrastante ho scelto la terza alternativa, perchè personalmente, ciò che ritengo più importante, quando utilizzo l'autobus sono il tempo di percorrenza e la sicurezza.
Nell'alternativa scelta impiego meno tempo e, essendo la fermata indipendente dalla carreggiata, è anche *più sicura da raggiungere* . Naturalmente questo avrà un costo più elevato rispetto alle altre alternative.

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1. Controllo della velocità lungo la strada

	Percorso obbligatorio con molte curve	*Cunette basse e strette ogni 800 m*	*Dossi larghi ogni km*	*Due semafori intelligenti (onda verde)*	*Auto velox ogni km*	*Nessuna modifica*
Sicurezza (No. vittime evitate)	3	2	5	4	0	0
Variazione tempo di percorrenza (per automobilisti)	+ 3.5 min	+ 2.5 min	+ 3 min	+ 4 min	+ 2 min	0
Variazione del comfort	- -	- - -	- -	-	0	0
Costo (SFr.)	65,000	60,000	100,000	70,000	5,000	0
LA SUA SCELTA ☒	□	□	□	□	□	□

2. Sicurezza di notte lungo la strada

	Maggior numero di autobus notturni	*Maggior numero di guardie nottune*	*Aumento illuminazion e stradale*	*Tutti i semafori funzionanti anche di notte*	*Cartelli stradali provvisti di luci*	*Nessuna modifica*
Sicurezza (No. vittime evitate)	3	6	10	8	6	0
Variazione tempo di percorrenza (per automobilisti)	+ 5 min	0	0	+ 3 min	0	0
Variazione del comfort	+++	+++	++	-	+	0
Costo (SFr.)	70,000	150,000	100,000	5,000	10,000	0
LA SUA SCELTA ☒	□	□	□	□	□	□

3. Incrocio con scarsa visibilità

	Rotatoria	*Specchi solo in angoli =< 90°*	*Specchi in ogni angolo con scarsa visibilità*	*Semaforo con fotocell.*	*Semaforo regolato "a priori"*	*Nessuna modifica*
Sicurezza (No. vittime evitate)	10	4	6	12	12	0
Variazione tempo di percorrenza (per automobilisti)	- 3 min	- 2 min	- 3 min	+ 2 min	+ 5 min	0
Variazione del comfort	+++	+	++	+++	++	0
Costo (SFr.)	800,000	3,000	5,000	200,000	140,000	0
LA SUA SCELTA ☒	□	□	□	□	□	□

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2. Approccio "Stima delle Priorità"

Immagini che la sua amministrazione comunale, per il prossimo anno, voglia stanziare **800,000 CHF**, proveniente dalle imposte comunali, da investire in progetti di miglioramento nel settore dei trasporti e del traffico, lungo una strada di 5 km, nella sua città.
Immagini di fare le veci dell'incaricato, che deve scegliere come investire questo stanziamento.
Di seguito Le propongo tre possibilità di miglioramento, ognuna caratterizzata da diverse alternative. Ogni alternativa è contraddistinta da un *costo*, e da diverse variazioni di *sicurezza*, *tempo di percorrenza della strada* e *comfort*, parametri descritti in precedenza.

Le regole sono:

- **Tutto lo stanziamento (o la maggior parte) disponibile deve essere utilizzato**. La *somma dei costi* delle tre scelte fatte non deve superare 800,000 franchi svizzeri.
- **E' obbligatorio scegliere un'alternativa in ogni tabella**, mettendo una croce nello spazio sottostante.

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Stanziamento **: 800,000 CHF**
N.B. La **somma** dei costi delle scelte fatte nelle 3 tabelle non deve superare questa cifra

1. Pedoni lungo la strada

	Eliminazione barriere architetton.	*Strisce pedonali ogni 300 m*	*Strisce pedonali con salvagente ogni 300 m*	*Strisce pedonali con semaforo ogni 300m*	*Un ponte o sottopass.*	*Nessuna modifica*
Sicurezza (No. vittime evitate)	1	2	3	4	5	0
Variazione tempo di percorrenza (per automobilisti)	0	+ 10 min	+ 6 min	+ 15 min	0	0
Variazione del comfort	+++	+	++	++	+++	0
Costo (SFr.)	90,000	50,000	150,000	200,000	500,000	0
LA SUA SCELTA ☒	☐	☐	☐	☐	☐	☐

2. Fermate e corsie degli autobus lungo la strada

	Nuova fermata lungo la strada, corsia non indipend.	*Spazio per la nuova fermata, corsia non indipend.*	*Nuova fermata e corsia indipend. dalla carreggiata*	*Più informazioni e attrezzature nelle fermate esistenti*	*Corse autobus più frequenti lungo le fermate esistenti*	*Nessuna modifica (8 fermate, ogni 600 m)*
Sicurezza (No. vittime evitate)	1	2	3	0	0	0
Variazione tempo di percorrenza (per automobilisti)	+ 3 min	+ 2 min	+ 1 min	0	-2 min	0
Variazione del comfort	+	+	++	++	+++	0
Costo (SFr.)	60,000	200,000	400,000	20,000	70,000	0
LA SUA SCELTA ☒	☐	☐	☐	☐	☐	☐

3. Agevolazioni per ciclisti lungo la strada

	Pista ciclabile sulla carreggiata, divise da una linea	*Pista ciclabile sul marciapiede*	*Pista ciclabile divisa dal marciapiede, vicino alla strada*	*Pista ciclabile lontana dalla strada*	*Parcheggio coperto per bici, alla fermata dell'autobus*	*Nessuna modifica*
Sicurezza (No. vittime evitate)	2	3	5	5	0	0
Variazione tempo di percorrenza (per automobilisti)	- 5 min	- 3 min	- 8 min	- 6 min	0	0
Variazione del comfort	+	+	++	+++	+++	0
Costo (SFr.)	80,000	100,000	400,000	500,000	95,000	0
LA SUA SCELTA ☒	☐	☐	☐	☐	☐	☐

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3. Approccio "Scelte fissate"

Qui di seguito Le propongo 6 combinazioni di cinque possibili conseguenze legate al traffico, lungo una strada nella sua città, **lunga 5 km**.

La sua scelta deve esser fatta tra *2 possibilità*:
I. Non fare nessuno stanziamento per il prossimo anno
II. Stanziare una certa quantità di denaro, proveniente dalle tasse pagate dai cittadini

Per ogni tabella:

1. Confronti i valori delle variabili tra la colonna "nessuno stanziamento" e la colonna con lo stanziamento
2. Scelga la colonna tra le due che la soddisfa maggiormente, mettendo una croce nello spazio sottostante.

Esempio:

Stanziamento (SFr.)	Nessuno stanziamento	500,000
No. di vittime/anno in incidenti come autista o passeggero di auto e moto	4	2
No. di vittime/anno in incidenti come ciclista	2	3
No. di vittime/anno in incidenti come pedone	3	4
Tempo di percorrenza della strada per automobilisti (min)	9	6
% Automobili che superano i limiti di velocità	60	70
LA SUA SCELTA ⌦	X	☐

Per la tabella sovrastante ho fatto il seguente ragionamento.
Se è fatto lo stanziamento :
- le vittime come autista o passeggero di automobile o moto diminuscono
- le vittime come pedoni o ciclisti aumentano
- in automobile impiegherò meno tempo a percorrere la strada
- ci saranno più auto che supereranno i limiti di velocità

⇒ Usando principalmente la bicicletta e non l'automobile, secondo me è piu importante che le vittime in bicicletta o come pedoni diminuiscano, non tanto che in auto ci si impieghi meno tempo. Fare lo stanziamento non è quindi conveniente per me; ho scelto quindi di NON FARE NESSUNO STANZIAMENTO (croce sotto "Nessuno Stanziamento").

N.B.

⇒ In questo approccio i valori delle variabili nella terza colonna sono stati creati per *simulare la realtà*, in cui, al contrario della logica, non sempre investendo si possono ottenere miglioramenti dappertutto, bensì miglioramenti, peggioramenti o mantenimento della situazione iniziale.
Non vi stupite se *una situazione sembra illogica* e ripetete il ragionamento come mostrato nell'esempio per ogni tabella.

⇒ Confrontare le tabelle tra di loro non serve, hanno tutte dei valori diversi.

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1.Stanziamento (SFr.)	Nessuno stanziamento	1,000,000
No. di vittime/anno in incidenti come autista o passeggero di auto e moto	4	2
No. di vittime/anno in incidenti come ciclista	2	1
No. di vittime/anno in incidenti come pedone	3	5
Tempo di percorrenza della strada per automobilisti (min)	9	10
% Automobili che superano i limiti di velocità	60	70
LA SUA SCELTA ☒	□	□

2.Stanziamento (SFr.)	Nessuno stanziamento	800,000
No. di vittime/anno in incidenti come autista o passeggero di auto e moto	4	2
No. di vittime/anno in incidenti come ciclista	2	4
No. di vittime/anno in incidenti come pedone	3	4
Tempo di percorrenza della strada per automobilisti (min)	9	11
% Automobili che superano i limiti di velocità	60	40
LA SUA SCELTA ☒	□	□

3.Stanziamento (SFr.)	Nessuno stanziamento	500,000
No. di vittime/anno in incidenti come autista o passeggero di auto e moto	4	2
No. di vittime/anno in incidenti come ciclista	2	1
No. di vittime/anno in incidenti come pedone	3	4
Tempo di percorrenza della strada per automobilisti (min)	9	10
% Automobili che superano i limiti di velocità	60	65
LA SUA SCELTA ☒	□	□

4.Stanziamento (SFr.)	Nessuno stanziamento	500,000
No. di vittime/anno in incidenti come autista o passeggero di auto e moto	4	2
No. di vittime/anno in incidenti come ciclista	2	3
No. di vittime/anno in incidenti come pedone	3	2
Tempo di percorrenza della strada per automobilisti (min)	9	6
% Automobili che superano i limiti di velocità	60	30
LA SUA SCELTA ☒	□	□

5.Stanziamento (SFr.)	Nessuno stanziamento	1,000,000
No. di vittime/anno in incidenti come autista o passeggero di auto e moto	4	5
No. di vittime/anno in incidenti come ciclista	2	0
No. di vittime/anno in incidenti come pedone	3	4
Tempo di percorrenza della strada per automobilisti (min)	9	6
% Automobili che superano i limiti di velocità	60	40
LA SUA SCELTA ☒	□	□

6.Stanziamento (SFr.)	Nessuno stanziamento	1,000,000
No. di vittime/anno in incidenti come autista o passeggero di auto e moto	4	5
No. di vittime/anno in incidenti come ciclista	2	1
No. di vittime/anno in incidenti come pedone	3	5
Tempo di percorrenza della strada per automobilisti (min)	9	11
% Automobili che superano i limiti di velocità	60	65
LA SUA SCELTA ☒	□	□

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4. Questionario

- *Di che sesso è ?*
  Maschio □
  Femmina □

- *In che anno è nato/a ?* __/__/__/__

- *Dove abita al momento ?*
  In una grande città (>80.000 abitanti) □
  In una piccola città (tra 20.000 e 80.000 abitanti) □
  In un paese vicino ad una città □
  In un paese in zona rurale □

- *Ha la patente di guida ?*
  Si □ No □

- *Se si, in che anno l'ha ottenuta?* __/__/__/__

- *Ha un' automobile disponibile:*
  Sempre □ Spesso □ Raramente □ Mai □

- *In che modo dispone dell'automobile?*
  Possiedo un'automobile □
  Nella mia famiglia qualcuno possiede un'automobile □
  Un amico possiede un'automobile □
  Utilizzo un'auto aziendale, anche per usi privati □
  Utilizzo un'auto aziendale, ma non per usi privati □
  Utilizzo il "car-sharing" □
  Altre forme □
  Non dispongo di un'automobile □

- *Quanti km ha fatto lo scorso anno in automobile ?* __/__/__/__/__/__

- *Ha un* ***Abbonamento Generale*** *(AG) ?*
  Si □ No □

- *Ha un* ***Abbonamento Metà-Prezzo*** *?*
  Si □ No □

- *Ha un* ***abbonamento mensile/annuale*** *per la sua città o per un determinato percorso?*
  Si □ No □

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- *Quanti giorni ha viaggiato in **autobus, tram, o treno** la scorsa settimana?*
  0 □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □

- *Quanti viaggi ha fatto in autobus, tram, o treno, la scorsa settimana?*
  (se ha fatto dei cambi durante lo stesso tragitto, conta solo uno.
  Andata e ritorno conta doppio)

  __/__/__/

- *Quanti giorni ha viaggiato in **bicicletta,** la scorsa settimana?*
  0 □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □

- *Quanti giorni ha viaggiato in **automobile** la scorsa settimana?*
  0 □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □

- *Quanto si sente sicuro/a, a camminare da solo/a nel suo quartiere dopo le 10 di sera?*
  Molto sicuro □
  Abbastanza sicuro □
  Un po' insicuro □
  Molto insicuro □
  Non vado in giro dopo le 10 di sera, per ragioni di sicurezza □
  Non vado in giro dopo le 10 di sera, ma non per ragioni di sicurezza □

- *Quanto si sente sicuro/a, dopo le 10 di sera, nei mezzi pubblici?*
  Molto sicuro □
  Abbastanza sicuro □
  Un po' insicuro □
  Molto insicuro □
  Non uso i mezzi pubblici dopo le 10 di sera, per ragioni di sicurezza □
  Non uso i mezzi pubblici dopo le 10 di sera, ma non per ragioni di sicurezza □

- *Ha mai avuto un incidente stradale?*
  Si □ No □

- *Se si, quanti ne ha avuti…?*

  Guidando un'automobile __/__/
  Da passeggero di un'automobile __/__/
  Guidando una moto __/__/
  Da passeggero di una moto __/__/
  Andando in bicicletta __/__/
  Camminando __/__/
  Da passeggero di autobus/tram/treno __/__/

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- *Che reddito mensile lordo ha la sua famiglia?*

<2000	SFr.	□
2000-4000	SFr.	□
4001-6000	SFr.	□
6001-8000	SFr.	□
8001-10.000	SFr.	□
10.001-12.000	SFr.	□
>12.000	SFr.	□

....

- *Quante persone contribuiscono al reddito famigliare?* /__/

....

Molte grazie per la partecipazione all'inchiesta.

Commenti :

....

....

....

Appendix B

The next tables will show how the alternatives presented within the first test and the PE test, grouped in six experiment, have been classified in the categories service improvement, small infrastructure and big infrastructure, employed during the analysis of the models.

Table 12.1 Alternatives classified as service improvement

Experiment	Alternative
Night security	More night buses
	More night security guards and policeman
	All traffic light working also at night
Bus stop and/or lane	All existing bus stops with more informations and facilities
	More frequent buses through existing bus stops

Table 12.2 Alternatives classified as big infrastructures

Experiment	Alternative
Night security	Increase in the lighting
Speed control	Obligatory route with many curves
	High and larger bumps every km
Crossroad with bad visibility	Roundabout
Pedestrian	Pedestrian crossing with traffic islands every 300 m
	Tunnel of bridge across the road
Bus stop and/or lane	Space for new bus stop, bus lane not independent
	New bus stop and bus lane independent from the car lane
Bike facilities	Bike path divided from footway, close to the road
	Bike path faraway from the road

Table 12.3 Alternatives classified as small infrastructures

Experiment	Alternative
Night security	Illuminated road signs
Speed control	Narrow and low bumps every 800 m
	Two intelligent traffic light
	Speed camera every km
Crossroad with bad visibility	Mirrors just in corner with angle =<90°
	Mirrors in every corner with bad visibility
	Traffic light with photocell
	Traffic light regulated a priori
Pedestrian	Elimination of architectural barriers
	Pedestrian crossing every 300 m
	Pedestrian crossing with traffic light every 300 m
Bus stop and/or lane	New bus stop, bus lane not independent
Bike facilities	Bike lane in the road
	Bike path on the footway
	Covered parking places for bikes close to bus stops

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