English translation

Umeå 12th of January, 1996

Hello!

Many of today's environmental problems are not limited to a particular country but affect people in the whole world. One example of such an environmental problem is the ongoing depletion of the ozone layer. Another is when wild animals and plants are exterminated. In the discipline of Economics, which really is about planning for the economic management of limited resources, we also carry out research on measures to protect and conserve threatened species. Knowledge about such measures increases our ability to treat our natural environment accurately, both nationally and internationally. It is, therefore, important that we obtain a picture of how Swedish people look upon measures for the protection/conservation of threatened species. The questions in this questionnaire are about **one** threatened species, namely the African elephant.

Through a random selection, you are one of the 1 500 persons from all over the country we hope will assist us in this research. Please complete the enclosed questionnaire **as soon as possible** (preferably within two weeks). Return it to us in the enclosed envelope. The envelope is **free of postage so you do not have to use a stamp**.

In a scientific study like this, it is important that people with different opinions - including those who perhaps are not interested in wildlife and threatened species or the natural environment - participate. We, therefore, ask you to bear in mind that the results of this study deteriorate with every answer not returned. Your reply **cannot** be replaced by someone else's.

You do not have to state your name. The number found in the top right hand corner of the questionnaire is solely there for us to know who has answered the questionnaire within two weeks - it makes no sense sending reminders to those who have answered already.

Naturally your response will be confidential. It will be impossible to tell what you or any other specific respondent have answered from the results we will publish. We will only report values for large groups and we **do not** collect any other information than requested in the questionnaire.

If there is anything in the questionnaire that is unclear, please contact **Maria Vredin** on telephone **090-16 54 49**.

Thank you very much in advance for your cooperation.

Yours sincerely

Karl-Gustaf Löfgren
Professor

Umeå University
Department of Economics

QUESTIONNAIRE

Read this before answering the questions!

The African elephant, the world's largest land mammal, is found in Africa south of the Sahara. Today's herd is estimated at approximately 600 000 animals. The smaller, Asian elephant, is found in southern Asia.

Between 1981 and 1989 the herd of African elephants was halved from 1 200 000 to 600 000 animals. It is above all the demand for tusks, the most important raw material for ivory, that has caused the dramatic decrease. In addition, the elephant has lost many of its natural habitats as a consequence of the increased demand for arable land following the growth of the African population. As the elephant needs large areas to forage and seek shade in order to survive, it often comes into direct conflict with Africans in rural areas. These conflicts can result in crops being destroyed and cattle and, at worst, people being killed.

Despite the dramatic decline in the number of elephants during the 1980's, they are still abundant in several African countries. In some cases the herds are even so large that they present a threat to the vegetation and other animal species. In these countries, cullings have been carried out in order to reduce the number of elephants.

The African elephant is today classified as a *vulnerable* species, which means that its survival is not judged as secured in the long run. In 1989 Sweden prohibited trade in and imports of ivory and other animal products, both from the African and the Asian elephant. There are almost 400 species of *vulnerable* and *threatened* mammals in the world, but as only about half of all mammals are surveyed, the number could be substantially greater.

This was a brief background to the questions we would like to ask you.

We would be grateful if you could consider the following when answering the questions:

Even if you think that it is difficult to give a precise answer to a particular question - please give the best answer you can (give an approximate answer rather than none at all). In a few places there are • instructions• to the questions - please study these carefully before answering the questions.

Thank you for your cooperation!

First some general questions about you and your household.

1. **Are you a woman or a man?**

   (mark with a cross)

   ( ) Woman ( ) Man

2. **How old are you?**

   Answer: _____ years

3. **Approximately, how many years of school education do you have?**

   Answer: _____ years

4. **In which county do you live?**

   Answer: _____ county

5. **How many persons are there in your household (yourself included)?**

   Answer: _____ persons

6. **How many children (younger than 18 years) are there in your household?**

   Answer: _____ persons

Now follow some questions about your attitude towards nature and the African elephant.

7. **On average, how often do you spend time in the countryside** (for example, for walks, berry-picking or recreation)**?**

   (mark with **one** cross)

   ( ) Less than once a month

   ( ) One to three times a month

   ( ) Once a week or more

8. How important do you consider it is that the African elephant exists in Africa?

(mark with **one** cross)

( ) Not very important

( ) Quite important

( ) Very important

( ) Do not know

9. What do you think of when you hear the words • African elephant• ?

_____

_____

10. On the map at the very end of the questionnaire we have marked (numbered) those countries where the African elephant exists.

a) Have you ever visited any of the numbered countries?

(mark with a cross)

( ) Yes ( ) No

If • Yes• , which one/ones? Answer by stating the number/numbers of the country/countries:

_____

b) Do you consider it likely that you will visit any of the numbered countries in the next <u>ten</u> years?

(mark with a cross)

( ) Yes ( ) No

If • Yes• , which one/ones? Answer by stating the number/numbers of the country/countries:

_____

We ask the following questions in order to gain an understanding of the value Swedes place on the African elephant. One can have different reasons for wanting - or not wanting - to pay for a project aimed at saving the African elephant. Everybody has good reasons for thinking the way they do.

When you answer the questions you should note that there may be other things in nature to which you would like to pay regard - perhaps there are other environmental issues you consider to be more important. Moreover, perhaps there are social issues that you believe urgent. <u>Therefore, carefully consider your valuations before answering the questions!</u>

In some cases you might think that the questions are out of touch with reality. However, the questions are still important since it is only by posing such questions that we can gain insight into Swede's valuations. Bearing this in mind, we ask you to do your best to answer the questions.

11. There are approximately 600 000 elephants in Africa today. Which future development of the African herd of elephants would you prefer?

(mark with **one** cross)

I would prefer the herd of elephants in Africa to:

( ) Be reduced

( ) Remain as it is today

( ) Be increased

( ) Do not know

12. a) Are you or anyone else in your household a member of an environmental organisation (World Wide Fund for Nature, Greenpeace, Swedish Society for Nature Conservation or equivalent)**?**

(mark with a cross)

( ) Yes ( ) No

If • Yes• , which organisation/organisations: _____

If • Yes• , approximately how much does your household spend annually on this/these membership(s) (include in this sum <u>all</u> payments your household makes to the organisation/organisations, i.e. membership fees, voluntary gifts etc.)**?**

Answer: _____ kr

b) Are you or anyone else in your household actively involved in voluntary work in an environmental organisation?

(mark with a cross)

( ) Yes ( ) No

13. **Suppose that you have an annual sum of money that you would like to distribute between different voluntary organisations. As you know, these various voluntary organisations have different fundamental aims with their activities. How would you distribute the money between the various activities? Imagine that your money is equivalent to 100 • points• . Distribute these points between the activities given below. The more money you would like to give to a certain activity the higher the score it gets. <u>Remember that the distribution of points must add up to 100 points.</u>** (Please note that there are many different organisations involved in each activity- the examples name merely <u>one of many</u> organisations in every field of activity).

Children rights organisations (e.g. Swedish Save the Children)	_____ points
Human rights organisations (e.g. Amnesty International)	_____ points
Environmental organisations (e.g. World Wide Fund for Nature)	_____ points
Religious organisations (e.g. Salvation Army)	_____ points
Aid- and peace organisations (e.g. Africa Groups of Sweden)	_____ points
Other organisations	_____ points
TOTAL	**100 points**

The African elephant exists in poor countries which are seldom able to pay by themselves for projects to secure the survival of the elephant. Suppose instead that a project was designed and organised by a global environmental organisation (for example, the World Wide Fund for Nature). If the project is carried out, the survival of today's approximately 600 000 African elephants is guaranteed. If the project, on the other hand, is not carried out, the future for the African elephant is highly insecure. The project is financed through gifts from the environmental organisation's members. It is these voluntary contributions that make the project possible.

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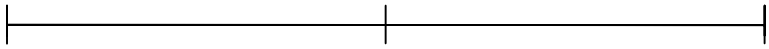
14. **How much, <u>at most,</u> would your <u>household</u> be willing to pay annually to such a project?**

Answer: _____ kr

Answer question 15 <u>only</u> if you were willing to make a donation to the project in question 14.

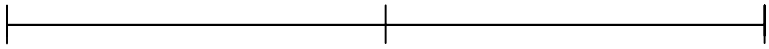
15. Below are given some possible motives for wanting the herd of African elephants to remain as it is today or to increase. <u>Which motives do you consider to be important</u>? Answer by marking a cross on the line below each stated motive.

a) Own experiences of the African elephant (e.g. through safaris, tv-programs, books etc.)



Of no importance — Very important

b) Other people can appreciate the African elephant.



Of no importance — Very important

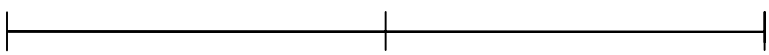
c) All species have the right to exist.

Of no importance — Very important

d) Future generations will be able to enjoy the African elephant.

Of no importance — Very important

e) Other motive, namely: _____



Of no importance — Very important

16. Approximately how large is your <u>household's</u> total income <u>before tax</u> every month? (Here we refer to labour- and capital income, pensions, unemployment and sickness benefits).

(mark with **one** cross)

( )	0-5 000 kr	( )	20 001-22 500 kr	( )	45 001-50 000 kr
( )	5 001-7 500 kr	( )	22 501-25 000 kr	( )	50 001-55 000 kr
( )	7 501-10 000 kr	( )	25 001-27 500 kr	( )	55 001-60 000 kr
( )	10 001-12 500 kr	( )	27 501-30 000 kr	( )	60 001-65 000 kr
( )	12 501-15 000 kr	( )	30 001-35 000 kr	( )	More than 65 001 kr
( )	15 001-17 500 kr	( )	35 001-40 000 kr		
( )	17 501-20 000 kr	( )	40 001-45 000 kr		

Now you have answered many questions that are of interest to us. Below we leave a few lines where you yourself can write down your views and opinions about the questionnaire, the African elephant or something else connected to this study that is important to you.

_____

_____

_____

_____

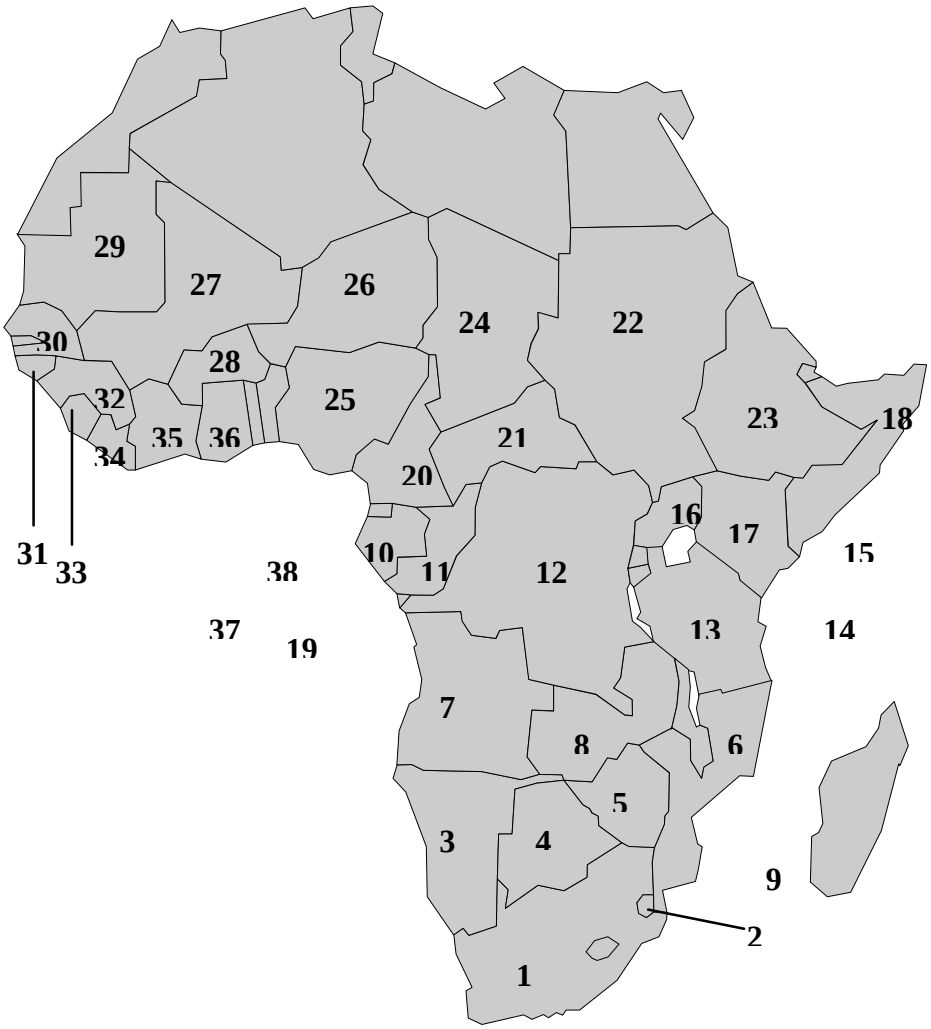
_____

_____

Return the completed questionnaire as soon as possible, preferably today. Use the enclosed envelope - stamps are not needed.

THANK YOU FOR YOUR COOPERATION!

Map of Africa



Countries where the African elephant exists (to a greater or lesser extent):

1 South Africa
2 Swaziland
3 Namibia
4 Botswana
5 Zimbabwe
6 Mozambique
7 Angola
8 Zambia
9 Malawi
10 Gabon
11 Congo
12 Zaire
13 Tanzania
14 Burundi
15 Rwanda
16 Uganda
17 Kenya
18 Somalia
19 Equatorial Guinea
20 Cameroon
21 Central African Republic
22 Sudan
23 Ethiopia
24 Chad
25 Nigeria
26 Niger
27 Mali
28 Burkina Faso
29 Mauritania
30 Senegal
31 Guinea-Bissau
32 Guinea
33 Sierra Leone
34 Liberia
35 Ivory Coast
36 Ghana
37 Togo
38 Benin

A:

14. How much, <u>at most</u>, would your <u>household</u> be willing to pay annually to such a project?

Answer: _____ kr

B:

14. How much, <u>at most</u>, would your <u>household</u> be willing to pay annually to such a project (imagine that the payment is due every year for a period of <u>three</u> years)?

Answer: _____ kr

C:

14. How much, <u>at most</u>, would your <u>household</u> be willing to pay annually to such a project (imagine that the payment is due every year for a period of <u>ten</u> years)?

Answer: _____ kr

D:

The African elephant exists in poor countries which are seldom able to pay by themselves for projects to secure the survival of the elephant. Suppose instead that a project was designed and organised by a global environmental organisation (for example, the World Wide Fund for Nature). If the project is carried out, the survival of today's approximately 600 000 African elephants is guaranteed. If the project, on the other hand, is not carried out, the future for the African elephant is highly insecure. The project is financed through contributions from the environmental organisation's <u>membership countries</u>. It is this funding that makes the project possible.

---

14. Suppose that your household could contribute to the accomplishment of the project by paying an annual amount of money in <u>tax</u>. Provided that everybody else in Sweden contributes - how much would your <u>household</u> be willing to pay <u>at most</u> as an annual <u>tax</u> to such a project?

Answer: _____ kr

English translation

Borlänge 1st of December, 1997

Hello!

In order for a society like ours to function well is it important with good communications and transports. It is, for example, important that one quickly can call for an ambulance when there has been an accident in the same way as it is important that the ambulance arrives fast and safe to the hospital. It is also important in other, more everyday life, situations that transports and communications work satisfactory. An example is our daily trips to and from work. These trips must work flexibly - irrespective of whether we bike, drive, go by bus or train.

In order for communication and transport systems to function satisfactory, extensive national planning is required. A part of this national planning is about understanding how, and why, people choose the travel modes they do. It may be a question of choice of travel modes for everyday trips, like trips to work, or of choice of travel modes for trips that are undertaken more seldom, like longer holiday trips. In this work is it important to gain an understanding of the attitudes and assessments behind the choices. It is, therefore, important to find out what you think and what assessments you make.

Through a random selection, you are one of the 480 persons from the Falun-Borlänge area we hope will assist us in this research. Please complete the enclosed questionnaire **as soon as possible** (preferably within a week). Return it to us in the enclosed envelope. The envelope is **free of postage so you do not have to use a stamp**.

In a scientific study like this, it is important that people with different opinions - including those who perhaps are not interested in transportation issues - participate. We, therefore, ask you to bear in mind that the results of this study deteriorate with every not returned answer. Your reply **can not** be replaced by someone else's.

You do not have to state your name. The number found in the top right hand corner of the questionnaire is only there for us to know who has answered the questionnaire - it makes no sense sending reminders to those who have answered already.

Of course your response will be confidential. It will be impossible to tell what you or any other specific respondent have answered from the results we will publish. We will only report values for large groups and we **do not** collect any other information than requested in the questionnaire. If there is anything in the questionnaire that is unclear, please contact **Maria Vredin** on telephone **0243-77 85 54**.

Thank you very much in advance for your co-operation.

Yours sincerely

Karl-Gustaf Löfgren
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Professor
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Tel: 023-77 85 24

Umeå University
Department of Economics

Dalarna University
Centre for Research on Transportation and Society (CTS)

QUESTIONNAIRE

We would be grateful if you could consider the following when answering the questions:

Even if you think it is difficult to give a precise answer to a particular question - please give the best answer you can (give an approximate answer rather than none at all). In a few places there are • instructions• to the questions - please study these carefully before answering the questions.

Thank you for your co-operation!

First some general questions about you and your household.

1. Are you a woman or a man?

(mark with a cross)

( ) Woman ( ) Man

2. How old are you?

Answer: _____ years

3. Approximately, how many years of school education do you have?

Answer: _____ years

4. How many persons are there in your household (yourself included)?

Answer: _____ persons

5. How many children (younger than 18 years) are there in your household?

Answer: _____ persons

6. Do you hold a driving licence?

( ) Yes ( ) No

7. Which is your main occupation at present?

( ) Employed
( ) Studying
( ) Unemployed
( ) On maternity/paternity leave
( ) Other, _____

If you answered • Employed• in question 7 - please continue to answer the questions in the questionnaire!
If you belong to one of the other groups you do not need to answer further questions. Of course your views and opinions are of interest to us but, since we have chosen to study work trips in this questionnaire, it will be hard for you to answer the rest of the questions. Therefore, we ask you to return the questionnaire with your responses.
In that way, you will not get a reminder in the post box. You are welcome to comment the questionnaire on the final page. We are grateful for your co-operation!

8. Do you work full time or part time?

( ) Full time
( ) Part time, _____%

9. How do you travel to/from work an ordinary day of work?

( ) I walk
( ) I ride a bike
( ) I drive an auto
( ) I am a passenger in an auto
( ) I go by bus
( ) Nothing of the above, I _____

10. Given your answer to question 9, which are the main reasons for choosing this particular travel mode?

Answer: _____

11. Approximately how far is it to your workplace?
(State the distance for a one way journey to your workplace).

Answer: _____ kilometers

12. Approximately, how long does it take you to travel to your workplace?
(Count the time from leaving your home until you arrive at your workplace).

Answer: _____ minutes

13. Approximately how much does it cost you to travel to your workplace?
(State the price for a one way journey to your workplace).

Answer: _____ kronor

Answer question 14 and 15 only if you in question 9 answered that you drive an auto to work. Otherwise, continue to question 16.

14. What kind of auto do you have?

Type: _____ Model: _____

15. Are you entitled to tax deductions for your journeys to and from work?

( ) Yes ( ) No

16. What alternative travel modes do you have for a trip to work?
(Assume that the travel mode you normally use is not possible to use - then how would you travel to work? State as many feasible options you think you have).

Answer: First, I would choose: _____
Second, I would choose: _____
Third, I would choose: _____
More alternatives: _____

( ) I have no alternative. The main reason/reasons for that is/are:
_____

_____

Answer question 17 and 18 only if you in question 16 stated some alternative travel mode/modes. Otherwise, continue to question 19.

17. Approximately how long would it take you to travel to your workplace by the alternative travel mode(s)?
(Count the time from leaving your home until you arrive at your workplace).

Answer: _____ minutes by _____
_____ minutes by _____
_____ minutes by _____

18. Approximately how much would it cost you to travel to your workplace by the alternative travel mode(s)?
(State the price for a one way journey to your workplace).

Answer: _____ kronor by _____
_____ kronor by _____
_____ kronor by _____

In the question below we would like you to compare two different travel modes for a journey to your workplace; auto and bus. We would like you to do the comparisons even if you do not have an auto and even if it is impossible to go by bus to your workplace. Try to imagine what it would be like if both alternatives existed.

19. As you know different travel modes are associated with different attributes, for example different travel time, cost, safety and environmental friendliness. How do you perceive the different travel modes with respect to respective attribute?

Start out from the auto's attributes and make comparisons. **The attributes of the auto are always 100%**. **Example:** If you perceive the travel time with bus equal to the travel time with auto, you answer **100%**. If you perceive the travel time with bus three times as long as the travel time with auto, you answer **300%**. If you perceive the travel time with bus half of the travel time with auto, you answer **50%**. You may, of course, use any percentages - the important thing is that you, as accurately as possible, describe your own perceptions.

a) Compared with auto, I perceive the TRAVEL TIME with bus to be: _____%

b) Compared with auto, I perceive the COST with bus to be: _____%

c) Compared with auto, I perceive the SAFETY with bus to be: _____%

d) Compared with auto, I perceive the ENVIRONMENTAL FRIEND-LINESS with bus to be: _____%

We ask the following two questions to find out how people value different attributes in a journey to work.

<u>Suppose</u> you are confronted with the choice between two hypothetical travel modes (A and B) for <u>a journey to your workplace</u>. These travel modes are characterised by <u>four different attributes</u> (travel time, cost, safety and environmental friendliness). There are no • real• travel modes that are described, but travel modes characterised by combinations of different attributes. Now we ask you to <u>make a choice between A and B</u> on the basis of the attributes that characterise travel modes A and B. How you choose is up to you, but we ask you to think thoroughly through your opinions before answering question 20 and 21.

<u>Remember</u>: There are no right or wrong answers! You have the right to think and choose as you like - it is <u>your</u> opinions that are important to us.

20. Which alternative (A eller B) do you prefer?

Attributes	**A**	**B**
Travel time like:	Auto	Bus
Cost like:	Bus	Auto
Safety like:	Auto	Bus
Environmental friendliness like:	Auto	Bus

Answer: I prefer (mark with **one** cross):

( ) Travel mode A
( ) Travel mode B
( ) The alternatives are equal

21. Which alternative (A eller B) do you prefer?

Attributes	**A**	**B**
Travel time like:	Bus	Auto
Travel cost like:	Bus	Auto
Safety like:	Auto	Bus
Environmental friendliness like:	Auto	Bus

Answer: I prefer (mark with **one** cross):

( ) Travel mode A
( ) Travel mode B
( ) The alternatives are equal

In the question below we ask you to state your household's monthly income before tax. We ask this question because we believe that the monthly income plays an important role in the everyday decisions and choices of the household.

<u>Remember</u>: Your answers are protected. From the results we will use it will be impossible to see what you, or any other particular respondent, have answered. We will only report values for large groups of people.

22. Approximately how large is your household's total income <u>before tax</u> every month?
(Here we refer to labour- and capital income, pensions, unemployment and sickness benefits).

(mark with **one** cross)

( )	0-5 000 kr	( )	20 001-22 500 kr	( )	45 001-50 000 kr
( )	5 001-7 500 kr	( )	22 501-25 000 kr	( )	50 001-55 000 kr
( )	7 501-10 000 kr	( )	25 001-27 500 kr	( )	55 001-60 000 kr
( )	10 001-12 500 kr	( )	27 501-30 000 kr	( )	60 001-65 000 kr
( )	12 501-15 000 kr	( )	30 001-35 000 kr	( )	Mer än 65 001 kr
( )	15 001-17 500 kr	( )	35 001-40 000 kr		
( )	17 501-20 000 kr	( )	40 001-45 000 kr		

Now you have answered many questions that are of interest to us. Below we leave a few lines where you yourself can write down your <u>views and opinions</u> about the questionnaire, what was <u>hard or easy to respond to</u>, <u>suggestions to changes</u> or something else connected to this study that is important to you.

<u>Note: More space was given in the Swedish version of the questionnaire.</u>

Return the completed questionnaire as soon as possible, preferably today. Use the enclosed envelope - stamps are not needed.

THANK YOU FOR YOUR CO-OPERATION!

Valuing a Peripheral Environmental Amenity. The Swedes' Willingness to Pay for the Survival of the African Elephant*

Maria Vredin Johansson†

Abstract

Data from a contingent valuation (CV) survey are used to estimate the Swedes' willingness to pay (WTP) for the preservation of the African elephant. Also addressed are some methodological issues associated with the CV method, such as the method's susceptibility to differential valuation stimuli. Tests are performed for variations in the time-horizon of the payment obligation and for different payment vehicles. The overall mean WTP is found to be SEK 238 annually, while the median WTP is SEK 100 annually. None of the different treatments have a significant impact on the mean WTP.

Key words: Contingent Valuation, Payment Vehicle, Intertemporal Embedding.

*I would like to thank Mattias Boman, Chuan-Zhong Li, Per Johansson, Bengt Kriström, Karl-Gustaf Löfgren and Jørn Stage for valuable comments and suggestions. Financial support from The Swedish Council for Reasearch in Humanities and Social Sciences (HSFR) is gratefully acknowledged.

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1 Introduction

The rate at which species become extinct is increasing rapidly in the world (Emanoil, 1994). It is hard to tell exactly how large the actual rate of extinction is as only about ten percent of the estimated total number of species have been described, named and surveyed by scientists (*ibid.*). Altogether, there are between 5,000 and 6,000 threatened[1] species of animals known to scientists in the world today (IUCN, 1993). Among these, there are almost 400 species of vulnerable and endangered *mammals* (*ibid.*). One of these is the African elephant (*Loxodonta africana*).

The African elephant is a quasi-public good, which, when living in the wild, is unowned, but which, through a successful hunt, can be converted into a private good. Classified as a globally vulnerable species, it is expected to become globally endangered if the causal factors currently in place continue to operate. Since 1989 the African elephant is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which means that all legal trade in ivory and other elephant products is prohibited by countries ratifying the ban. The main reason for protecting the African elephant is its dramatic decrease in numbers between 1981 and 1989 when the herd was halved from 1.2 million to 600,000 animals. It was above all the demand for tusks that led to the decline. In addition, the elephant has lost many of its natural habitats as a consequence of the increased demand for arable land following the rapid population growth in Africa.

Even though the preservation of threatened species is costly for society, most people agree on aesthetic, ethic, ecological or emotional grounds that threatened species need to be protected. However, the preservation of endangered species of animals may also represent an *economic* value for society. The total economic value of a natural resource, such as a wild animal, consists

[1] IUCN classifies threatened species as species that are either *endangered* (species whose continued survival is unlikely if the causal factors continue to operate), *vulnerable* (species that are expected to join the endangered category if the factors which causes the threat continue to operate), *rare* (species at risk which exist in small populations), *indeterminate* (species that are either endangered, vulnerable or rare) or *insufficiently known* (species that are suspected to belong to any one of the above listed categories) (IUCN, 1993). To avoid a too extensive terminology the terms *endangered* and *threatened* will be used interchangeably in this paper, including all categories classified as threatened by the IUCN.

of two types of values; *use* values[2] and *passive use*[3] values. The use value is derived from the actual use of the natural resource, in this case the African elephant, via, for example, safari hunting, ivory trade and game viewing. The passive use value largely consists of values derived from the willingness to pay (WTP) for the preservation of the elephant by individuals who do not presently utilise it.

In order to measure the *total* value of an unmarketed good such as the African elephant, a method called the contingent valuation method (CVM) can be applied. In a CV survey, a surrogate market for the unmarketed amenity is constructed and, through this market, the researcher, via interviews or questionnaires, elicits the respondents' maximum WTP for improvements in the amenity.[4]

There have been numerous attempts to measure the value of species of wild fauna (cf. Boman & Bostedt, 1995; Fredman, 1994; Desvousges et al., 1993; for a comprehensive bibliography of CV papers and studies, see Carson et al., 1995). Many of the surveys carried out concern species of a "close-to-home" character to the respondent, whereby the valuation may reflect both use and passive use values. The survey performed here differs from these, since it concerns a species peripheral to most of the respondents. However, we hypothesise that even people not living in Africa might value improvements in the situation for the African elephant. If the Swedes have a positive valuation of the African elephant, this valuation may include both passive use values and non-consumptive use values.[5]

We have three major aims with our survey; the first is to measure the Swedes' WTP for the conservation of the African elephant, the second is to

[2] Consisting of both consumptive and non-consumptive use values.

[3] The term passive use value encompasses a number of subvalues, such as nonuse value, existence value, bequest value, intrinsic value and option value (Carson et al. draft, 1996)

[4] In a study, Vredin (1995), examine the economic values of an African elephant. The ivory value (US$ 2,734 in 1987 current prices) and the trophy fee value (US$ 2,366 in 1989 current prices) clearly reveal consumptive use values, while the value derived from a CV survey in Kenya (Brown & Henry, 1989) tells us something about the non-consumptive use value (US$ 1,562 in 1989 current prices).

[5] Through subscriptions to environmental organisations, such as the World Wide Fund for Nature (WWF) people make donations to save endangered species even though they may never visit the areas where the animals reside. These voluntary subscriptions can be regarded as revealed preferences for the existence value people all over the world place on wildlife. In 1995 the Swedish WWF received SEK 56.2 million (US$ 7.9 million) from the general public (WWF, 1996).

examine whether the CVM is susceptible to intertemporal embedding, i.e. insensitivity to the time-horizon of the payment obligation, and the third is to explore differences in WTP due to the type of payment vehicle used.

The first aim is straightforward to accomplish by calculating the mean and median annual WTP. The second and third aims are somewhat related and address methodological issues associated with the CV method, such as the valuation's susceptibility to differential valuation stimuli. For the results of a CV study to be valid, it is important that respondents are sensitive to relevant methodological factors, i.e. factors predicted by economic theory, and insensitive to factors not predicted by economic theory. Consequently, there are some things in a CV survey that should matter and there are others that should not. For instance, the timing and frequency of payments ought, according to economic theory, matter, while, according to empirical evidence, they do not necessarily do so (Kahneman & Knetsch, 1992; Schkade & Payne, 1993; Spaninks & Hoevenagel, 1995). The existence of intertemporal embedding is troublesome, since it facilitates manipulations of the results from CV surveys, simply by changing the payment schedule. A related issue is the choice of payment vehicle. If, for instance, there is strong aversion to a particular payment vehicle, the resulting valuation could be reduced, no matter what the "true" valuation is. Through experiments within the survey, we explore these potentially troublesome manipulations of benefit estimates from CV studies.

The remainder of this paper is organised as follows: the next section gives a description of the survey and the experiments carried out within the survey, section three provides the results from the survey, section four contains benefit estimates and findings from a sensitivity analysis, section five presents the results of the experiments within the survey and, finally, section six discusses the results.

2 The Survey

In January 1996, the questionnaire was mailed to 1,500 Swedish residents (born between 1920-77, i.e. aged 18 to 75 years) randomly selected from the Swedish Official Register of Persons and Addresses (SPAR) (the motive behind the age-qualification was that we wanted respondents who arguably could have some influence on the household budget). The questionnaire described the African elephant, its habitat, its status as a vulnerable species,

the present threats against its survival, and also the fact that the elephant might be harmful to its environment. In total, there were 16 questions plus a map of Africa, showing the countries were the elephant - to a greater or lesser extent - exists (see Appendix A for the questionnaire in its entirety). In the beginning of February, a follow-up reminder was mailed and, at the end of February, a second reminder was sent to the remaining non-respondents.

Apart from socio-economic questions and questions regarding the respondent's interest in the natural environment in general and in the African elephant in particular, there was a question, preceding the valuation question, intended to make the respondent aware of his budget constraint. The question urged the respondent to consider the fact that there might be other worthy causes and/or social issues of interest to him, bearing in mind the limits on his budget. In fact, our survey implicitly assumes that respondents perform *two-stage budgeting* (Hausman, 1993; Deaton & Muellbauer, 1980), where the individual first decides how to divide his total expenditure between *groups* of commodities and then allocates the expenditure for that group across the *commodities* in that group. Two-stage budgeting implies *weak separability* of the utility function so that the marginal rate of substitution between, in this case, African elephants and wealth is independent of the quantities of other goods in the utility function.

In the question following the valuation question, the respondent was asked to motivate his valuation if it was positive. Four prespecified motives plus one optional were given. The reason behind the motivation question was to facilitate a division of the total valuation into different subcomponents, such as use and passive use values.

In our survey we use an *open-ended* question to elicit the willingness to pay. An open-ended question asks the respondent to state his maximum WTP in a question like: "What is the most your household would be willing to pay for...?". Another possible formulation is the *closed-ended* questioning format, where the respondent is asked to accept or reject a prestated bid, expressed in terms like: "Would your household be willing to pay $\$x$ for...?" (different respondents are confronted with different prestated amounts). The open-ended format was standard practise until the mid-1980s, but, since then, the closed-ended format has practically become *comme il faut*. It is argued that the closed-ended format is similar to an ordinary market transaction where people are confronted with posted prices and, therefore, is said to facilitate the valuation process (Hanemann, 1994). However, provided that the respondent answers truthfully and reveals his true preferences (instead

of, for example, the perceived cost of the amenity being valued), there is more informational content in an answer to an open-ended CV-question. Other studies (Green et al., 1995[6]; Schulze et al., 1981), indicate that there are significant disadvantages with the closed-ended format, since it is prone to starting point bias, which means that respondents are influenced by the bid given in the questionnaire. To a great extent, the respondents tend to regard the bid as reasonable, no matter how misleading it is. The experiments performed in Green et al. (*ibid.*) show that, even for nonmonetary valuation, the closed-ended format gives a significantly larger mean value than the open-ended format. In our survey, we have chosen, what we consider a conservative strategy, and employed an open-ended question to elicit the WTP. In doing this, we face the risk of discouraging responses and, thereby, reducing the response rate. However, since we are looking for the maximum WTP people are actually willing to pay - not just a hypothetical value stated in monetary terms - we believe that exaggerated responses would damage our study more severely than a low response rate.

Furthermore, our survey asks for the WTP for maintaining the individuals' initial level of utility, i.e. for preserving the *present* herd of elephants. No experiments using different population levels were attempted for several reasons. First, it is very hard for the average Swede to judge whether a population of a certain size is viable or not and, second, studies of Swedish fauna (Boman & Bostedt, 1995; Fredman, 1994) indicate that, even though the respondents perceived - in these cases the wolf and the whitebacked woodpecker - as environmental goods (as opposed to environmental bads), they mainly valued securing their survival, not the population levels themselves. A similar conclusion is reached by Cummings et al. (1986), who argue that the WTP to save lives, to a great extent, will be independent of the number of lives saved. If the protection of endangered species is viewed as a matter of principle, this is a likely outcome. In short, it seems as though there is either satiation in the purchase of threatened species, i.e. when the species is said to have reached something like its minimum viable population[7] there is

[6] Published in *Resource and Energy Economics,* 1998, **20**, 85-116.

[7] The minimum viable population (MVP) of a species is defined as the threshold number of individuals of a certain species that is needed for the continued existence of the species for a given period of time (Gilpin & Soulé, 1986). MVP depends on the species reservoir of genes, the environment etc. A rule of thumb for the MVP is 500 effective individuals in the population. Effective individuals are defined as individuals who are genetically idealised, that is the degree of inbreeding is zero (Begon et al., 1990). The effective population of

no willingness to pay for further increases, and/or that the valuation of lives is too value-laden to be fruitfully experimented with.

Moreover, in the WTP scenario, elephant protection was treated as an "all-or-nothing" choice. The respondents were asked to state their WTP for a project that, with a 100 percent certainty, would guarantee elephant survival. The consequence of failing to pay was the risk of elephant extinction. Since a conservation program must be viewed as a means of providing an increase in the *likelihood* of species survival, instead of as a *guarantee* for survival, our scenario can, in that aspect, be viewed as a little dishonest.

Furthermore, there is no doubt about the fact that many Swedes have been influenced by information from outside the scenario created in the questionnaire, since there have been many newspaper articles and TV-programs describing the situation for the African elephant. It is, therefore, difficult to completely restrict the elicitation to the information presented in the questionnaire.

2.1 Experiments within the Survey

Apart from trying to estimate the Swedes' willingness to pay for the preservation of the African elephant, we also wanted to address some methodological issues associated with the CVM, such as the method's susceptibility to differential valuation stimuli. Through experiments within the survey, we checked for differences in WTP due to variations in the time-horizon of the payment obligation and for differences in WTP due to the type of payment vehicle used.

To accomplish the experiments, we divided our sample into four groups consisting of 375 individuals each. Each subgroup (A-D) was randomly assigned a different treatment. Small variations in elements of the scenario regarding the payment vehicle and the time-horizon of the payment obligation, meant that each subgroup received a slightly different valuation question. Subgroup A's payment vehicle was an annual *voluntary* payment, subgroup B's payment vehicle was an annual *voluntary* payment made every year for *three* years, subgroup C's payment vehicle was an annual *voluntary* payment made every year for *ten* years and, finally, subgroup D's payment vehicle was a *tax* receipt due every year (see Appendix A).

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individuals is, therefore often much less than the actual population.

2.1.1 Intertemporal Embedding - Insensitivity to Time-Framing

Differences in WTP following variations in timing and frequency of payments is one kind of embedding effect[8] that influences the results from CV studies if respondents are unable to correctly discount future payments. Intertemporal embedding is the respondent's invariance to the time-horizon of the payment obligation.

While economic theory does not predict that the value of a good should be a function of the frequency with which one has to pay for it[9], aggregated WTP estimates can be much larger when the payment is described as a continuous, long-term commitment than as a once and for all, lump sum, fee (Kahneman & Knetsch, 1992). If intertemporal embedding is present, there is no significant difference between asking for a one-time payment and asking for a stream of payments - respondents will give the same amount regardless of the number of times they are being asked to pay. The total discounted WTP would naturally be higher in a continuous question, which, if used for policy decisions, could heavily influence the outcome. Consequently, the existence of intertemporal embedding is troublesome since it facilitates manipulations of the WTP.

Previous studies testing for intertemporal embedding are inconclusive. Kahneman and Knetsch (*ibid.*) compared a one-time payment with a five year continuous payment and found no evidence for discrimination between the two payment schedules. Spaninks & Hoevenagel (1995), on the other hand, found significant differences between a monthly (aggregated to a yearly) and a yearly payment schedule. Carson et al. (1992, p. 28), in a pilot study, found that "[...] *some people had difficulty accepting long term payment obligations*". Their conclusion was that individuals were prepared to commit themselves to paying during (a maximum of) three years - longer payment schemes were prone to recontracting.

To test the hypothesis of intertemporal embedding, we performed an ex-

[8] Many different kinds of nesting and sequencing issues have been collected under the heading embedding, some predicted by economic theory, others not (Carson & Mitchell, 1995). Since one can assume that preferences often are shaped by the eliciting method, any demonstration that preferences are susceptible to sequencing and/or nesting would raise doubts about the applicability of the CVM (Cummings et al., 1986). If responses to CV surveys are susceptible to manipulations (in any desired direction), and these valuations are input in benefit-cost analyses used for legal or policy decisions, they can be of considerable political significance.

[9] See Johansson, 1987, ch. 9, for a further discussion on this topic.

periment with different time-horizons for the payment obligation. Since there is no agreed basis on which to choose between a one-time payment and a continuous payment scheme, many CV surveys ask for a one-time payment and completely avoid the problem of intertemporal embedding. However, as the likelihood of elephant survival changes every year (due to changes in the environment, effects from poaching etc.), we found it more reasonable to use a continuous payment scheme. In effect, we used *three* different specifications of the time-horizon in our questionnaire. The main aim was to compare the annual WTP from a three year commitment with that from a ten year commitment. It was, however, also possible to compare these specified commitments with an unspecified commitment. Our hypothesis was that if the respondents did not accept the long-term character of the commitment, there would be no significant difference in mean annual WTP of subsamples A (unspecified), B (three years) and C (ten years).

2.1.2 Payment Vehicle Issues

As amenities being valued in CV surveys are not market goods, the payment vehicle is chosen on the basis of realism, i.e. what method of payment would most likely be the case if the good was an ordinary market good. The payment vehicle chosen should, therefore, have a plausible and realistic connection to the good valued. However, remembering that valuation is claimed to be *context dependent* (Cummings et al., 1986; Carson et al., 1996), different payment vehicles or different institutions of provision may result in different valuations.

In our survey, we believe that *two* different payment vehicles are feasible - a voluntary donation and a tax payment. The voluntary donation is plausible since environmental organisations, such as for instance the WWF, routinely work to raise funds to preserve endangered species and ecosystems. Accordingly, it seems to be an established way for respondents to "buy" such amenities. The tax payment perhaps needs further explanation. Since there is a growing concern for environmental problems, there is also a growing awareness that many of the world's environmental problems are of a global character. The preservation of threatened species is one such world-wide problem. In order to slow down, or halt, the process of species extinction, it is probably necessary for nations to cooperate. Such global cooperation would, most likely, be handled by the state at the national level, and, consequently, a tax payment would be appropriate.

If we assume the tax to be of distortionary character, we can compare the welfare effects from the tax with the welfare effects from the voluntary payment, given a prespecified revenue from the different payments. If the individual under one payment scheme loses more in welfare than in the other, there would be no rational reason for him to be willing to pay *more* under the scheme where he loses more.

Formally, the individual confronts the problem of maximising his utility $u(\mathbf{x}, q)$, where $\mathbf{x}$ is a vector of conventional market commodities and q is the status of a non-market environmental commodity (elephants), subject to a budget constraint. Solving the utility maximisation problem yields a set of demand functions and an indirect utility function, $v(\mathbf{p}, q, y)$, where $\mathbf{p}$ is a vector of market prices and y is the individual's income.

Suppose that q has two states, q^0 and q^1, where q^0 represents the present stock of African elephants and q^1 a state where elephants are extinct. A change in q from q^0 to q^1, leads to a reduction in welfare. The maximum amount an individual would be willing to pay to avoid this welfare deterioration is equal to the equivalent variation (E). E is defined as the amount making Equation (1) hold true:

$$v(\mathbf{p}, q^0, y - E) = v(\mathbf{p}, q^1, y). \tag{1}$$

A general result following from economic theory is that if preferences are convex, the individual is worse off facing a distortionary tax, t, than a lump sum tax, T, generating the same revenue, R (Varian, 1992, ch.8). This is the case since all taxes, apart from lump sum taxes, cause deadweight losses. Consequently, it can be shown that $v(\mathbf{p}, q^0, y - T) > v(\mathbf{p}, q^0, (1 - t)y)$, given $T = R(t)$.

Consider two schemes, one where the individual pays a voluntary lump sum, T, and another where he pays a distortionary tax, t_e, generating the same revenue for elephant protection, $T = R(t_e)$. If T is calibrated to equal E in Equation (1), it follows that the indirect utility achieved under the voluntary payment scheme is larger than the indirect utility achieved under the tax payment, $v(\mathbf{p}, q^1, y) = v(\mathbf{p}, q^0, y - E) > v(\mathbf{p}, q^0, (1 - t_e)y)$. In order to equate the last part of this expression, the revenue from the distortionary tax payment $R(t_e)$ must be less than E, i.e. $R(t_e) < E$.

Therefore, we expect that respondents will be willing to pay more (or at least not less) when being asked to pay voluntarily, than when being asked to pay a tax. Hence, we want to test whether the WTP from the tax payment is significantly *smaller* than the WTP from the voluntary payment.

Table 1: Response rates of the different subsamples.

	A	B	C	D	Total
Main sample	375	375	375	375	1,500
Real sample	367	371	369	369	1,476
Returned blank	8	10	13	7	38
Responses	233	221	213	221	888
Response rate (%)	63.5	59.6	57.7	59.9	60.2

Note: The real sample is the main sample less the questionnaires that were undeliverable due to unknown address, severe illness or longer stays abroad.

3 Results from the Survey

3.1 The Response Rate

The response rate to a mail survey can depend on several features of the questionnaire: *design, subject content, length, complexity and timing* (Brown et al., 1989). Efforts were made to reduce the complexity of the questions and to make the questionnaire as short and attractive as possible to the respondent. As mentioned above, the questionnaire was mailed in January and February. We judged that the choice of these two months would maximise the response rate, as people are at home and indoors to a greater extent than at other times of the year (at least in Sweden). However, it could be suspected that the subject of the questionnaire, the African elephant, would only be of peripheral concern to most of the respondents, a fact that could possibly lead to a lower response rate (Mitchell & Carson, 1989).

Of the 1,500 questionnaires that were sent out, 888 completely or partially answered were returned. Adjusting for those that were returned due to unknown address, severe illness or longer stays abroad (a total of 24), the overall response rate was 60.2 percent (see Table 1).

3.2 General Characteristics of the Sample

In order to be able to make inferences from our survey, it is important that our sample does not, in any substantial way, differ from the population from

Table 2: Descriptive characteristics, swedish averages (SA) from SCB (1995).

Variable	Mean	CI (95%)	SA
Household size	2.65	2.56 - 2.74	2.14
Children per household	0.68	0.61 - 0.74	0.47
Age (years)	44.22	43.19 - 45.25	43.35[a]
Sex (male=0/female=1)	0.51	0.47 - 0.54	0.51
Education (years)	11.64	11.42 - 11.86	11.47[b]
Membership[c]	0.18	0.15 - 0.20	0.08[d]
Household income (SEK/month)	23,158	22,250 - 24,066	22,700[e]

[a] Refers to all Swedish citizens born between 1920-77.

[b] Refers to the educational level of persons in the labour force aged between 16-64 years.

[c] Membership of an environmental organisation.

[d] Häll (1994). Refers to members (aged between 16 and 84 years) of environmental organisations ("miljöorganisationer"), such as Greenpeace and the Swedish Society for Nature Conservation in 1992.

[e] Income 1996, i.e. income 1994 adjusted with an index of labour costs.

which it is drawn. We have, therefore, made comparisons between the characteristics of the sample and their national counterparts (see Table 2).

Two sample means that are significantly different from their national counterparts are the household size and the number of children (persons $<$ 18 years) in the household. Other CV studies performed in Sweden (Fredman, 1994; Boman & Bostedt, 1995; Löfgren et al., 1995) have also found household sizes of the same order of magnitude. A plausible reason for the difference between the sample and the population, is that persons older than 75 years were omitted from the sample (many such households are single person households), while their inclusion would reduce the average household size. In this sense there was an overrepresentation of young households in the sample - a fact that also may explain the higher presence of children.

3.3 Sample Self-Selection

A potential problem in CV mail surveys, which results from nonresponse, is bias caused by self-selection. Mitchell & Carson (1989) suggest that the WTP amount obtained from a mail survey could be biased upward, since those more interested in the good are more likely to return the questionnaire. If for instance, in our case, members of environmental organisations have above average response rates and above average environmental values, the benefit estimate will be overestimated. If this bias is severe, aggregate benefit estimates can overestimate the benefits with as much as 50 percent (Whitehead, 1991).

The statistic indicating membership of an environmental organisation, is higher in our realised sample than the national equivalent. A fact that could contribute to inflating our value is our definition of membership: if the respondent indicated that he was member or had contributed financially to an environmental organisation (sometimes without being a "real" member), the value of membership was set equal to one. An alternative interpretation would be that the higher membership value indicates that our sample suffers from sample self-selection. Since the national average reported by Häll (1994) is divided into two groups: "Miljöorganisationer" (Environmental Organisations) and "Friluftsföreningar" (Recreational Organisations)[10], it is not possible to make a straightforward comparison between our sample and the national figure. Häll (*ibid.*) estimates that 8.5 percent of the population between 16-84 years belong to an environmental organisation, while the membership of recreational organisations is 9.3 percent. When asking for membership in our survey, three different examples of environmental organisations were given (World Wide Fund for Nature, Greenpeace, the Swedish Society for Nature Conservation). If the respondent stated membership of an environmental organisation, he was asked to name the organisation(s). Since there is no close match between the organisations stated under the different headings by Häll, and the organisations reported by our respondents, a comparison makes little sense. Moreover, there is no correspondence between the age groups used by Häll and the ones in our survey. Solely by comparison with Häll's figures, it is inconclusive whether sample self-selection exists in our realised sample[11].

[10] Author's translation.

[11] The mean WTP for members is SEK 258.50 (median SEK 150), while for non-members it is SEK 233.80 (median SEK 100). Testing for significant differences between the means

Table 3: Mean and median for the early, intermediate and late arrivals.

Arrival	Mean	Median	Cases
Early	249.3	100	438
Intermediate	230.8	100	233
Late	200.2	100	106

Note: Table values are based on the WTP1 measure (see Appendix C).

Nevertheless, albeit, in a crude way, we were able to test the hypothesis of self-selection. As we registered the date of arrival for the questionnaires, it was possible to compare *early* arrivals (no follow-up mailing) with *intermediate* (one follow-up) and *late* arrivals (two follow-ups). Our hypothesis was that early arrivals were more interested in the African elephant and, therefore, placed a higher value on its survival.

Merely by looking at the means (Table 3), we see that the mean from early arrivals is larger than the mean from intermediate arrivals, which, in turn, is larger than the mean from late arrivals. The Scheffé[12] test reveals no significant differences between the three groups at the 5 percent level. However, using the nonparametric Kruskal-Wallis H-statistic[13], we can reject the hypothesis that all three groups have equal distributions (p-value: 0.0018). Pairwise Mann-Whitney tests[14] of early, intermediate and late arrivals re-

with a t-test, no significant difference is found at the 5% level.

[12]The Scheffé test is a conservative procedure for making several comparisons of means simultaneously. The procedure widens the individual confidence intervals so that all comparisons between means hold true simultaneously, at a prescribed level of confidence. Another advantage is that the procedure does not require equal sample sizes. For further details, see Miller & Wichern (1977).

[13]The test is performed by combining and ranking the observations from the three samples (the smallest willingness to pay is given rank 1, the next is given 2 and so forth). The value of each observation is then replaced by its rank and, consequently, by using the rank instead of the actual value, the test is not affected by outliers. For each group the ranks are summed and the Kruskal-Wallis H-statistic is computed. The H-statistic has approximately a chi-squared distribution. Since the Kruskal-Wallis test statistic is based on the *ranks* of the bids, there is reason to suspect that the underlying distributions are different if one of the groups has more than its share of large values for the willingness to pay (Norusis, 1993).

[14]The Mann-Whitney test, or the Wilcoxon test, is a nonparametric test for differences

veal significant differences between early and intermediate arrivals (p-value: 0.0059), and between early and late arrivals (p-value: 0.0039). However, no significant difference is found between intermediate and late arrivals (p-value: 0.4219). Thus, it seems as though there are more high bids among early arrivals than among intermediate and late arrivals. This is a more convincing indicator of sample self-selection, compared with the sample-statistic for membership of environmental organisations. It is worth noting that the median is SEK 100, irrespective of whether the respondent received no or one or two follow-up reminders. Thus, if the median is used as a benefit measure, the potential bias from sample self-selection is mitigated.

3.4 Intersample Differences

Another question that arises, having different subsamples, is whether the subsamples differ from each other in any significant way, i.e. are there intersample differences? As we want to compare means (μ^j) from different subsamples ($j = A, B, C, D$), it is important that other characteristics, such as social and economic status, are similar between the subsamples. The existence of intersample differences would complicate hypothesis testing, since we would not be able to tell with certainty whether a difference is real, or due to some difference in socio-economic variables. The hypothesis we want to test for intersample differences is

$$H_0 : \mu_i^A = \mu_i^B = \mu_i^C = \mu_i^D$$

where i = household size, children per household, age, sex, education, membership and monthly gross income.

If we are unable to reject H_0 for any of the socio-economic variables i, we can proceed with making comparisons between mean WTP of subsamples A-D.

Testing the above hypothesis with Scheffé tests, we find no significant differences between the subsamples for household size, children per household, age, education, monthly gross household income and membership. However, we find a significant difference between subsamples C and D concerning the

in the distribution of *two* independent samples. As in the Kruskal-Wallis test, the values of the observations are replaced by ranks. The test statistic is the sum of ranks for each of the two groups (Norusis, 1993).

proportion of male respondents. It appears that there is an underrepresentation of men in subsample C compared with subsample D. However, since we have no hypothesis to test that requires a direct comparison between these subsamples, the practical implications of this difference are somewhat reduced.

3.5 Nonresponses

Failing to respond to a mail survey is an inexpensive strategy for the respondent, as he does not personally have to inform the interviewer about his decision. Therefore, the nonresponse rate is frequently higher in mail surveys than in personal or phone interview surveys (Whitehead, 1991). Since we received 888, more or less, usable answers, there were 612 nonresponses to our questionnaire. These nonresponses consist of non-returned unit nonresponses[15] (565), returned unit nonresponses (38) and reported absent (24). Included in the returned unit nonresponses are fifteen anonymously returned questionnaires. As we could not at any point identify and, therefore, remove anonymous respondents from our sample, it was inevitable that every anonymous respondent received two follow-up reminders. Consequently, there is a small possibility that we received more than one answer from some, or all, of the anonymous respondents. As we could not single out anonymous respondents, we have, in total, 627 nonrespondents.

The existence of nonresponses could lead to sample nonresponse bias and/or sample selection bias. Since no follow-up survey of the nonrespondents was carried out, the only information we have about the nonrespondents is their age, sex and place of residence. Naturally, some differences are bound to exist between respondents and nonrespondents - in this case the average age is higher and there are more women and urban residents among the nonrespondents (mean values). However, testing for equality of means between respondents and nonrespondents using two-sided t-tests, no significant differences can be found at the 5 percent level. Non-parametric tests at the 5 percent level (Mann-Whitney for age and chi-squared tests of proportions for sex and residence) further reinforce the conclusion that there are no significant differences between respondents and non-respondents.

Taking into consideration that the realised sample was fairly representa-

[15] Unit nonresponse occurs when the respondent fails to respond to all of the questions of the questionnaire.

tive for the Swedish population and that the nonrespondents did not significantly differ from the respondents in the variables common to both groups, we believe that it is reasonably safe to make value inferences.

4 Benefit Estimates

4.1 Mean and Median

In order to accomplish the first aim of our survey, we calculated mean and median WTP for the different subgroups (see Table 4). No explicitly stated *don't know* alternative was given as an option in the valuation question, even though this is recommended by Mitchell and Carson (1989) in order to lighten the task for respondents who are not able to conceptualise the amenity sufficiently to be able to value it. We believed it would be too easy a way out and chose to omit the alternative. Based on the answers to the valuation question, the data on WTP can be divided into five different categories; *positive values, zeros, don't knows, "bars"*[16] and *blanks*. The positive values and the zeros can be merged into a non-negative group, which consequently consists of responses with valid WTP values ranging between 0 and 5,000.[17] Altogether there were 37 different bids (including zero) given by the respondents, out of which 13 were given by only one respondent. Hence, there were clusters of bids, ranging from bids with two responses to bids with 202 responses (SEK 100). Some of the responses with zero WTP could be expected to be protest zeros, i.e. instead of stating his true WTP the respondent states a WTP of zero in objection to something in the scenario. We did not attempt to make a distinction between true zeros and protest zeros. An argument for maintaining all zeros is that hypothetical scenarios created in CV surveys are integral parts of the commodity being valued and it is, therefore, difficult to separate the value of the commodity from the way it is provided and paid for. No matter what scenario is created, there will most likely be some protest zeros, but they still reveal something about the respondents' reaction to the hypothetical scenario.

Altogether, there were 33 explicitly stated don't knows, 57 bars and 73 blanks in the returned questionnaires. The question is whether these re-

[16] A "bar" occurs if the respondent marks the area left for stating his WTP with just a stroke of his pen.

[17] There were 164 zeros in the raw data.

Table 4: Mean, median and confidence intervals (CI) for WTP1

Subsample	Mean	Median	CI (95%)	Cases
A	252.2	100	184.3 - 320.2	202
B	247.0	100	197.0 - 297.0	199
C	191.6	100	150.1 - 233.0	185
D	259.0	100	194.4 - 323.7	196
Total	238.2	100	209.6 - 266.8	782

sponses should be treated as missing values or zeros. There are at least four different ways of defining WTP, defined as WTP1-WTP4 (see Appendix C), depending on which observations are treated as missing values and zeros (a sensitivity analysis of the different definitions is performed below).

4.2 Sensitivity Analysis

Altogether, there were 725 nonnegative answers to the WTP question, corresponding to a response rate of 49.1 percent. In total, the item non-response to the WTP question was 18.4 percent. If the response to the WTP question was formulated as an interval, the midpoint of the interval was the registered answer. There were 13 observations with extremely high WTP, corresponding to 1.5 percent of the nonnegative answers. The range for these unusually high valuations is SEK 1,500-5,000. Even though the WTP question was formulated as an annual payment for all subsamples, we suspect that some of the respondents might have interpreted the question as a once-and-for-all payment, and thereby stated a higher WTP. These responses have ample effect on the mean WTP, but since there is no *a priori* agreed upon way to determine which responses to reject, every qualified attempt to identify outliers is to some extent *ad hoc*. However, setting up different criteria for rejection (Filter I and II) results in different mean estimates.

With all the observations included, WTP4 is the most conservative measure. As such, it gives a lower boundary for the WTP. If this measure is used the potential bias from sample self-selection is reduced. Based on different criteria, different observations are excluded when applying Filters I and II (see Appendix B for excluded observations). The reason behind the different filters was to get a "consistency edit" (Mitchell & Carson, 1989), i.e. to

Table 5: Sensitivity of overall annual mean WTP.

Cause	Median	Mean	Incl/excl (%)	$\Delta\overline{\text{WTP}}$	$\Delta\overline{\text{WTP}}$ (%)
WTP1 (Base case)	100	238.2	0	0	0
WTP2	100	228.6	+4.2	-9.6	-4.0
WTP3	100	257.0	-7.3	+18.8	+7.9
WTP4	100	209.8	+13.6	-28.4	-11.9
Filter I[a]	100	202.3	-1.7	-35.9	-15.1
Filter II[b]	100	217.2	-1.7	-21.0	-8.8

[a] Filter I: Cases with WTP>SEK 1,200 excluded from WTP1.

[b] Filter II: Cases with WTP$\geq$1% of Gross Annual Income excluded from WTP1.

control the effect on mean and median from the removal of certain observations. These removals were based on different criteria, deemed as logical in the context of the survey.

Naturally, both the subsample means and the overall mean are sensitive to how WTP is defined and to which observations are left out. However, the median is the same for all treatments. Consequently, the median seems to be a robust measure of a Swedish household's WTP for the preservation of the African elephant.

When testing the CV method's susceptibility to differential valuation stimuli below, we use the WTP1 definition where bars are treated as zeros and don't knows and missing values as missing values. Using this definition, the overall mean is found to be SEK 238, while the median is SEK 100 (see Table 4).

4.3 Existence Value Motives, Symbolic and Part-Whole Biases

When treating the responses to the WTP question as WTP1, there were 221 cases with WTP equal to zero. If the respondent stated a positive WTP he was asked the reasons for doing so. The respondents were given four prespecified motives - benefit through own experience, benefit through others' experiences, benefit through future generations and benefit through the existence of the elephant in its own right. The respondents were also free to

Table 6: Mean scores of different motives behind stated WTP.

Variable	Mean	Cases	% of WTP
Own experience	55.03	489	18
Others	56.79	481	18
Future generations	82.11	503	28
Existence value motive	86.40	510	30
Other motive	91.37	106	6

Note: Percent of WTP is based on weighted means of the total number of valid observations (517 cases).

state some other motive that made them willing to contribute to a project for preserving the African elephant (*Other motive*). The different motives were rated, not ranked, and the values allowed for each motive ranged between $0 - 100$, where $0 =$ *Of no importance* and $100 =$ *Very important*. That is, instead of forcing out a ranking where the respondent has to indicate which of the prespecified motives he considers to be the most important, the next most important, and so on, he was asked to judge, for each prespecified motive, how important that specific motive was for his valuation. Since the respondent might know which motive is the most important for him when stating a positive WTP, he might also know which motive is the least important for him. However, for the motives ranked in between, it could be difficult to make a clear distinction, and the resulting ranking could be rather *ad hoc*. We, therefore, preferred the rating system were all motives could have the same value for the respondent.

As can be seen in Table 6, the existence value motive obtained the highest mean score of the prespecified motives. Furthermore, there were most reported cases in this group. The most frequently stated *Other motive* was concern for ecological balance. It seems natural that the *Other motive* got the highest mean score, as it would be odd for a respondent to, of his own free will, state another reason for his WTP and then give it a low score.

The fourth column shows how much of the WTP that is driven by each of the different motives. If we rely on the median as the benefit estimate, we can see that SEK 30 out of SEK 100 is motivated by existence values. In a similar way, contingent valuation surveys of threatened Swedish species (Fredman, 1994; Boman & Bostedt, 1995) have found existence value motives

to be the most frequently stated motive behind the WTP.

Moreover, in the presence of existence value motives, we would like to examine the existence of *symbolic* and/or *part-whole* biases - different kinds of amenity misspecification biases (Mitchell & Carson, 1989). Symbolic bias occurs if the respondent reacts to symbolic factors and lets them interfere with the valuation of the good. The valuation stated by the respondent is, therefore, to a greater extent a measure of the strength of the feeling aroused by the question, rather than his valuation of the amenity. In our survey, a reflection of general environmental anxiety or concern for environmental issues could induce this kind of bias. Part-whole biases result if the respondents are not attentive to the specific description of the good offered in a CV survey, but respond to the good as a "global symbol". According to Mitchell & Carson (1989), a scenario that induces existence value motives could encourage symbolic responses if the respondents treat the amenity as representative of a much larger group of goods. That is, if the respondent in his mind is unable to isolate the African elephant from other wild animals in Africa, a larger class of goods is in fact being valued.

Since we presumed that the African elephant could have a symbolic value and be taken as a representative of a broader class of amenities, we wanted to examine whether our survey showed evidence of these kinds of biases. We, therefore, asked the question: " *What do you think of when you hear the words African elephant*?" (question 9, Appendix A). Our hypothesis was that we faced symbolic bias and/or part-whole bias if many respondents answered by naming other wild African animals, or by giving general notions of African nature.

Out of the 888 returned questionnaires, about 774 had given some answer to the question above. This is equivalent to an item non-response rate of almost 13 percent. The responses mainly focused on the typical characteristics of African elephant. *Huge*, *grey*, *tusks* and *big ears* were common remarks. Some people talked about ivory and poaching and others about safaris, circuses and zoos. Some 60 people mentioned the word *savannah* in their responses, which, in perspective of not being mentioned anywhere in the questionnaire, is rather astonishing. Furthermore, some (approximately 20) respondents talked in general terms about the steppe, jungle and wildlands. A few people (three) stated directly that the African elephant was a symbol for Africa and African wildlife. Even though not overwhelming, there is some evidence of symbolic and/or part-whole biases in our survey. In this case it would bias the valuation upward since the respondents, to some degree, value

something more inclusive and larger than intended.

5 Results from Experiments within the Survey

5.1 Testing for Intertemporal Embedding

In tests involving CV features, as in testing for treatment effects, two-sided tests may be called for. However, previous research and/or economic theory might give clues to the direction of the treatment effect. It is, therefore, both reasonable and efficient, to formulate one-sided hypotheses whenever possible.

In our survey we want to test whether the respondents discriminate between an annual payment obligation for three years and an equivalent commitment for ten years. That is, we want to see if the respondents perform the necessary discounting, and pay regard to the time-horizon of the payment obligation. If they do, the mean three-year annual payment (μ^B) ought to be larger than the mean ten-year annual payment (μ^C). Consequently, we want to test the hypothesis

$$H_0 : \mu^B - \mu^C \geq 0$$

against the alternative

$$H_A : \mu^B - \mu^C < 0.$$

The hypothesis was tested using a single-sided t-test, where H_0 was barely rejected at the 5 percent level. To see whether there are significant differences between WTP with explicitly stated time-horizons (subsamples B and C), and without specified time-horizon (subsample A), we test a second hypothesis

$$H_0 : \mu^A = \mu^B = \mu^C$$

This hypothesis can be tested using Scheffé and Kruskal-Wallis tests. None of these tests lead us to reject the null-hypothesis at the 5 percent level. Even though valuation is claimed to be context dependent, there seems to

be weak context-dependence in this case, since respondents show almost the same mean WTP no matter what time-horizon of the payment obligation.

Naturally, if the mean *present values* of the streams of payments are calculated and compared, the result is quite different. Since questions A and D lacked a specification of the time-horizon for the payment obligation, the choice of time period (n), in these subsamples, is rather *ad hoc*. However, our intention in leaving out the specification was to imply that the stated WTP was to be paid every year for an extended period of time (the respondents might even have perceived it as a once and for all payment). In these cases, it seems reasonable to use a time-horizon exceeding ten years, which was the highest prespecified time-horizon. We argue that most people find 15-25 years to be quite a long time and, accordingly, we calculate present values of subsamples A and D based on $n = 15, 20$ and 25. Another question relevant to present value calculations, is what discount rate (r) to use. In short, the differences between the present values of the different means are reduced the higher the discount rate and the shorter the time-horizon employed.

When discounting the WTP of the different subsamples with varying discount rates ($r = 1\%, 3\%, 5\%, 10\%, 15\%$ and 20%) and different values of n, and testing for significant differences in the means using Scheffé tests, we found significant differences, at the 5 percent level, between the subsamples without a specified time-horizon (A and D) and the subsample with the shortest time-horizon (three years), B, no matter what r and n were used. The means of the present value calculations of the WTP of subsample A and D are much larger than the comparable means from subsamples B and C, primarily following the use of a larger n. On the whole, it seems as though the total estimated WTP increases with the number of times the respondent is asked to pay. Since respondents do not seem to perform any discounting, CV valuations are vulnerable to the specification of the time-horizon of the payment obligation.

5.2 Testing for Differences in Payment Vehicle

Payment vehicle bias is present when either the mean willingness to pay or the number of protest zeros varies significantly with the choice of payment vehicle (Cummings et al., 1986). Studying Table 4, we can see that the mean willingness to pay from the tax alternative is slightly larger than the mean from a voluntary payment, while the medians are equal. The number of zeros in the tax alternative is 66, and in the voluntary vehicle 61. Hence,

there is no great difference. Furthermore, there was no noticeable difference between the number of negative comments in the "feedback" section of the questionnaire, regardless of whether it was a tax or a voluntary payment.

Based on the economic theory of section 2.1.2, we hypothesised that

$$H_0 : \mu^A - \mu^D \geq 0$$

$$H_A : \mu^A - \mu^D < 0.$$

That is, is the WTP larger when being asked to donate voluntarily than when being asked to pay a tax?

Since the mean WTP from the tax vehicle proved to be *larger* than the mean WTP from the voluntary vehicle, the hypothesis was immediately rejected. An explanation for the anomalous outcome is that a tax could be perceived as more equitable, as it would be paid by everybody in Sweden. As a matter of fact, we were unable to detect *any* significant differences between the WTP resulting from the different payment modes.

The conclusion from our experiments with regard to the type of payment vehicle used, is that respondents do not discriminate between different methods of payment.

6 Discussion

The research reported here has three objectives: to estimate the Swedes' willingness to pay for the preservation of the African elephant, to see whether the WTP is sensitive to intertemporal embedding and to examine if the WTP is affected by the payment vehicle used.

The overall mean WTP is found to be SEK 238 annually, while the overall median WTP is SEK 100 annually. The means from the different treatments (A-D) range between SEK 192 - 259 per year. In every subsample the median is found to be SEK 100.

None of the different treatments can be shown to have a significant impact on the WTP, i.e. no distinction is made between different time-horizons for the payment obligation or between different payment vehicles.

The most alarming of these findings is that respondents are willing to pay the same amount every year, regardless of the time-aspect of their commitment. This result indicates that CVM is vulnerable to manipulations of the

time specification of the payment obligation, and that respondents do not perform any discounting.

In our survey, we are unable to prove that valuation is context dependent, as the WTP is highly insensitive to differences in the valuation scenario. Since it seems as though much time and effort must be spent on making certain that the respondent understands important aspects of the hypothetical scenario, mail surveys are probably not appropriate for CV surveys, if the results are to be reliable.

It could be deemed objectionable to put a price on a single species, such as the African elephant, since it is a small part of a large and important ecosystem. The part a single species plays in an ecosystem is hard to tell exactly, but the elimination of an entire ecosystem would clearly have greater cost to society than the elimination of a single species. As there is some evidence of symbolic and part-whole biases in our survey, we, in order to be conservative, interpret the WTP as a lower boundary for African flora and fauna, instead of merely the WTP for the African elephant. Even though gross values based on the median do not have the same, natural, interpretation as gross values based on the mean (Kriström, 1990), we adhere to the median-voter theorem and assume that a payment of SEK 100 per household would pass in a referendum. Aggregating over all Swedish households, a lower bound for the preservation of African flora and fauna is found to be SEK 383 million (US$ 53.7 million) annually. Thus, there is a substantial valuation of goods peripheral to Swedes.

Appendix A: The Questionnaire

Translated version of the introductory letter and the questionnaire (version A).

Appendix B:

Table B1: Extreme observations (ID) excluded from the calculations of mean and median WTP. Exclusion based on $WTP > 1,200$.

ID	12	313	316	388	422	452	512
WTP	1,500	5,000	2,000	1,500	1,800	3,000	2,000
ID	566	611	633	739	866	876	
WTP	2,500	3,500	1,500	2,500	1,900	2,000	

Table B2: Extreme observations (ID) excluded from the calculations of mean and median WTP. Exclusion based on $WTP \geq 1\%$ of gross annual household income (AGI).

ID	36	86	144	313	324	354	422
WTP	500	500	1,000	5,000	1,200	500	1,800
AGI	30,000	30,000	75,000	255,000	105,000	30,000	135,000
ID	452	493	569	611	704	849	
WTP	3,000	500	1,000	3,500	500	300	
AGI	225,000	30,000	75,000	285,000	30,000	30,000	

Appendix C:

Table C1: Definitions of the WTP.

Variable	Definition
WTP1	Bars=0, Don't knows=missing and Missing=missing.
WTP2	Bars=0, Don't knows=0 and Missing=missing.
WTP3	Bars=missing, Don't knows=missing and Missing=missing.
WTP4	Bars=0, Don't knows=0 and Missing=0.

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Determinants of Charitable Giving. Evidence from Hypothetical Data on Willingness to Pay*

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Abstract

The determinants of charitable giving at the household level are studied in a discrete/continuous choice model. Based on data from a contingent valuation survey of Swedish households' willingness to pay for the preservation of the African elephant, a double hurdle model is estimated with Heckman's two-step estimator. The determinants of the choice to give are found to be different from the determinants of the size of the donation.

Key words: Voluntary Giving, Double Hurdle Model.

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1 Introduction

In the discipline of economics there exists a special kind of human being; *homo economicus* - the economic man, characterised by egocentricity and utility maximising behaviour. However, in some real life circumstances the traditional theory of rational, selfish behaviour is too narrow to account for actual behaviour. For instance, in the case of publicly supported nongovernmental organisations, theory dictates that they cannot exist, since free-riding would be the rational behaviour of every economic man. But such organisations do exist, and their existence can be said to be a "public goods paradox" (Margolis, 1982, p.19).

As theory falls short of reality, a relevant question is why this paradox appears. One explanation - which suits economists - is that the individual (or household) gains utility from the act of giving, i.e. the individual has altruistic[1] preferences. Presumably, there are many factors influencing the decision to give; social pressure, guilt, sympathy, desire for "warm glow" feeling etc., and we are interested in studying why some people have a greater propensity to give than other.

The aim of this paper is to examine whether the factors affecting the decision to give at the *extensive* margin (i.e. the decision whether to give or not) are different from the factors affecting the decision to give at the *intensive* margin (i.e. how much to give). Based on hypothetical data from a contingent valuation survey of Swedish households' willingness to pay (WTP) for the survival of the African elephant, we estimate a model for the decision to give and the size of the donation by means of a double hurdle model. In such a model, the household must pass two hurdles before being observed with a positive WTP for elephant protection, where the first hurdle is the contribution decision (whether to give or not) and the second hurdle is the expenditure decision (how much to give). Hence, the variables that affect the decision to give are allowed to be different from the variables that affect the size of the donation.

The remainder of this paper is organised as follows; the next section describes the data, section three provides the theoretical framework for discrete/continuous choice models, section four discusses different models for charitable giving, and section five describes estimation procedures and re-

[1] Altruism is defined as acts that affect the utility of other people, or society, with the qualification that the actor/donor (not necessarily the recipient) regards his behavior as beneficial (Margolis, 1982).

sults from the empirical analysis. In section six, model assumptions are tested, and, finally, section seven discusses and summarises the results.

2 The Data

Data on WTP were collected through a contingent valuation (CV) survey during January-March 1996. A mail questionnaire was sent to 1,500 randomly selected Swedish residents. Apart from the open-ended valuation question, the questionnaire contained socioeconomic questions and questions regarding the respondent's interest in the natural environment in general and in the African elephant in particular. The overall response rate was 60.2% (Vredin, 1997).

Apart from estimating the Swedes' annual WTP for the African elephant, the survey also addressed some methodological issues associated with the CV method, such as the method's susceptibility to differential valuation stimuli. In order to carry out a number of experiments, the total sample was split in four equally sized groups, where respondents were randomly assigned one of four different treatments. Small variations in elements of the scenario regarding the time-horizon of the payment obligation and the payment vehicle, meant that each subgroup received a slightly different valuation question. In three of the different subgroups the payment vehicle was a voluntary donation. Although hypothetical, a positive WTP in response to one of these questions reveal a positive willingness to make a charitable donation. The fourth subgroup received a valuation question where the payment vehicle was in the form of a tax. Obviously, a tax could be perceived as more compulsory than a voluntary payment. However, since the respondents were free to refuse to pay, a positive WTP in this case may also be interpreted as a willingness to make a voluntary contribution. Therefore, we use annual household WTP as the dependent variable and dummy variables to account for differences between subgroups in the estimation.

The open-ended valuation question used to elicit the respondent's preferences generated data ranging between zero and 5,000 Swedish kronor (SEK). The median WTP was SEK 100 in every subsample.[2]

[2] Admittedly, data on WTP were not collected in a two-step fashion, although modelled as such below. However, we believe it reasonable to assume that respondents with positive WTP would give an affirmative answer to a question (assumed to precede the valuation question) asking about the existence of WTP, whereas a respondent with zero, or negative,

Table 1: Summary statistics for contributors and noncontributors.

	Contributors		Noncontributors	
	Mean	St dev	Mean	St dev
WTP (SEK)	332	448	0	0
Income (SEK)	24,825	13,210	19,712	12,341
Age (years)	41	14	50	16
Education (years)	12	3	11	3
Membership	0.23	0.42	0.09	0.28
n	561		221	

Note: WTP and income variables are based on household measures. Membership is a dummy variable indicating membership of environmental organisations.

Table 1 gives summary statistics for the contributors and the noncontributors.

3 Discrete and Continuous Choice

In order to examine whether the zeros and positive answers are generated by different processes, and if the decision to give at the extensive margin is influenced in different ways by the same set of explanatory variables as the decision to give at the intensive margin, we need a model that first allows us to analyse the determinants of the decision to give, then allows us to examine the determinants of the size of the donation.

Models for discrete and continuous choices have been used to analyse behaviour in many different markets; the demand for urban travel modes (Domencich & McFadden, 1975), the demand for housing (Lee & Trost, 1978), the demand for electric appliances and electricity consumption (Dubin & McFadden, 1984) and the choice of shopping destination and shopping expenditures (Barnard & Hensher, 1992). The following general model for a household's discrete choice between charities and its continuous choice of how much to spend is based on Hanemann (1984), Dubin and McFadden (1984), and Barnard and Hensher (1992).

WTP would give a negative answer.

A representative household (suppressing indexation) can be assumed to maximise the (deterministic) utility function:

$$\max_{\mathbf{c},s} u = u(\mathbf{c}, s; \mathbf{x})$$

subject to

$$\begin{aligned} y &= \mathbf{p}'\mathbf{c} + s \\ \mathbf{c} &\geq \mathbf{0} \\ s &> 0 \end{aligned}$$

$\mathbf{c}$ is a $Q \times 1$ vector of charities, s a Hicksian composite good condensing the consumption of ordinary goods, $\mathbf{x}$ is a vector of household specific characteristics, $\mathbf{p}$ is a $Q \times 1$ price vector for charities and y is household income.[3] The utility function is assumed to be quasiconcave and increasing in $\mathbf{c}$ and s.

A simplifying assumption is that the household views different charities essentially as substitutes and, therefore, chooses to consume only *one* kind of charity. Consequently, the household consumes ordinary goods and a single charity, implying that one of the c's is positive, while the rest are zero.

In solving the utility maximisation problem, the household can be regarded as solving a two-stage maximisation process, with first a discrete, then a continuous choice. The discrete part of the problem relates to which of the charities chosen, while the continuous part relates to the magnitude of the donation.

If we assume that charity j is chosen, $c_j > 0$ and $c_i = 0$ for all $i \neq j$. Consequently, the household's maximisation problem can be redefined as:

$$\max_{c_j,s} u_j = u_j(c_j, s_j; \mathbf{x})$$

subject to

$$y = p_j c_j + s_j$$

and the relevant nonnegativity restrictions. Conditional on the choice of charity j, the solution of this problem yields a conditional demand function for the household's purchase of the charity:

$$c_j^* = c_j^*(p_j, y; \mathbf{x}).$$

[3] Since giving to charities is assumed to be voluntary, there are no conventional prices for charities. Consequently, the price for charities can be normalised to one, i.e. buying a unit of charity cost one. Moreover, the price for charities and the income has been normalised by the price of the Hicksian commodity.

Associated with the conditional demand function is a conditional indirect utility function, which defines the maximum attainable utility level, conditional on the choice of charity j:

$$v_j^* = u_j^*(c_j^*, s_j^*; \mathbf{x}) = v_j^*(p_j, y; \mathbf{x}).$$

The household will choose charity j if:

$$v_j^*(p_j, y; \mathbf{x}) > v_i^*(p_i, y; \mathbf{x}), \text{ for all } i \neq j.$$

That is, the household will choose charity j if it generates the highest conditional indirect utility. The conditional indirect utility function will be used in modelling the discrete choice part of the problem.

In modelling the continuous part, we will use the conditional demand function obtained by Roy's identity (Varian, 1992):

$$c_j^*(p_j, y; \mathbf{x}) = -\frac{\partial v_j^*/\partial p_j}{\partial v_j^*/\partial y}, \tag{1}$$

to define a "charity expenditure function" (d_j^*):[4]

$$d_j^* = p_j c_j^*(p_j, y; \mathbf{x}). \tag{2}$$

Equations (1) and (2) link the choice of charity and the sequential choice of expenditure level.

Although the utility function is deterministic for the individual household it contains elements that are unobservable to the researcher. We now introduce a random term to explain why two identical households (with regard to background characteristics) make different choices between charities. There might, for instance, be unobservable household factors or charity attributes that affect the household's choice. All these unobservable elements are collected in an error term. Thus, allowing for randomness, we may specify the conditional indirect utility function and the expenditure function associated with charity j and household n as:

$$v_{jn}^* = \overline{v}_{jn}\ (p_j, y_n; \mathbf{x}_n) + \varepsilon_{jn} \tag{3}$$

$$d_{jn}^* = p_j c_{jn}^*(p_j, y_n; \mathbf{x}_n) + u_{jn}. \tag{4}$$

[4]Note that this is *not* the conventional expenditure function in microeconomic theory, i.e. the inverse of the indirect utility function, but merely a price-times-quantity function.

$\bar{v}_{jn}$ is the deterministic part of the conditional indirect utility function, while ε_{jn} and u_{jn} are the error terms. Since the error terms are added to the functions, they are treated outside the utility theoretical framework (for an integrated approach, see Hanemann, 1984).

In order to simplify the estimations, we have chosen a form for $\bar{v}_{jn}$ that gives a linear charity expenditure function. A family of functions that satisfy this requirement can, following Dubin and McFadden (1984), be expressed as[5]:

$$\bar{v}_{jn} = f_1 \left[f_2(p_j, y_n; \mathbf{x}_n) e^{-\beta p_j} \right]$$

where f_2 is linear in its arguments. Assuming a specific form of $\bar{v}_{jn}$:

$$\bar{v}_{jn} = \left[\alpha_0^j + \frac{\alpha_1^j}{\alpha_2^j} + \alpha_1^j p_j + \alpha_2^j y_n + \mathbf{x}_n' \boldsymbol{\gamma}^j \right] e^{-\alpha_2^j p_j} \tag{5}$$

generates the nonstochastic part of the charity expenditure function, $\bar{d}_{jn} = p_j c_{jn}^*$:

$$\bar{d}_{jn} = p_j(\alpha_0^j + \alpha_1^j p_j + \alpha_2^j y_n + \mathbf{x}_n' \boldsymbol{\gamma}^j), \tag{6}$$

where α_0^j, α_1^j and α_2^j are parameters, while $\boldsymbol{\gamma}^j$ is a vector of parameters.

Assuming that there are Q charities for the household to choose between, estimation requires data on household expenditures on each and every one of the Q charities. Since we have systematic missing data for expenditures on charities other than elephant protection, we only attempt to estimate a partial demand system. Specifically, as our data only permit the analysis of *one* charity, the household's choice between different charities is reduced to the choice between elephant protection and an alternative charity (or no charity at all).

[5] According to Dubin & McFadden (1984), any function $v(.)$ that has the necessary and sufficient properties of an indirect utility function can be used when constructing functional forms for discrete/continuous choice models. In order to represent a valid indirect utility function, $v(.)$ must be non-increasing in prices and non-decreasing in income, continuous in prices and income, quasi-convex in prices and homogenous of degree zero in prices and income. Since charities have no conventional prices, it is not possible to test for the price properties. However, Dubin & McFadden (*ibid.*) found their functional form to be consistent with economic theory.

4 Models for Charitable Giving

Considering the characteristics of the data produced in the CV survey (the dependent variable is nonnegative, where zero is a common and meaningful value), Tobit analysis might be the obvious choice when analysing the determinants of charitable giving. However, the Tobit model is very restrictive. For instance, in the Tobit model a variable that increases the probability of a positive observation also increases the conditional mean value. In some cases it is more likely that the effects are the opposite. For example, the probability of a building catching fire and the consequential loss due to the fire both depend on the age of the building, but in contrary directions (Lin & Schmidt, 1984). Furthermore, in Tobit analysis all zeros are regarded as corner solutions. Thus, the Tobit model does not recognise that there may be different processes behind the participation (contribution) and the consumption (expenditure) decisions. For example, for non-smokers and teetotallers, the non-consumption of cigarettes and alcohol is frequently the result of medical or social principles and not economic decisions (Pudney, 1989, ch. 4). Since such non-consumption do not represent ordinary corner solutions (no prices or income would induce the individuals to consumption), there is reason to examine whether zeros and positive answers are generated by two different processes.

Considering the limitations of the Tobit model, we need a less restrictive model. Such a model can be found in the family of double hurdle models, where models differ from each other depending on the assumptions made about the dependence between, and the relative importance of, the different processes (cf. Jones, 1989, for an overview).

We give a brief exposition of a subset of possible double hurdle models. First, independence between the two different processes results in the *Cragg* model (Cragg, 1971). In the Cragg model, the zeros are assumed to be qualitatively different in that there are true zeros and ordinary corner solutions.[6] When specified as in Lin and Schmidt (1984)[7], the Cragg model nests the Tobit. Consequently, a likelihood ratio (LR) test between the two models

[6] The qualitative difference between true zeros and corner solutions usually arises from non-observability and the surveying method. For instance, surveying households' purchases of meat a specific day will most likely produce some zeros. Out of these zeros, a few households are likely to be vegetarians (true zeros), while others, have a positive demand for meat even though we do not observe it the particular day of investigation.

[7] Based on Equations (7) and (8), p. 831, in Cragg, 1971.

will determine whether charitable giving is best modelled by a single equation or a double hurdle model. When estimating the Cragg model (even though it is incompatible with the theoretical model outlined in section 3)[8] on our data (see Appendix A for explanatory variables and Appendix B for results), the likelihood function was very flat, however increasing, in the standard deviation parameter (σ_{tr}), so that convergence was difficult. Nonetheless, fixing this parameter at the Tobit estimate of the standard deviation (σ_t), we are able to perform a LR test where the Tobit model is strongly rejected.[9] Hence, we have evidence on the appropriateness of modelling the problem in two parts.

The Cragg model's assumption of independence between the contribution and the expenditure decisions might seem unrealistic. Correlation of the error terms may, for instance, result from uncertainty about the functional form of the conditional indirect utility function since there may be unobservable factors that increase the household's probability of giving (e.g. household benevolence, compassion etc.), which also increase the amount donated by the household. Therefore, assuming dependence and that the contribution decision "dominates" the expenditure decision so that only those with WTP > 0 are modelled in the charity expenditure function, results in a *first hurdle dominance* model. In this model zeros and positive values are generated by different processes. The first hurdle dominance model corresponds to Heckman's sample selection model (Heckman, 1979), which may be estimated either by maximum likelihood (ML) or by a two-step estimator.

Furthermore, if the expenditure decision dominates the contribution decision *and* independence is assumed between the two decisions, the *complete dominance* model follows. This simplifies to a probit for the contribution and an ordinary least squares (OLS) for the charity expenditure function.

With the more realistic assumption of dependence between the two decisions, and, with our data on WTP, where corner solutions are unlikely due to the survey design, we base our empirical analysis on the first hurdle dominance model where all zeros are treated as true zeros.[10]

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[8] In the theoretical model of section 3, giving to elephant protection is *defined* by $c_j > 0$ (charity j represents elephant protection). Since there is no minimum price for c_j, it seems unlikely that a respondent would agree to give to elephant protection (pass the first hurdle) and then state a zero bid. Corner solutions for elephant protection are, therefore, implausible.

[9] LR test statistic: 126.75 (p-value < 0.000).

[10] However, protest zeros would produce corner solutions.

5 Estimation and Empirical Results

In order to reduce estimation complexity, we make the standard assumption that ε_{jn} and u_{jn} in Equations (3) and (4) are bivariate normally distributed with correlation ρ, i.e. $(\varepsilon_{jn}, u_{jn}) \sim$ bivariate normal $(0, 0, 1, \sigma_u, \rho)$. Only in the case where ρ is zero, is there independency between ε_{jn} and u_{jn}, and the discrete and continuous parts of the model may be estimated separately (if, indeed, $\rho = 0$, the parameters are more efficiently estimated separately, without the correction term).

The parameters of this model can be estimated with ML. A consistent alternative two-step procedure, following Heckman (1979), is, however, simpler, albeit less efficient (Greene, 1993, ch. 22). In this procedure, a probit model is estimated for the decision to give and a linear regression model for the charity expenditure function.

If we only have *two* different charities, i and j, we may represent the households' discrete choices of charity j by a binary valued index function, $I_{j1}, ...I_{jN}$, where $I_{jn} = 1$ if elephant protection is chosen and $I_{jn} = 0$ if it is not.[11] Hence, we may write:

$$I_{jn}(p, y; \mathbf{x}) = \begin{cases} 1 \text{ if } v^*_{jn}(p_j, y; \mathbf{x}) > v^*_{in}(p_i, y; \mathbf{x}) \\ 0 \text{ otherwise.} \end{cases}$$

With randomness included in the model, the probability that household n will choose charity j is equal to:

$$\Pr\left[I_{jn} = 1\right] = \Pr\left[\overline{v}_{jn} + \varepsilon_{jn} > \overline{v}_{in} + \varepsilon_{in}\right].$$

Hence, the household will give a positive amount to charity j if $\overline{v}_{jn} - \overline{v}_{in} > \varepsilon_{in} - \varepsilon_{jn}$.

Substituting the expressions for $\overline{v}_{jn}$ and $\overline{v}_{in}$ with the relevant forms of Equation (5), and, as the prices for charities i and j are unobservable, we may express the probability on the reduced form:

$$\Pr\left[I_{jn} = 1\right] = \Pr\left[\varepsilon_{in} - \varepsilon_{jn} < \quad \widetilde{\alpha}_0 + y_n(\widetilde{\alpha}^j_2 - \widetilde{\alpha}^i_2) + \mathbf{x}'_n(\widetilde{\boldsymbol{\gamma}}^j - \widetilde{\boldsymbol{\gamma}}^i)\right], \qquad (7)$$

where $\widetilde{\alpha}_0 = (\alpha^j_0 + \alpha^j_1/\alpha^j_2 + \alpha^j_1 p_j)\exp(-\alpha^j_2 p_j) - (\alpha^i_0 + \alpha^i_1/\alpha^i_2 + \alpha^i_1 p_i)\exp(-\alpha^i_2 p_i)$, $\widetilde{\alpha}^j_2 = \alpha^j_2 \exp(-\alpha^j_2 p_j)$, $\widetilde{\alpha}^i_2 = \alpha^i_2 \exp(-\alpha^i_2 p_i)$, $\widetilde{\boldsymbol{\gamma}}^j = \boldsymbol{\gamma}^j \exp(-\alpha^j_2 p_j)$ and $\widetilde{\boldsymbol{\gamma}}^i = \boldsymbol{\gamma}^i \exp(-\alpha^i_2 p_i)$.

[11] In the empirical estimations, $I_{jn} = 1$ if the respondent has reported a positive WTP and $I_{jn} = 0$ if the respondent has reported a zero WTP or a "bar" (a "bar" occurs if the respondent marks the area left for stating his WTP with just a stroke of his pen).

To further simplify notation, let $\eta_{ijq} = \varepsilon_{in} - \varepsilon_{jn}$, $\tilde{\alpha}_2^{ji} = \tilde{\alpha}_2^{j} - \tilde{\alpha}_2^{i}$ and $\tilde{\boldsymbol{\gamma}}^{ji} = \tilde{\boldsymbol{\gamma}}^{j} - \tilde{\boldsymbol{\gamma}}^{i}$ and define the parameter vector, $\boldsymbol{\theta} = (\tilde{\alpha}_0, \tilde{\alpha}_2^{ji}, \tilde{\boldsymbol{\gamma}}^{ji\prime})'$ and a vector of exogenous variables, $\mathbf{z}_n = (1, y_n, \mathbf{x}_n')'$. Equation (7) may now be expressed as:

$$\Pr[I_{jn} = 1] = \Pr\left[\eta_{ijq} < \mathbf{z}_n'\boldsymbol{\theta}\right]. \tag{8}$$

Maximum likelihood estimates of the parameters in (8) are obtained by maximising

$$\ln L = \sum_{n=1}^{N} \left[I_{jn} \ln \Phi\left(\mathbf{z}_n'\boldsymbol{\theta}\right) + (1 - I_{jn}) \ln\left(1 - \Phi\left(\mathbf{z}_n'\boldsymbol{\theta}\right)\right)\right]$$

with respect to $\boldsymbol{\theta}$. Here, $\Phi(.)$ is the standard normal cumulative distribution function.

Using the observed data on household expenditure to estimate the parameters of the charity expenditure function (6) with OLS generally produces inconsistent estimates since $E(u_{jn}) \neq 0$. This can be seen in the following expression:

$$\begin{aligned} E(d_{jn}^* \mid I_{jn} = 1) &= p_j(\alpha_0^j + \alpha_1^j p_j + \alpha_2^j y_n + \mathbf{x}_n'\boldsymbol{\gamma}^j) + E(u_{jn} \mid \eta_{ijq} < \mathbf{z}_n'\boldsymbol{\theta}) \\ &= \beta_0 + \beta_1 y_n + \mathbf{x}_n'\boldsymbol{\varphi} + \beta_\lambda \lambda_n, \end{aligned}$$

where $\beta_0 = \alpha_0^j p_j + \alpha_1^j p_j^2$, $\beta_1 = \alpha_2^j p_j$, $\boldsymbol{\varphi} = \boldsymbol{\gamma}^j p_j$, $\beta_\lambda = \rho\sigma_u$ and $\lambda_n = \phi(\mathbf{z}_n'\boldsymbol{\theta})/\Phi(\mathbf{z}_n'\boldsymbol{\theta})$, the Heckman correction term where $\phi(.)$ is the standard normal density function.

Hence, unless, $\rho = 0$, the OLS estimator is inconsistent. To produce consistent estimates, λ_n can be estimated from the probit estimates from the first step to compute the Heckman correction term $\hat{\lambda}_n = \phi(\mathbf{z}_n'\hat{\boldsymbol{\theta}})/\Phi(\mathbf{z}_n'\hat{\boldsymbol{\theta}})$. Subsequently, we can estimate

$$d_{jn}^* = \beta_0 + \beta_1 y_n + \mathbf{x}_n'\boldsymbol{\varphi} + \beta_\lambda \hat{\lambda}_n + \xi_{jn} \tag{9}$$

with OLS. Here, $E(\xi_{jn}) = 0$ since $\xi_{jn} = d_{jn}^* - E(d_{jn}^* \mid I_{jn} = 1)$.[12] The results from this first hurdle dominance model estimated with Heckman's two step estimator are given in Table 2 (see Appendix A for a description of the explanatory variables).

[12] However, the variance, $V(\xi_{jn})$, is heteroscedastic (cf. Greene, 1993, ch. 22).

6 Testing Model Assumptions

In order to evaluate the quality of the model, it is important to determine the validity of the model assumptions. When estimating the first hurdle dominance model with the Heckman two- step estimator, bivariate normality is assumed. Pagan and Vella (1989) devise a conditional moment test for bivariate normality, based on a squared power series expansion around the baseline bivariate normal density.[13] A simple way to perform the test is to add three variables, calculated as $\hat{\lambda}_n \ (\mathbf{z}_n' \ \hat{\boldsymbol{\theta}})^k$, $k = 1, 2, 3$, to Equation (9). If the coefficients of these variables jointly are zero, we cannot reject the assumption of bivariate normality. An F-test for this restriction has the value 1.01, which is insignificant at any conventional level of significance.

Given bivariate normality, the insignificance of the Heckman correction parameter, β_λ, implies that we are unable to reject the hypothesis of independence between the error terms, ε_{jn} and u_{jn}. Consequently, the discrete and continuous parts of the model may be estimated separately, which indicates that the decision to give at the extensive margin is independent of the decision to give at the intensive margin. However, when estimating such complete dominance model to get a more efficient estimator, a Breusch-Pagan test (BP) cannot reject heteroscedasticity (see Table 2).[14] Since the first hurdle dominance model is inherently heteroscedastic, the BP test speaks in favour of this model.[15]

7 Conclusions

The aim of this paper is to find determinants of charitable giving. In order to do that, a two-step model for discrete/continuous household choices is developed, where the household first confronts the dichotomous choice of giving versus not giving to elephant protection, then, conditional on the decision to give, confronts the problem of how much to give. Based on the

[13] For technical details, see Gallant and Nychka (1987).

[14] Test statistic: $\chi^2 = 322.17$ with 17 degrees of freedom.

[15] Due to Heckman's correction term, multicollinearity problems in the linear regression part of the first hurdle dominance model are not uncommon. Here, however, the R^2 and the significance of explanatory variables do not indicate severe multicollinearity. Furthermore, when estimating the OLS part of the complete dominance model, we get almost the same results as in the OLS part of the first hurdle dominance model (see Table 2).

hypothetical CV data on the Swedes' willingness to pay to protect the African elephant, the model is estimated using Heckman's two-step procedure.

As can be seen from Table 2, the variables that increase the probability of giving at the five percent level are; household income, membership of environmental organisations, a dummy variable indicating that the respondent thinks that it is very important that the elephant exists in Africa (IMPDUM), and a dummy variable indicating that the respondent would like to see an increase in the herd of elephants in the future (FUTDUM). The probability decreases with the square of income.

Determinants of the size of the donation are, at the five percent significance level, age and the square of age. The negative sign of the age parameter is consistent with previous empirical CV findings (Carson, 1995), while the positive sign of the square of age indicates that the amount given decreases at a decreasing rate. A variable indicating that the respondent had visited Africa prior to receiving the questionnaire (POSTVIS) and the membership dummy both affect the size of the donation at the ten percent level. While the amount given increases with POSTVIS, it decreases with membership of an environmental organisation.

Hence, membership is the only variable that, at any conventional level of significance, effects both the extensive and the intensive margin of the decision to give. While membership of an environmental organisation increases the probability of giving, it decreases the amount given. Perhaps members to environmental organisations feel that they already have paid their fair share when paying the membership fee and are, therefore, less inclined to donate large amounts of money.

The dummy variables for the different treatments (QB-QD) are all insignificant, indicating that none of the treatments has significant impact on the willingness to pay - a result that reinforces earlier findings (Vredin, 1997).

While some of the variables are statistically significant, we still have to consider the economic relevance of these parameter estimates. The more interesting part to study is then how the size of the donation is affected by the explanatory variables. From the results of the OLS part of the first hurdle dominance model in Table 2, we see that the *unconditional* (on the decision to give or not*)* mean WTP, $E[d_{jn}^{*}]$, increases with SEK 188 if the respondent has visited Africa prior to receiving the questionnaire, whereas it decreases with SEK 145 if the respondent is a member of an environmental organisation. The unconditional mean WTP also decreases with the age of

the respondent, i.e. by SEK 24 per year.[16]

Contrary to the reasoning in Pudney (1989, ch. 4), the decision to give seems to be more of an economic decision than a decision based on other principles since income is significant for the decision to give, whereas it is insignificant for the expenditure decision. Thus, in order to voluntarily contribute to elephant protection, the household needs to have some surplus financial resources. On the other hand, the decision on how much to give is not affected by income and is therefore less of an economic decision.

Overall, considering the type of amenity valued, these variables seem to be reasonable predictors of the decision to give and of how much to give. Apart from income, we find that the driving force behind the willingness to pay for elephant protection is merely some kind of interest in elephants. As the determinants of giving to elephant protection seem reasonable, the results of this paper enhance the reliability of the benefit estimates from the CV survey, notwithstanding its hypothetical nature.

[16] The corresponding figures for the *conditional* mean WTP, $E[d^*_{jn} \mid I_{jn} = 1]$, are SEK 190 if the respondent had been to Africa prior to receiving the questionnaire and SEK 53 if the respondent is a member of an environmental organisation. Furthermore, the conditional mean WTP decreases by SEK 24 with the age of the respondent. Thus, the largest change in the marginal effects between conditional and unconditional values is due to membership. Since membership positively affects the probability of giving, it also affects WTP through its presence in the Heckman's correction term.

Appendix A

Appendix B

Under the normality assumption, the log likelihood for the Tobit model ($\ln \ell_t$) is given by:

$$\ln \ell_t = \sum_{n=1}^{N} \left\{ (1 - I_n) \ln \left[\Phi(-\mathbf{z}_n' \boldsymbol{\beta}/\sigma) \right] + I_n \left[-\frac{1}{2} \ln(2\pi\sigma^2) - \frac{1}{2\sigma^2} (y_n - \mathbf{z}_n' \boldsymbol{\beta})^2 \right] \right\},$$

where I_n is an indicator variable with value 1 if (willingness to pay) $y_n > 0$ and zero otherwise, $\mathbf{z}_n$ is a vector of explanatory variables, $\boldsymbol{\beta}$ the corresponding parameter vector and $\Phi(.)$ the standard normal cumulative distribution function.

The log likelihood for the Cragg model ($\ln \ell_c$) is given by:

$$\ln \ell_c = \sum_{n=1}^{N} \left\{ (1 - I_n) \ln \left[\Phi(-\mathbf{z}_n' \boldsymbol{\beta}_1) \right] + I_n \begin{bmatrix} \ln \Phi(\mathbf{z}_n' \boldsymbol{\beta}_1) - \ln \Phi(\mathbf{x}_n' \boldsymbol{\beta}_2/\sigma) \\ -\frac{1}{2} \ln(2\pi\sigma^2) - \frac{1}{2\sigma^2} (y_n - \mathbf{x}_n' \boldsymbol{\beta}_2)^2 \end{bmatrix} \right\},$$

where $\mathbf{z}_n$ is a vector of explanatory variables used to explain the probability of a limit observation, i.e. $y_n = 0$ with $\boldsymbol{\beta}_1$ as the corresponding parameter vector, $\mathbf{x}_n$ is a vector of explanatory variables used to explain the non-limit observations with $\boldsymbol{\beta}_2$ as the corresponding parameter vector. Specified like this, the log likelihood function is a combination of a probit and a truncated regression model. Consequently, the Cragg model may be estimated in two parts, a probit part and a truncated regression part.

When $\beta_1 = \beta_2/\sigma$ and $\mathbf{z}_n = \mathbf{x}_n$, the Tobit model follows from the Cragg model. Since the models are nested, a likelihood ratio (LR) test between the models could be performed.[17] In both the Tobit and the truncated regression part of the Cragg model, we estimate the standard deviations (defined as σ_t, for the Tobit model and σ_{tr} for the Cragg model). However, the log likelihood function was very flat in σ_{tr} in the Cragg model and an optimal solution hard to find. Consequently, no ordinary LR test between the models could be performed. However, by fixing σ_{tr} at σ_t, we are able to estimate the Cragg model and perform an LR test. The LR test statistic equals $\lambda = 2(\ln \ell_p + \ln \ell_{tr} - \ln \ell_t)$, where $\ln \ell_p$ and $\ln \ell_{tr}$ are the log likelihood values of the probit and the truncated regression models, respectively. Here, $\lambda = 126.75$, which, with 18 degrees of freedom, strongly rejects the null of the Tobit

[17] The LR test statistic is chi-square distributed with degrees of freedom equal to the number of restrictions.

model. Thus, the different decisions on contribution and expenditure seem to best be modelled in two parts, i.e. with some kind of double hurdle model.

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Table 2: Results from the first hurdle and complete dominance models.

			First hurdle		Complete	
Variable	Probit	t-value	OLS	t-value	OLS	t-value
Constant	-0.2378	-0.419	1050.8	2.318	628.8	2.600
SEX	0.0687	0.605	10.6	0.231	20.7	0.545
AGE	0.0027	0.113	-24.3	-2.323	-20.5	-1.750
AGESQ	-0.0002	-0.888	0.3	1.960	0.2	1.502
EDUCATION	-0.0067	-0.328	-0.8	-0.100	-1.4	-0.246
CHILDREN	0.0466	0.735	-13.7	-0.577	-8.7	-0.450
RESIDENCE	0.0545	0.451	19.1	0.406	25.8	0.621
POSTVIS	0.0102	0.038	188.2	1.880	188.3	2.387
PREVIS	0.1787	1.082	71.5	1.161	97.9	1.578
MEMBER	0.4700	2.929	-145.0	-1.662	-71.8	-1.876
INCOME	0.0473	3.433	0.2	0.022	9.0	1.655
INCOMESQ	-0.0006	-2.504	-0.1	-0.058	-0.0	-1.183
OUTDUM	0.0518	0.453	64.2	1.384	74.1	1.690
IMPDUM	0.4795	4.089	-104.2	-1.010	-8.1	-0.176
FUTDUM	0.2909	2.274	64.7	1.011	110.7	2.806
QB	0.0801	0.525	-32.2	-0.527	-20.0	-0.356
QC	0.0077	0.049	-81.4	-1.300	-83.9	-1.591
QD	0.0828	0.543	23.4	0.376	35.4	0.583
β_λ			-436.1	-1.083		
R^2			0.085		0.083	
Cases	703		517		517	
ln ℓ	-345.77		-296.14		-306.41	

Note: OLS t-values are corrected for heteroscedasticity (Greene, 1993, ch. 14 and 22) and the dependent WTP variable is measured in thousand SEK.

Table A1: Exogenous variables and definitions.

Variable	Definition
SEX	Dummy variable for sex, with one for female respondents.
AGE	The age (in years) of the respondent.
AGESQ	The squared age of the respondent.
EDUCATION	The education (in years) of the respondent.
CHILDREN	The number of children (17 years old or younger) in the respondent's household.
RESIDENCE	Dummy variable for residence, with one for the counties of Stockholm, Göteborg and Malmö.
POSTVIS	Dummy variable with value one if the respondent had visited Africa before receiving the questionnaire.
PREVIS	Dummy variable with the value one if the respondent expects to visit Africa in the next ten years.
MEMBER	Dummy variable with value one if the respondent subscribes to an environmental organisation.
INCOME	Monthly taxable household income (in 1,000 SEK).
INCOMESQ	The squared income of the respondent.
OUTDUM	Dummy variable with value one if the respondent participates in outdoor recreational activities more than once a week.
IMPDUM	Dummy variable with value one if the respondent believes the existence of the African elephant to be very important.
FUTDUM	Dummy variable with value one if the respondent prefers the herd of African elephants to increase in the future.
QB	Dummy variable for questionnaire B.
QC	Dummy variable for questionnaire C.
QD	Dummy variable for questionnaire D.

Table B1: Result from the Tobit model and the Cragg model with $\sigma_{tr} = \sigma_t$.

	Tobit		Cragg			
Variable	Tobit	t-value	Probit	t-value	Truncated	t-value
Constant	0.1346	0.678	-0.2378	-0.419	0.4825	1.240
SEX	0.0280	0.697	0.0687	0.605	0.0451	0.546
AGE	-0.0125	-1.443	0.0027	0.113	-0.0568	-3.224
AGESQ	0.0001	0.533	-0.0002	-0.888	0.0049	2.355
EDUCATION	-0.0017	-0.244	-0.0067	-0.328	0.0004	0.024
CHILDREN	-0.0014	-0.068	0.0466	0.735	-0.0295	-0.673
RESIDENCE	0.0311	0.736	0.0545	0.451	0.0870	1.024
POSTVIS	0.1518	1.687	0.0102	0.038	0.5500	3.677
PREVIS	0.1159	2.228	0.1787	1.082	0.2817	3.097
MEMBER	0.0139	0.280	0.4700	2.929	-0.2567	-2.467
INCOME	0.0170	3.412	0.0473	3.433	0.0274	2.621
INCOMESQ	-0.0002	-2.529	-0.0006	-2.504	-0.0341	-2.059
OUTDUM	0.0682	1.679	0.0518	0.453	0.2632	3.118
IMPDUM	0.1096	2.473	0.4795	4.089	-0.0341	-0.344
FUTDUM	0.1458	3.399	0.2909	2.274	0.3680	4.386
QB	-0.0018	-0.033	0.0801	0.525	-0.0773	-0.719
QC	-0.0727	-1.292	0.0077	0.049	-0.3316	-2.681
QD	0.0444	0.817	0.0828	0.543	0.1277	1.198
σ_t	0.4875	15.199			0.4875	Fix
Cases	703		703		517	
ln ℓ	-493.56		-345.77		-84.42	

Note: The dependent WTP variable is measured in thousand SEK.

Using Modal Perceptions to Determine Work Trip Travel Mode*

Maria Vredin Johansson†

Abstract

We estimate standard and random parameters logit models of commuters' modal choices based on stated choice data. The models relate the respondent's choice to the perceived time, cost, safety, and environmental friendliness or flexibility of the alternatives. From the estimated models we assess attribute values for time and safety. For work trips, the value of time is found to be SEK 40 per hour. A lower bound for the value of statistical life in road traffic is estimated at SEK 4.3 million.

Key words: Value of Time, Value of Statistical Life, Random Parameters Logit, Stated Preference.

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1 Introduction

In the empirical literature on travel mode choice, most choice models use objective (actual) modal attributes and individual characteristics as explanatory variables (cf. Algers et al., 1995). Nonetheless, few people reject the thought of travel mode choice also depending on harder-to-measure, qualitative variables, such as comfort and convenience. It has even been suggested that the choice of travel mode can depend on the perceptions[1] and images of the alternatives.

For instance, Koppelman and Pas (1980) argue that, as models with only demographic and objective attribute levels only provide a limited understanding of the behavioural processes underlying choice, incorporation of perceptions and feelings would improve the understanding of modal choices. Interestingly, Adamowicz et al. (1997) have in a recent study in the field of environmental economics found that a model based on perceptions slightly outperformed a model based on objective attribute measures.

Moreover, as it is recognised that objective information about a travel mode can be quite different from the perception of the information (Lichtenstein et al., 1978; Lee, 1981; Slovic et al.,1981; Mowen, 1990, ch. 2), the idea that objectively measured attributes are the only influential variables in travel choice models is open to question. If people actually respond to what they perceive, i.e. make choices on basis of their perceptions, the perceptions about the modal attributes are the relevant response variables to which people react, not objective attribute levels. Consequently, reconsideration when it comes to explaining travel choices seems both warranted and welcome.

In this paper, we use a mail survey to measure the individual's perceptions of five modal attributes (time, cost, safety, environmental friendliness and flexibility) and see how these perceptions affect modal choice for work trips. A difference between our survey and traditional ones, is that we do not attempt to inform, or educate, people about, for instance, the costs or risks of travelling. Instead, we *record* the respondents' perceptions about the modal attributes.

The work in this paper is based on the paradigm of individual choice behaviour depicted in Figure (1). In the figure latent variables are depicted by ovals and observable variables by boxes. Decision maker characteristics and

[1] In this paper, perception is defined as an individual's subjectively formed opinions and ideas about a stimulus or a piece of information.

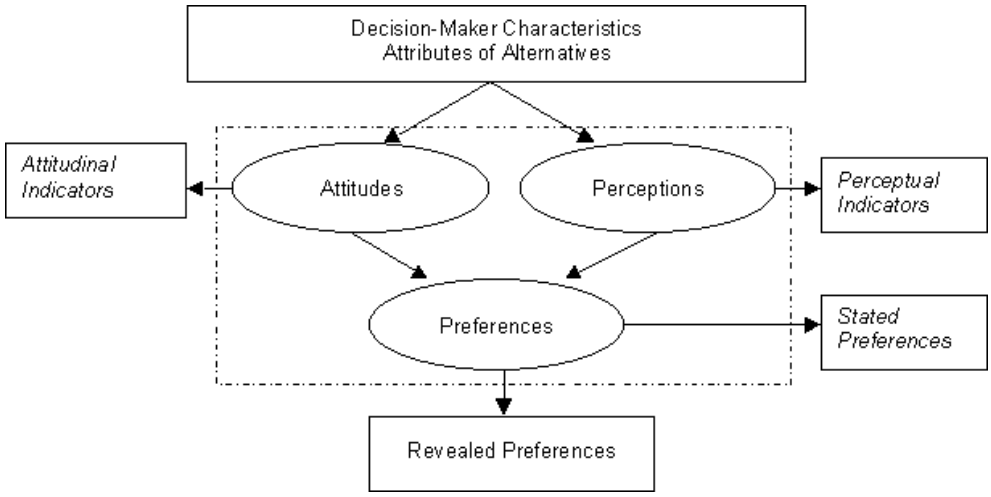

Figure 1: The Consumer Decision Process (adapted from Morikawa et al., 1990, p. 3).

actual attributes of alternatives are assumed to affect the *attitudes*, *perceptions* and *preferences* of the decision maker.[2] These latent variables - all assumed to affect choice - constitute the "black box" of the consumer. Because perceptions and attitudes are assumed to affect the individual's preferences and, as the preferences are assumed to determine choice, it is likely that incorporation of perceptions in travel choice models will improve the models' explanatory power.

While staying within the traditional microeconomic framework of rational utility maximisers (where preferences are expressed by utility functions), we enrich standard and random parameters logit choice models by perceptions data. From the estimated models we derive values of time. We also make a tentative attempt to measure the monetary value of safety. Because the Swedish National Road Administration (SNRA) uses both a value of time savings and a value of safety (i.e. value of "statistical life") in their project evaluations it is desirable to estimate both values in the same model (presently the SNRA uses values derived in separate studies). As far as we know, this has not been done in Sweden before. Because we estimate these

[2] *Attitudes* are defined as the decision maker's subjective importance of the attributes, *perceptions* as the decision maker's perceived values of attributes and *preferences* as the desirability of alternatives.

values simultaneously, we are able to explore whether values estimated in conjunction differ from values estimated in isolation.

This paper has three objectives:
(*i*) to elicit individuals' perceptions about the modal attributes time, cost, safety, environmental friendliness and flexibility,
(*ii*) to use these perceptions to explain modal choice, and
(*iii*) to derive monetary values for time and safety in the same model.

The remainder of the paper is organised as follows; the next section describes the data collection and the experimental design, section three gives a theoretical framework for stated preference discrete choice models, section four presents the results from the empirical estimations and, finally, section five concludes and discusses the results.

2 Data Collection and Experimental Design

2.1 Focusgroup Interviews

In order to gain information about what travel mode attributes people consider when making modal decisions, focusgroup interviews were conducted at Dalarna University College in November 1997. Altogether, seven persons were interviewed and another four contacted by mail. The sample was a convenience sample consisting of volunteers employed at Dalarna University College.[3] Conclusions from the focusgroup interviews were that travel time, travel cost and flexibility of the travel mode were the most important attributes when travelling to and from work. Less important were safety concerns and concern for the mode's environmental friendliness. When making holiday journeys (both summer and winter), safety, together with travel cost and travel time, were regarded as the most important attributes, while flexibility of the travel mode had lower priority.[4]

[3]The dominating travel mode was auto, and the mean, oneway, distance was 16 km (with variations between 5 and 45 km).

[4]The interviewees spontaneously described important attributes *before* being presented with attributes that *a priori* were believed to be important. Several attributes were discussed, such as the importance of being able to be "active" while travelling (work, read etc.) and the possibility of transporting things. These attributes were regarded inferior to the ones described above.

2.2 The Survey

In the subsequent mail survey, we limited our interest in travel mode choice to the study of work trip modal choices. There were several reasons for this limitation. First, work trips are easy to define for most people. Second, work trips are repeated journeys for which the nodes does not change (unless the respondent has varying places of work). Third, work trips are frequently performed and people are, therefore, often well-informed about alternative modes of travelling. Consequently the individuals' preferences for different travel modes can be assumed to be fairly well known. Finally, according to Statistics Sweden (SCB, 1998) almost half of the trips in 1997 consisted of trips to and from work/school, a fact that makes work trips imperative to study.

In total, there were 22 questions in the questionnaire (see Appendix A). Apart from socio-economic questions and questions regarding the respondent's habitual mode of travelling to and from work (revealed preference (RP) information), the questionnaire contained a question to elicit the respondent's perceptions of modal attributes of two different travel modes (auto and bus) and two stated preference (SP) choice questions where the respondent was asked to choose the preferred of two hypothetical travel modes. Each travel mode was described by four *attributes* (also called *variables* in the following).

Even though the data collection covered RP, SP, attribute perceptions and socio-economic data from each respondent, we employed a mail survey. There were two reasons for doing that. First, we wanted to see whether the mail survey format was a viable option when collecting information on people's perceptions and, second, we had to be financially conscious because the survey was only intended as a first step, a pilot, in a sequence of studies.

In December 1997, the questionnaire was mailed to 480 residents of Borlänge and Falu municipalities randomly selected[5] from the Swedish Official Register of Persons and Addresses (SPAR).[6] In the beginning of January 1998, a follow-up reminder was mailed to the non-respondents at that time. The overall response rate from the two mailings was 66.8 percent.

[5]Because we wanted respondents who, with a larger probability compared to a completely random sample, were working, the respondents were required to be aged between 36 and 55 years, i.e. to be born between 1942 and 1961.

[6]Borlänge and Falu municipalities are situated approximately 200 km north-east of Stockholm in the Dalecarlia region.

Table 1: Variables of the two subsamples.

Subsample I	Subsample II
Travel time (t)	Travel time (t)
Travel cost (c)	Travel cost (c)
Safety (s)	Safety (s)
Environmental friendliness (e)	Flexibility (f)
$n_I = 240$	$n_{II} = 240$

2.2.1 Attributes

Based on the results from the focusgroup interviews we chose to explore the significance of five different modal attributes for work trips: time, cost, safety, environmental friendliness, and flexibility.

Although unimportant in the focus groups, we included safety in the survey for two reasons: first, there is evidence (Noland, 1995) that decreases in the perceptions of a travel mode's safety reduces the probability of that mode being chosen and, second, safety improvements are the second most important benefit (with time savings as the most important) in the cost-benefit analyses of road investment projects made by the SNRA and, consequently, of considerable policy interest.

The mode's environmental friendliness is added because we wish to identify and include as many influential variables as possible in the choice experiment.[7]

Because we judged it unnecessary, and potentially too burdensome, for the respondents to evaluate five different attributes, we split the total sample in two so that each subsample consisted of 240 individuals, and let each subsample evaluate four different attributes. Travel time, travel cost and safety were the three "base" attributes used in both subsamples, while environmental friendliness and flexibility were used interchangeably. In this way we obtained an "environmental friendliness" subsample (I) and a "flexibility" subsample (II). Thus, the distinguishing feature between the two subsamples is their fourth variable (see Table 1).

[7] Naturally, as researchers, our individual perspectives influence the assumptions regarding what attributes are and are not important. Inclusion of environmental friendliness is a small concession to our own way of thinking.

Table 2: Alternatives and signs for a 2^4 factorial design.

Alternative	Attributes			
	t	c	s	ef
1	-	-	-	-
2	+	-	-	-
3	-	+	-	-
4	+	+	-	-
5	-	-	+	-
6	+	-	+	-
7	-	+	+	-
8	+	+	+	-
9	-	-	-	+
10	+	-	-	+
11	-	+	-	+
12	+	+	-	+
13	-	-	+	+
14	+	-	+	+
15	-	+	+	+
16	+	+	+	+

2.2.2 Attribute Levels

All variables are varied in two levels, a high and a low level. In the factorial design (Table 2) the high level is marked by a plus (+) sign and the low level by a minus (-) sign. For the factorial design, we construct a new, artificial, attribute, ef, which symbolises the environmental friendliness (e) attribute in subsample I and the flexibility (f) attribute in subsample II. Having four, instead of five variables, reduces the complexity of the factorial design because the number of alternatives is reduced from 2^5 to 2^4. In Table 2, the resulting 16 different alternatives can be seen.

The intrinsic natures of the attributes in this survey differ because travel time and travel cost are quantitative variables for which objective (researcher defined) values are common, while safety, environmental friendliness and flexibility are, more or less, qualitative variables where objective values are rather uncommon. For the inherently qualitative variables other measurement scales

than objective or actual must be used. For instance, a measure of the travel mode's objective risk (safety) can be defined as the actual risk the individual faces during the specific trip, expressed in number of annual fatalities. For the mode's environmental friendliness an objective measure would be the average emissions per passenger kilometer (Lenner, 1993). For the mode's flexibility it is harder to conceive of a good objective measure. Possible solutions are to use some kind of qualitative measure, such as low, medium and high, or, to endogenise the measurement by defining the prevailing level as the one from which changes are made. If we were to use objective values on all attributes in the SP survey, the values of the qualitative attributes would have to be invented and communicated to the respondents.

In this survey we circumvent the problem of constructing objective values for the more qualitative variables by using the respondent's perceptions of these variables. As a matter of fact, in order to simplify and make the questionnaire consistent, we use the respondent's perceptions of *all* variables - even for those with relatively obvious objective values.[8]

To elicit the respondents' perceptions of modal attributes, we propose a new approach, implemented by the four-step procedure described below. To the best of our knowledge, this approach has no previous applications.

The first step is to use the *names* of two travel modes, auto and bus, as levels for *all* attributes. Thus, an alternative could be described as having travel time "like auto", travel cost "like bus", safety "like bus" and environmental friendliness or flexibility "like auto". Consequently, one of the 16 alternatives in Table 2 describes a travel mode with all attributes "like auto" while another has all attributes "like bus". All other alternatives are pure hypothetical constructs. To the best of our knowledge, this "like"-approach has only been used once before in an SP survey, by Louviere and Johnson (1991) who, in a marketing study, explored the retail images of different supermarkets.[9]

The second step is to decide whether auto (bus) represents the high or the low level of the different attributes. Five assumptions about the attribute

[8] An advantage of using perceptions is that we do not have to concentrate on a specific type of traveller for whom we know the modal attribute levels beforehand (it would be impossible to construct realistic alternatives unless we had information about the respondent's actual travel mode). By using perceptions we are able to survey respondents with a mail questionnaire.

[9] Louviere and Johnson (1991) used attribute levels in the "like" form (e.g. "like K-Mart") and measured the perceptions of the different supermarkets through ratings.

Table 3: Designed attribute levels.

Attribute	High level (+)	Low level (-)
Travel time (t)	Bus	Auto
Travel cost (c)	Auto	Bus
Safety (s)	Bus	Auto
Environm. Friendliness (e)	Bus	Auto
Flexibility (f)	Auto	Bus

levels were used in the experimental design (see Table 3); (i) Going a specific distance by auto is normally faster than going the same distance by bus, due to the stops the bus makes - consequently, the high level of travel time was designated bus and the low level auto, (ii) The travel cost of auto was considered larger than the equivalent for bus, considering the additional costs of buying and running an auto, rendering auto the high and bus the low level, (iii) Based on historical statistics of traffic fatalities (SIKA, 1998; Kommunikationsdepartementet, 1997), bus safety was regarded superior to auto safety and, therefore, safety on bus is high, while safety in auto is low, (iv) Because the discharges per passenger kilometer from buses are lower than those from autos (Lenner, 1993) the environmental friendliness of bus is assumed to be higher than that of auto, and (v) When assigning a high and a low level to the (admittedly ambiguous) notion of flexibility, we considered three dimensions of travel mode flexibility: departure times, walking distances and freedom in choice of route. Because autos, in addition to having a greater freedom in route choice, generally, has more flexible "departure times", and can often be parked in proximity of the travel destination, we regarded auto as the more flexible travel mode.

The individual's preferences for the attributes are assumed to be monotone (increasing or decreasing). If the respondents perceive the attributes the way we do, lower travel cost and travel time are always preferred, as are higher safety, environmental friendliness and flexibility. Of course, the respondents may perceive the attributes differently or make different assumptions about the attribute levels.[10] This should not be a weakness of the design, because

[10] Gårder et al. (1994), for example, show that experts may judge on-street bicycle lanes as less safe (compared with no lanes at all) whereas the cyclists themselves perceive them as being safer.

the respondents make the choices based on their own preferences, not on our assumptions about their preferences.

The third step is measurement. Most desirable would be to measure modal perceptions on a equidistantly graded scale with an absolute zero, a quotient scale, so that comparisons could be made both within and between respondents.[11] To obtain quotient data, we apply a method originating in measurement scales for comparative judgements in psychophysics (cf. Björkman & Ekman, 1957). In this method the respondents make pairwise comparisons between a stimulus (a weight or a shade of gray, for example) and a standard. The respondent's perception of the stimulus is frequently expressed as a multiple or a fraction of the standard, so that, for instance, the stimulus is either twice or half of the standard. In our survey we let the respondents compare bus (the stimulus) to auto (the standard)[12] on every attribute and state the perceived difference between the two in percentages. That is, while auto is assumed to be "100%" on each attribute, the respondents are asked to state how, compared to auto, they perceive the attributes of bus (see question 19, Appendix A). For instance, if a respondent perceives the travel time of bus to be three times that of auto, she responds "300%" and, if she perceives the cost of bus to be a third of that of auto, she responds "33%". Consequently, the perceptions obtained are either multiples or fractions of the auto standard.

The fourth step is to infer "real" values, i.e. values in minutes and Swedish kronor (SEK)[13], from the percentage measured perceptions of time and cost by using the RP information provided by the respondent. For example, if the respondent travels to work by auto, the information about the actual time and cost by auto can, in conjunction with the perceptions of the time and cost by bus, be used to give the "like auto" and the "like bus" levels real value interpretation. A simple example: assume that the respondent travels to work by auto and that it takes 10 minutes and costs SEK 20.

[11] Ranking yields data with individual-specific scale units and origins (ordinal data), whereas rating yields equidistantly measured data with individual-specific origins (interval data). While ordinal data only describe the respondent's preferences (e.g. $X_1 < X_2 < X_3 < X_4$), interval data also describe the magnitude of the difference in preference (e.g. $X_4 - X_2 = 2(X_2 - X_1)$). Only data measured on a quotient scale can express the *intensity* of preferences (e.g. X_2 is twice as good as X_1, $X_2 = 2X_1$) (Björkman & Ekman, 1957).

[12] The choice of auto as the standard is merely one of convenience, but because auto is the most frequently used travel mode for work trips (SCB, 1998), we believe that most people find it easier to compare bus to auto than the other way around.

[13] US$ 1 is approximately equal to SEK 8.

The same respondent perceives the travel time of bus to be twice that of auto and responds "200%" to the relevant part of question 19. Similarly, the travel cost of bus is perceived to be half that of auto and, therefore, she responds "50%" to that part of the question. Using the RP information, i.e. $t_{auto} = 10$ and $c_{auto} = 20$, we can calculate the travel time of bus (t_{bus}) to 20 minutes and the travel cost (t_{bus}) to SEK 10.[14] Consequently, travel time "like auto" equals 10 minutes and travel time "like bus" equals 20 minutes in the SP choice questions. Analogously, real values can be inferred for the cost attribute.

Equivalent transformations for the time and cost variables can easily be performed for respondents who ride a bus to work and, in fact, for any respondent who has stated that either bus or auto is a feasible option. However, both the actual mode's time *and* cost must be known because it is unlikely that the travel mode is a part of the respondent's choice set if the respondent is unaware of the mode's time and cost.

For the variables, safety, environmental friendliness and flexibility such translations cannot be made because we have no RP values for these variables. Consequently, both inferred real values and "pure" attribute perceptions are used to explain the SP choices in the estimation. The main advantage of inferring real values from perceptions is that we are able to calculate a value of time that is easy to interpret and compare with other values of time.

2.2.3 Experimental Design

Because the survey was performed as a postal questionnaire, it was important to keep it short and simple to obtain a high response rate. Therefore, we restricted the size of the choice experiment, which is a function of the number of attributes to be varied. With $n = 16$ we could construct as many as $n(n-1)/2 = 120$ different paired comparisons (full factorial).[15] As no respondent could arguably be required to evaluate 120 different pairs, we had to reduce the number of comparisons. By selecting the smallest orthogonal main effects plan from the full factorial through "blocking" (see Appendix B), we are able to estimate unconfounded main (attribute specific) effects. In our survey,

[14] General formulas for the calculations are: $t_{bus} = t_{auto} \cdot \frac{\tau}{100}$ and $c_{bus} = c_{auto} \cdot \frac{\psi}{100}$, where t_{bus} is travel time by bus, t_{auto} travel time by auto, c_{bus} travel cost by bus and c_{auto} travel cost by auto. τ and ψ are the perceptions of travel time and travel cost of bus compared to auto expressed in percent.

[15] We do not compare an alternative with itself or consider the sequencing of alternatives.

Table 4: Response rates of the different subsubsamples.

	Subsample I				Subsample II				Total
Subsubsample	A	B	C	D	E	F	G	H	
Main sample	60	60	60	60	60	60	60	60	480
Real sample	59	60	60	60	60	59	59	59	476
Returned blank	1	0	0	1	0	1	0	0	3
Responses	37	37	44	39	43	38	37	43	318
Response rate (%)	62.7	61.7	73.3	65.0	71.7	64.4	62.7	72.9	66.8

Note: The real sample is the main sample less the questionnaires that were undeliverable due to unknown addresses, severe illnesses or longer stays abroad.

the smallest orthogonal main effects design consists of eight pairs. Because we believed that no respondent could be required to perform more than two paired comparisons, i.e. two different choice questions, the eight pairs were divided into four sets of two pairs each. This particular experimental design ensures unconfounded main effects, but confounded (with the blocks) interaction effects. According to Batsell and Louviere (1991), interaction effects are rarely estimated in choice models and, unless the respondents in different blocks differ or behave differently, we will not expect block effects.

With two paired comparisons in each questionnaire and a subsample size of 240, we got four "subsubsamples", consisting of 60 individuals each (see Table 4). Each sampled individual was randomly assigned a treatment.

Because we kept the dominating and the dominated alternatives in the experiment, and as the pairs in the paired comparisons are *fold-over* pairs (which means that they are complementary as the signs of the attribute levels of the first alternative are reversed in the second, see Box et al. (1978) and Appendix B), we have one questionnaire in each subsample that contains a choice question of the designed "best" versus the "worst" alternative.[16] In subsample I, questionnaire B contains the designed best-worst pair and in subsample II, it is questionnaire F. If these designed best-worst questions, in

[16]When used as a consistency check, approximately 22 percent in the environmental friendliness subsample and about 3 percent in the flexibility subsample chose the worst alternative in the best-worst question. However, what is right and what is wrong is based on the individual's perceptions of the attributes. Therefore, we can not conclude that these respondents behaved inconsistently.

any way, are simpler for the respondent, we expect greater response rates for these questionnaires. However, as can be seen in Table 4, this is obviously not the case, since B, in fact, has the lowest response rate in subsample I and F has the second lowest response rate in subsample II.

Moreover, questionnaire B in subsample I and questionnaire G in subsample II contain existing alternatives (i.e. have all attribute levels "like bus" or "like auto"). As G has the lowest response rate in the flexibility subsample, it is possible that the respondents were offended by the hypothetical formulation of the SP choice questions.

3 Modelling Choices

The behavioral assumption underlying the model for travel mode choice in this paper is maximisation of individual utility, i.e. the individual who, with certainty, knows the utility associated with every travel mode, chooses the alternative that maximises utility. A prerequisite for such an assumption is the existence of stable and well known preferences. Although the utility model has limitations when it comes to describing the human decision making process as it focuses on the final choice (Kahneman & Tversky, 1979), it makes empirical estimation possible. Therefore, it plays a major role in travel choice analysis as an approximation to real human decision making.

In traditional microeconomic utility maximisation, the individual's utility is maximised with respect to a bundle of continuous goods, $\mathbf{G}$, subject to a budget constraint. In a 1966 paper, Lancaster recognised that the primary source of utility is the qualitative attributes (e.g. comfort, flavour, softness) of the goods, and not the goods per se. Consequently, the individual's choice problem can be viewed one of choosing the alternative with the combination of attributes that gives the highest utility.

There are several ways of formulating discrete mode choice models, emphasising different aspects of modal choice (cf. Becker, 1965; DeSerpa, 1971; Train and McFadden, 1978; Jara-Diaz and Videla, 1989). Our model is based on the fairly general disaggregate choice model by Jara-Diaz and Videla (1989).[17] In this model, time is treated as one attribute among others assumed to affect modal choice. There is no explicit time constraint and, in its simplest form (which we will employ), income does not affect choice.

[17] See also Jara-Diaz, 1998.

A representative individual n (suppressing indexation) is assumed to choose both a discrete good (a mode) and continuous goods to maximise utility:

$$\max_{\mathbf{G},i} U = U(\mathbf{G}, \mathbf{Q}_i) \tag{1}$$

subject to

$$Y = \mathbf{1}'\mathbf{G} + c_i \tag{2}$$
$$i \in M$$

where $\mathbf{1}$ is a $K \times 1$ column vector of ones, $\mathbf{G} = [g_1, g_2, ..., g_K]$ is a $K \times 1$ column vector of consumed continuous goods, c_i is the travel cost of mode i, Y is income, $\mathbf{Q}_i = [q_{i1}, q_{i2}, ..., q_{iR}]$ is a $R \times 1$ column vector of "quality"attributes associated with travel mode i (excluding cost, but including time) and $M =$ the set of travel modes. The utility function is assumed to be twice differentiable, quasiconcave and increasing in $\mathbf{G}$. Equation (2) is the budget constraint, in which the travel cost and income are normalised by the price of $\mathbf{G}$. Conditional on the choice of travel mode i, we can derive conditional demands for $g_{ik} = g_{ik}(Y - c_i, \mathbf{Q}_i)$. Associated with the conditional demands is a conditional indirect utility function, which defines the maximum attainable utility level, conditional on the choice of travel mode i, $V_i = V_i(Y - c_i, \mathbf{Q}_i)$.

The travel mode chosen will be the alternative that renders the highest conditional indirect utility, i.e. mode i is chosen if $V_i \geq V_j$; $\forall j \neq i$. From the conditional indirect utility function it follows that the marginal utility of income (μ) is:

$$\mu = \frac{\delta V_i}{\delta Y} = -\frac{\delta V_i}{\delta c_i}.$$

The value of characteristic r is equal to the marginal rate of substitution between that characteristic and the (negative of the) marginal utility of income:

$$VOA_{ir} = \frac{\delta V_i / \delta q_{ir}}{\delta V_i / \delta c_i}.$$

If attribute t for mode i equals time, the value of time (VOT_i) is given by:

$$VOT_i = \frac{\delta V_i / \delta q_{it}}{\delta V_i / \delta c_i}.$$

However, we estimate a generic value of time because our experimental data do not consist of specific modes.

We assume that both the attribute vector associated with travel mode i ($\mathbf{Q}_i$) and the conditional indirect utility function are linear in arguments. Moreover, we add an error term, ε_i, to account for measurement errors. Thus, the conditional indirect utility function equals:

$$V_i = \alpha_i + \mu(Y - c_i) + \boldsymbol{\gamma}'\mathbf{Q}_i + \varepsilon_i. \tag{3}$$

When comparing V_i and V_j , only variables that vary between modes affect choice. Therefore, the relevant part of the conditional indirect function is, $\bar{V}_i$, a truncated conditional indirect utility function, where income is not included

$$\bar{V}_i = \alpha_i - \mu c_i + \boldsymbol{\gamma}'\mathbf{Q}_i + \varepsilon_i \ ; \ \forall i \in M.$$

In the estimation $\boldsymbol{\gamma} = \left[\gamma_t, \gamma_s, \gamma_{ef}\right]'$. If the respondent perceives the attributes the way we do, $\delta V_i/\delta c_i$ is expected to be negative (so that the negative of this parameter equals the marginal utility of income) because there is disutility from travel cost. By analogous reason, the time parameter, γ_t, is expected to be negative. Consequently, the VOT is a ratio between two negative numbers and, thus, expected to be positive. All other parameters in the vector $\boldsymbol{\gamma}$ are expected to be positive because utility is assumed to stem from increases in modal safety, environmental friendliness and flexibility. Therefore, the marginal rates of substitution between these attributes and cost are all expected to be negative.

Thus, the model used in the estimation is a linear, additive in the parameters, model. Linear additive models are compensatory which means that the individual can trade-off a low value on one attribute for a high value on another and achieve the same utility. Such models are not as restrictive and specialised as they might seem at first, because the vector of exogenous variables may contain transformations of the variables (e.g. power transformations and interactions) (McFadden, 1981). Empirically, compensatory choice models are found to work well in simple choice tasks such as in the choice between two alternatives (Payne, 1976).

4 Estimation

4.1 Standard Logit

In the SP choice experiment, the respondent n's choice set (M) - which is the set of alternatives available to the respondent - consists of two alternatives, A and B. The two alternatives are described by the same attributes, but the attribute levels differ between the alternatives, as described in section 2.2.2 above. The respondent is asked to indicate which of the two alternatives that she prefers, i.e. which alternative is "chosen".

The probability that the individual (suppressing individual indexation) will choose alternative B over A is stated as :

$$\Pr(B) = \Pr(U_B > U_A) = \Pr(V_B + \varepsilon_B > V_A + \varepsilon_A) = \Pr(\Delta\varepsilon > -\Delta V),$$

where $\Delta\varepsilon = \varepsilon_B - \varepsilon_A$ and $\Delta V = V_B - V_A$. The probability that A will be chosen over B is $\Pr(A) = 1 - \Pr(B)$.

Furthermore, let the dependent variable, $y_n \in \{0, 1\}$ be an indicator variable taking unit value if alternative B is chosen and zero if alternative A is chosen. Different assumptions about the distribution of the random terms ε_A and ε_B or about their difference, $\Delta\varepsilon$, lead to different choice models. If $\Delta\varepsilon$ is normally distributed, we have a probit model and if $\Delta\varepsilon$ is logistically distributed (the random terms are Gumbel or extreme value type I distributed) we have a logit model. For multinomial models, the logit model is generally more convenient analytically because it has a closed form, but for binary models, unless there are compelling reasons for assuming one distribution or the other, the choice between logit and probit is only a matter of preference. Here, we assume that $\Delta\varepsilon$ is logistically distributed and estimate a binary logit model.

For the representative individual, n, the choice probabilities for alternatives A and B are, respectively:

$$\underset{n}{\Pr}(A) = \underset{n}{\Pr}(y_n = 0) = \frac{1}{1 + \exp(\Delta V)} \text{ and}$$

$$\underset{n}{\Pr}(B) = \underset{n}{\Pr}(y_n = 1) = \frac{1}{1 + \exp(-\Delta V)}.$$

The log-likelihood function is written:

$$\ln \ell = \sum_{n=1}^{N} \left[(1 - y_n) \ln \left(\frac{1}{1 + \exp(\Delta V)} \right) + y_n \ln \left(\frac{1}{1 + \exp(-\Delta V)} \right) \right].$$

Table 5: Environmental friendliness subsample (I): Results from standard logit estimations of stated choices.

Attribute	Coefficient	St dev	t-value
Constant	0.063	0.214	0.293
TIME_I	-0.037	0.008	-4.752
COST_I	-0.028	0.010	-2.804
SAFETY_I	0.000	0.001	0.289
ENV. FRIENDL	0.000	0.000	1.037
n	77		
Choices made	143		
LRI	0.277		
$\ln \ell$	-71.50		

Note: The likelihood ratio index (LRI)=1-$(\ln \ell / \ln \ell_0)$.
$\ln\ \ell_0$ is the log-likelihood with only a constant term.

We estimate the empirical model:

$$\Delta V = \alpha_B - \alpha_A + \mu(c_B - c_A) + \boldsymbol{\gamma}'(\mathbf{Q}_B - \mathbf{Q}_A) + \Delta\varepsilon.$$

Pooling the environmental friendliness and the flexibility subsamples, and estimating the combined model with the use of dummy variables for the flexibility subsample result in rejection of the null hypothesis of equal subsamples.[18] Therefore, the two subsamples are treated separately.

The result for the environmental friendliness subsample is given in Table 5.[19] From the table we can see that the time and cost variables are significant at the five percent level with the expected signs (i.e. there is disutility from spending time and money on work trips). The safety and environmental friendliness parameters have the expected signs, but are insignificant. The standard deviation of the environmental friendliness parameter is very low, indicating a good precision of the estimate. Nonetheless, the environmental friendliness parameter is insignificant, which means that considerations about the mode's environmental impact are, indeed, unimportant when making modal decisions for work trips. The number of correctly predicted choices is 116.

[18] LR-test statistic: 11.02 with χ^2 critical value: 9.49.
[19] The standard logit estimations were conducted in LIMDEP for both subsamples.

Table 6: Flexibility subsample (II): Results from standard logit estimations of stated choices.

Attribute	Coefficient	St dev	t-value
Constant	0.989	0.219	4.506
TIME_{II}	-0.047	0.010	-4.587
COST_{II}	-0.069	0.018	-3.891
SAFETY_{II}	0.004	0.002	1.899
FLEXIBILITY	0.001	0.001	0.873
n	85		
Choices made	148		
LRI	0.232		
$\ln \ell$	-71.07		

Note: The likelihood ratio index (LRI)=1-($\ln \ell / \ln \ell_0$).
$\ln \ell_0$ is the log-likelihood with only a constant term.

Table 6 shows the result for the flexibility subsample. Here the time and cost variables are significant at the five percent level, with the expected signs. The safety parameter is significant at the six percent level with the expected sign. Contrary to the indications from the focus group interviews, the flexibility parameter is not significant, but has the expected sign. The relatively large variance of this parameter is likely to be a consequence of the lack of specificity in the definition of this attribute. Thus, the flexibility attribute seems to have been perceived very differently by the respondents. In this model, the number of correctly predicted choices is 114.

Given in Table 7, are the values of time for the two subsamples, calculated as:

$$VOT = \frac{\delta V/\delta \text{TIME}}{\delta V/\delta \text{COST}} = \frac{\hat{\gamma}_t}{-\hat{\mu}}. \tag{4}$$

Furthermore, the value of safety for the flexibility subsample, calculated as:

$$VOA_{s,II} = \frac{\delta V/\delta \text{SAFETY}_{II}}{\delta V/\delta \text{COST}_{II}} = \frac{\hat{\gamma}_{s,II}}{-\hat{\mu}_{II}}$$

is also given in Table 7. The standard errors are calculated using the Delta method (cf. Greene, ch. 10, 1993).

Table 7: SP values of time and safety, standard deviations and confidence interval (CI).

	Value	St dev	CI (95%)
VOT_I	79.50 SEK/hour	29.29	22.09 - 136.91
VOT_{II}	40.80 SEK/hour	8.85	23.45 - 58.15
$VOA_{II,s}$	0.07 SEK/percent	0.03	0.01 - 0.13

Note: The absolute value of $VOA_{II,s}$ is given.

We refrain from calculating values of environmental friendliness and flexibility because these variables were all insignificant. On the same grounds, we also refrain from calculating the value of safety in the environmental friendliness subsample.

The estimated values of time and safety are significant. The value of time in the environmental friendliness subsample (I) is almost twice the value time in the flexibility subsample (II). The difference is not significant, but the VOT_{II} has better precision than the VOT_I. A possible explanation for the lower value time in the flexibility subsample is the significance of the value of safety. That is, when the respondent considers one more attribute, the value of time may decrease.

In this survey, the value of safety is derived from the respondents' perceptions of auto and bus safety. After Jones-Lee (1990), individual n's marginal rate of substitution of wealth for risk is expressed by the ratio $WTP_{ns}/\delta\rho$, where $\delta\rho$ is the absolute change in risk level and WTP_{ns} defines the willingness to pay for a safety increase equal to $\delta\rho$. To illustrate the idea, we provide an example by Jones-Lee (1990): suppose that a group of 100,000 individuals are affected by a safety improvement that reduces the probability of death by exactly 1/100,000 for every member of the group in a forthcoming period (e.g., a year). On average, the individuals are willing to pay x for the safety improvement. Therefore, the aggregated value of statistical life equals $x \cdot 100,000$, which, in turn, is equal to the mean willingness to pay over the absolute risk reduction, $x/(1/100,000)$. Hence, if the risk reduction equals one, irrespective of how risk is measured (e.g. $\delta\rho = 1/100,000$ or $\delta\rho = 1/25,000$), the ratio gives the individual value of avoiding one statistical death, i.e. the value of a statistical life. In a group of individuals affected by an increase in safety, the aggregated value of a statistical life equals the

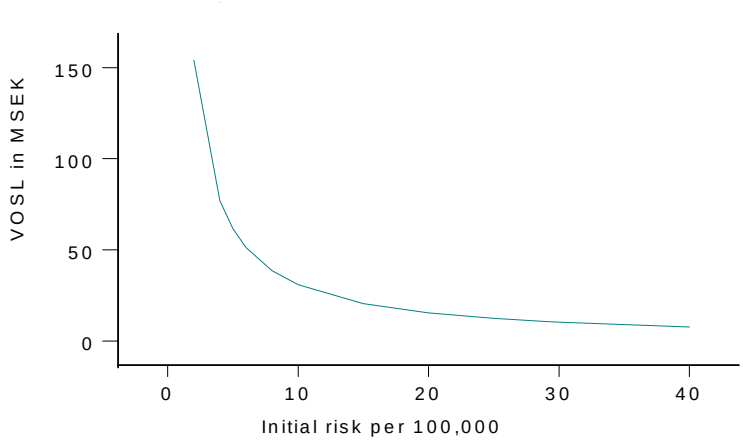

Figure 2: Value of statistical life (VOSL) at different initial risks

mean of these individual marginal rates of substitution. If the individuals affected by a risk reduction are relatively homogenous and the individual risk reductions are small, the value of statistical life is independent of the size of the group and the pattern of individual risk reductions. Under such circumstances, the total value of statistical life equals $WTP_s/\delta\rho$ where WTP_s equals mean willingness to pay.

In our survey, the $VOA_{II,s}$ for every work trip equals SEK 0.07 per percentage reduction in risk. Given that most people have two work trips per day and, on average, 220 workdays per year, we get an annual value of safety, a willingness to pay for safety (WTP_s), equal to SEK 30,80.

Because we used the respondents' perceptions of safety we are unable to calculate a *point estimate* for the value of statistical life.[20] Nonetheless, we can give a *function* for the value of statistical life at different levels of perceived risk. Assuming different initial levels of risk for work trips and reducing the risk by exactly $1/100,000$ gives rise to the function in Figure (2). For example, in 1997, the *objective* risk for being *killed* or *seriously injured* in an auto was approximately 29 per 100,000 of the average population (SIKA,

[20]We assume, everywhere mentioned, that the initial risk is equal to the risk of being *killed* in road traffic. Therefore, the value of statistical life can be calculated from every assumed initial risk level. However, if the respondents perceive the initial risk (safety) differently, so that, for instance, the initial risk is perceived as the risk for being *killed* or *seriously injured* in traffic, an unambiguous value of statistical life can not be calculated.

1998). If the average respondent perceives this level of risk as the risk for being killed in road traffic, the value of statistical life is equal to SEK 10.6 million based on the assumptions above.[21] Similarly, the risk for being *killed* in auto was 4 per 100,000 of the average population (SIKA, 1998).[22] If the respondents perceive this risk level, the value of statistical life equals SEK 77 million. Thus, the crucial assumption for the value of statistical life is the assumption about the perceived initial risk. A Swedish contingent valuation survey (Persson et al., 1998) has found the mean perceived risk for being killed in a traffic accident during a year to be $72/100,000$ (median: $4/100,000$). Employing their mean value gives a value of statistical life equal to SEK 4.3 million. This value could serve as a lower bound for the value of statistical life for work trips.

4.2 Random Parameters Logit

The standard logit model is simple to estimate. However, it imposes several restrictions on the coefficients of the model (McFadden, 1981; Ben-Akiva & Lerman, 1985). First, the parameters of the explanatory variables are assumed to be the same for all respondents, which means that two identical (with respect to the observed variables) respondents must have the same parameter values (tastes). Second, following from the assumption of IID extreme value error term, the logit model suffers from the independence of irrelevant alternatives (IIA). With IIA, the logit model necessarily predicts that a change in one attribute of an alternative (or the introduction of a new alternative or the elimination of an existing alternative) changes the probability for the other alternatives proportionately, so that the ratios of probabilities remain unchanged (Brownstone & Train, 1999). In many circumstances, this is an unrealistic assumption, resulting in implausible substitution patterns. Third, in cases where there are repeated choices, either over time, as in revealed preference situations, or over choices, as in stated preference situ-

[21] Reducing the risk from 29 to 28 in a hundred thousand equals a risk reduction of 3.45 percent. For all work trips in a year we have: $(-0.07 \cdot -3.45 \cdot 2 \cdot 220) \cdot (1/100,000)^{-1}$ $= 10,626,000$ or, more generally, $VOSL = VOA_s \cdot \delta\pi \cdot n_{trips} \cdot n_{days} \cdot \delta\rho^{-1}$, where $VOSL$ is short for value of statistical life and $\delta\pi$ is the risk reduction expressed in percent.

[22] In 1997, 348 persons were killed in auto accidents (SIKA, 1998). It is important to remember that these are "primary" fatalities (people being killed when travelling by car), whereas there are also "secondary" fatalities (people not travelling by car who are killed by a car).

ations, the standard logit model assumes that unobserved variables affecting choice are independent over time and choices so that there is no correlation in the unobserved utility over time and choices. In many settings, this is also an unrealistic assumption.

To relax the above restrictions, a less restrictive model, the "random parameters" logit model[23], was estimated. The random parameters logit model is a generalisation of the standard logit model, where the parameters of the attributes are allowed to vary randomly over respondents. The random parameters logit model does not exhibit the IIA property and may, therefore, represent any substitution pattern (Train, 1998). Furthermore, in the random parameters logit model the dependence of unobservable variables over choices is explicitly modelled. For instance, the individual's value of time (the ratio between the time and cost parameters) may depend on the unobserved variable "patience" which may vary among the respondents (Horowitz, 1981).

Lately, random parameters logit models have been applied in various settings, e.g. in recreational demand models for the choice of fishing site (Train, 1998), in consumption demand models for households' choice of appliance efficiency level (Revelt & Train, 1998) and households' choice between vehicles with different fuel types (Brownstone & Train, 1999), and in travel choice models (Algers et al., 1998).

In the random parameters logit model, the indirect utility of alternative i at choice situation t for individual n, is specified as $V_{nit} = \boldsymbol{\beta}_n' \mathbf{x}_{nit} + \varepsilon_{nit}$, where $\mathbf{x}_{nit}$ is a vector of explanatory variables and $\boldsymbol{\beta}_n$ is a vector of unobserved coefficients that varies in the population. The disturbance term, ε_{nit}, is still assumed to be IID extreme value distributed. This specification is analogous to the standard logit specification of V_i in Equation (3), except for the coefficient vector $\boldsymbol{\beta}_n$ which varies over respondents and the subindexation t which accounts for the data's panel character (the repeated choices). Following Train (1998) the coefficient vector $\boldsymbol{\beta}_n$ is expressed as the sum of the population means, $\mathbf{b}$, and individual deviations, $\boldsymbol{\eta}_n$, where $\boldsymbol{\eta}_n$ represents the respondent's taste relative to the population's. The utility may be reexpressed as:

$$V_{nit} = \mathbf{b}' \mathbf{x}_{nit} + \boldsymbol{\eta}_n' \mathbf{x}_{nit} + \varepsilon_{nit}. \tag{5}$$

The term $\boldsymbol{\eta}_n' \mathbf{x}_{nit} + \varepsilon_{nit}$ is unobserved and, as the researcher cannot separate the individual deviation from the independent error term, the existence of

[23] Also known as mixed logit, random coefficients logit and error components logit.

$\boldsymbol{\eta}_n$ induces heteroscedasticity and correlation over choices. That is, because the respondent uses the same "tastes" when evaluating choices and, as the researcher is unable to completely observe these tastes, there is correlation in the unobserved part of the indirect utility function.

Generally, the unobserved parameter vector $\boldsymbol{\beta}_n$ is assumed to vary in the population with density $f(\boldsymbol{\beta}_n \mid \boldsymbol{\theta})$, where $\boldsymbol{\theta}$ are the true parameters of the distribution (for instance, the mean and standard deviation). Our objective is to estimate $\boldsymbol{\theta}$, the true population parameters that describe the distribution of the individual parameters. Here, we assume $\boldsymbol{\beta}_n$ to be normally distributed, $\boldsymbol{\beta}_n \sim N(\mathbf{b}, \boldsymbol{\Sigma})$, which follows from the assumption that $\boldsymbol{\eta}_n \sim N(\mathbf{0}, \boldsymbol{\Sigma})$, where $\boldsymbol{\Sigma} = diag(\boldsymbol{\sigma}_p)$. Here, p equals the explanatory variables used in the standard logit model above. Thus, $\mathbf{b}$ and $\boldsymbol{\Sigma}$ are the vectors of parameters we wish to estimate.

The following description of estimation by maximisation of a simulated likelihood is largely adapted from Train (1998) and Revelt and Train (1998).

Suppose we knew $\boldsymbol{\beta}_n$. Then, the conditional probability that individual n chooses alternative i at time t would be the standard logit:

$$\mathcal{L}_{nit}(\boldsymbol{\beta}_n) = \frac{e^{\boldsymbol{\beta}'_n \mathbf{x}_{nit}}}{\sum_j e^{\boldsymbol{\beta}'_n \mathbf{x}_{njt}}}.$$

However, we do not know $\boldsymbol{\beta}_n$, so the unconditional probability is the integral of the conditional probability over all possible values of $\boldsymbol{\beta}_n$ (which depends on $\boldsymbol{\theta}$, i.e. $\mathbf{b}$ and $\boldsymbol{\Sigma}$)**:**

$$\mathcal{D}_{nit}(\boldsymbol{\theta}) = \int \mathcal{L}_{nit}(\boldsymbol{\beta}_n) f(\boldsymbol{\beta}_n \mid \boldsymbol{\theta}) d\boldsymbol{\beta}_n.$$

Assuming again that we know $\boldsymbol{\beta}_n$, we take the (within the survey) repeated choices into consideration and derive the likelihood for an individual's sequence of choices. The probability of individual n's sequence of choices (conditional on $\boldsymbol{\beta}_n$) is the product of standard logits:

$$\mathcal{S}_n(\boldsymbol{\beta}_n) = \prod_{t=1}^{2} \mathcal{L}_{nit}(\boldsymbol{\beta}_n).$$

Because we do not know $\boldsymbol{\beta}_n$, the unconditional probability for the sequence of choices is the integral of the conditional probability over all possible values of $\boldsymbol{\beta}_n$:

$$\mathcal{P}_n(\boldsymbol{\theta}) = \int \mathcal{S}_n(\boldsymbol{\beta}_n) f(\boldsymbol{\beta}_n \mid \boldsymbol{\theta}) d\boldsymbol{\beta}_n.$$

The log-likelihood function is $\mathcal{LL}(\boldsymbol{\theta}) = \sum_n \ln \mathcal{P}_n(\boldsymbol{\theta})$. Since the integral in $\mathcal{P}_n(\boldsymbol{\theta})$ can not be calculated analytically (it has no closed form), we approximate the probability through simulation and maximise the simulated log-likelihood function. That is, for a given value of $\boldsymbol{\theta}$ ($\mathbf{b}$ and $\boldsymbol{\Sigma}$), individual values for $\boldsymbol{\beta}$ are drawn for each individual. These $\boldsymbol{\beta}$'s represent the individual's "tastes", which are assumed to be constant over the repeated choices.[24] $\boldsymbol{\beta}_n$ is treated as fixed for individual n and used, together with the data, to calculate $\mathcal{S}_n(\boldsymbol{\beta}_n)$, i.e. the product of standard logits. This process is repeated for many values for $\boldsymbol{\beta}_n$ (many draws from the distribution described by $\boldsymbol{\theta}$) and the average of the resulting $\mathcal{S}_n(\boldsymbol{\beta}_n)$ is taken as the approximate choice probability:

$$\mathcal{SP}_n(\boldsymbol{\theta}) = (1/R) \sum_{r=1}^{R} \mathcal{S}_n(\boldsymbol{\beta}_n^{r|\theta})$$

where R is the number of repetitions, $\boldsymbol{\beta}_n^{r|\theta}$ denotes the r^{th} draw from $f(\boldsymbol{\beta}_n \mid \boldsymbol{\theta})$ and $\mathcal{SP}_n(\boldsymbol{\theta})$ is the simulated probability for n's sequence of choices. The simulated log-likelihood function equals $\mathcal{SLL}(\boldsymbol{\theta}) = \sum_n \ln(\mathcal{SP}_n(\boldsymbol{\theta}))$. Iterations performed with the BFGS algorithm yield new values for $\boldsymbol{\theta}$, which are used in new draws of $\boldsymbol{\beta}_n$, which, in turn, are used to calculate new $\mathcal{S}_n(\boldsymbol{\beta}_n)$, $\mathcal{SP}_n(\boldsymbol{\theta})$ and $\mathcal{SLL}(\boldsymbol{\theta})$. The process is repeated until the BFGS algorithm converges.

We estimate the parameters $\mathbf{b}$ and $\boldsymbol{\Sigma}$ in Equation (5) by maximisation of a simulated log-likelihood function (MSL) with $R = 1,000$ repetitions.[25] All random parameters logit models were estimated with ten different starting values to ensure the finding of a global maximum.[26]

To begin with, the most obvious way to introduce individual heterogeneity would be to estimate models with random intercepts while keeping all other variables fixed. However, compared to the standard logit models, such models do not improve the (simulated) likelihood functions and are rejected by likelihood ratio tests (not reported). Therefore, we fix the intercept terms of both models, and let, instead, the explanatory variables be random.[27] For

[24] Modification could be done so that the respondent's tastes vary over time (Train, 1998). However, in our case we assume that the time elapsed between the consecutive choices is too small to significantly affect the respondent's tastes.

[25] The estimations was conducted in a GAUSS program written by Kenneth Train, David Revelt and Paul Ruud. The program is available at http://elsa.Berkeley.EDU/ ~train/

[26] As starting values we use $\mathbf{b} = \hat{\boldsymbol{\lambda}} + \boldsymbol{\zeta}$, where $\hat{\boldsymbol{\lambda}}$ is a $p \times 1$ vector of standard logit estimates and $\boldsymbol{\zeta} \sim N(\mathbf{0}, \mathbf{0.1})$. For $\boldsymbol{\Sigma}$, we use draws from the distribution $\boldsymbol{\Sigma} \sim Uniform[0, 1]$.

[27] Allowing all coefficients to vary results in identification problems (Revelt & Train,

the flexibility subsample, this model is rejected by a likelihood ratio test (ln ℓ = -69.84) but, for the environmental friendliness subsample, we cannot reject this model (ln ℓ = -61.78).

The results from the environmental friendliness estimation are reported in Table 8. The mean of the time variable is significant at the five percent level and the mean and standard deviation of cost are significant at the ten percent level. Thus, there are significant variations in the cost parameter among the respondents in this subsample. The point estimate of the time coefficient implies that six percent of the respondents have a positive time parameter, while the point estimate of the cost coefficient implies that about 16 percent have a positive cost parameter. While it seems plausible that a few respondents may enjoy the time travelling to work, it seems less plausible that some respondents enjoy having more expensive work trips. An explanation for this unexpected value, also found by Algers et al. (1998), may be some respondents' eligibility to tax deductions for work trips.

Comparing the random parameters logit parameter estimates with those from the standard logit, we see that the estimated parameters are larger in absolute magnitude in the random parameters logit. Because the variance of the IID error term is greater in the standard logit than in the random parameters logit and, as the scale of utility is determined by the normalisation of the error term, this is what is to be expected (Brownstone & Train, 1999).

The point estimate of VOT_I (using $\hat{b}_{\text{time}}$ / $\hat{b}_{\text{cost}}$) is now SEK 41.37 per hour. Thus, it is lower than the equivalent from the standard logit model. Lower value of time, when employing a random parameters logit model with normal parameters, has also been found by Algers et al. (1998). Because each respondent now has an "own" value of time - which is the ratio between two normally distributed variables - the correct mean value of time would be given by integrating over this distribution. However, this considerably complicates the calculation and also leads to some individuals having implausible values of time as the normal distribution allows both negative and positive individual coefficients.

One may assume lognormal distributions for the time and cost parameters and, thereby, make sure that these variables get positive individual parameter values (when estimated on the negative of respective variable). However, for our dataset, this model failed to converge. Convergence failures in estimations with lognormally distributed variables are also recognised by

1998).

Table 8: Environmental friendliness subsample (I): Results from random parameters logit estimations of stated choices.

Attribute	Coefficient	St dev	t-value
Constant	0.119	0.426	0.280
Mean of time	-0.131	0.062	-2.107
St dev of time	0.086	0.062	1.382
Mean of cost	-0.190	0.113	-1.680
St dev of cost	0.191	0.111	1.715
Mean of safety	0.004	0.005	0.954
St dev of safety	0.007	0.009	0.773
Mean of env.friendl.	0.001	0.002	0.793
St dev of env.friendl.	0.000	0.002	0.176
n	77		
Choices made	143		
$SLRI$	0.376		
ln ℓ (simulated)	-61.78		

Note: The simulated likelihood ratio index ($SLRI$)=1-($\ln \ell_s / \ln \ell_0$). $\ln\ \ell_0$ is the log-likelihood with only a constant term.

Algers et al. (1998) and Brownstone and Train (1999).

5 Discussion and Conclusions

Based on a stated choice experiment, we estimate standard and random parameters logit models of commuters' choice of travel mode. The choices are explained by the individual's perceptions of five modal attributes; time, cost, safety, environmental friendliness and flexibility. Depending on the attributes evaluated by the respondent, the sample was divided into an environmental friendliness and a flexibility subsample. The respondents' preferences were elicited by a novel method in which the names of two modes (auto and bus) were used as attribute levels instead of objective levels. Based on the respondents' revealed preferences, we infer "perceptions-based" real values for the time and cost attributes. In the analysis the inferred values are used together with the perceptions of the other attributes. From the estimated model we derive a value of time for work trips and a monetary value for safety

improvements (value of statistical life). Time savings and saved statistical lives are the major benefits in project evaluations of the Swedish National Road Administration (SNRA). Whereas the SNRA uses values derived from separate studies, we estimate them in the same model.

Although the survey originally was intended to serve as a pilot survey, it produced several interesting findings. Overall, travel time and travel cost are found to be the most important attributes for work trip modal choice, while safety has a non-negligible influence in the flexibility subsample. Whereas a model specification with normally distributed parameters (the random parameters logit) improved model fit for the environmental friendliness subsample, the standard logit model with fixed parameters could not be rejected for the flexibility subsample. For both subsamples, the models with the best fit (highest loglikelihoods) resulted in values of time about SEK 40 per hour. In a national survey from 1994 (Algers et al., 1995), the value of time for work trips was found to be SEK 34 - 54 per hour for bus, auto and train. Adjusted for price changes, these figures are SEK 35 - 56 (1997 prices), which encompasses our estimate, even though a direct comparison is erroneous because the different values of time are estimated on different travel modes. Thus, in a "test-retest" sense, the point estimates of the value of time in our survey are reliable. Although our perceptions data do not dramatically change, or improve, the value of time estimate, our estimations prove that perceptions data, at least, are no less useful than objective data for explaining travel mode choices. Furthermore, the revealed preference information gathered was used to estimate a revealed preference value of time (VOT^{RP}). In a multinomial logit model for the choice between walk, bike, bus and auto, the point estimate for the VOT^{RP} was found to be SEK 87 (with standard deviation 53). The large standard deviation means that the point estimate has low precision. Consequently, a 95 percent confidence interval encompasses both zero and the corresponding, narrower, confidence interval for the stated preference value of time. In 1999, the value of time recommended to the Swedish National Road Administration (SNRA) for cost-benefit calculations is SEK 35 per hour for regional (< 50 km) trips (SIKA, 1999).

In this survey the work trip value of statistical life in road traffic depends on the perceived initial risk. We find a lower bound for the value of statistical life equal to SEK 4.3 million, based on a perceived initial risk of $72/100,000$. As is recognised in psychological research, people tend to underestimate the risks of well known, voluntary, low probability events (Lichtenstein et al., 1978). Because most people probably define driving to work as a low prob-

ability event, a much higher value of statistical life is implied. A recent Swedish contingent valuation survey found the value of statistical life to be SEK 19.4 million (Persson et al., 1998). In 1999, the value of statistical life recommended to the SNRA for cost-benefit calculations is SEK 13 million (SIKA, 1999).[28]

Though many things could have been done differently[29], the use of perceptions data is a novelty to SP analysis. Nonetheless, the findings from this survey are encouraging and constitute a point of departure for future research. In order to improve model fit and predictive power of travel choice models, future research will focus on identifying latent variables that affect choice. For instance, purposefully collected survey data, modelled in linear structural equation models, where the latent variables are related to indicator variables (Morikawa et al., 1990; Bollen, 1989), will, by estimation in the LISREL program (Jöreskog & Sörbom, 1993), help to identify latent variables. Such estimations could provide fitted values that may be used as explanatory variables in discrete travel choice models.

[28] Excluded are costs for medical care, police assistance, administration, vehicle damage, and other related costs, as is the present value of the victim's future output. These costs are estimated at SEK 1.2 million for a fatal injury. Consequently, the total cost for a statistical death in traffic is SEK 14.2 million (SIKA, 1999).

[29] For example, information gathering on exactly how the respondents perceive the attributes should be improved. Moreover, the survey should account better for situational constraints (such as bad weather and/or seasonal differences) and, in order to maximise validity, be related to specific and recent choice situations.

Appendix A: The Questionnaire

Translated version of the introductory letter and the questionnaire (version A).

Table B1: Signs for a 2^4 factorial design.

Alt.	Variables				Interaction effects										
	1	2	3	4	12	13	14	23	24	34	123	124	134	234	1234
1	-	-	-	-	+	+	+	+	+	+	-	-	-	-	+
2	+	-	-	-	-	-	-	+	+	+	+	+	+	-	-
3	-	+	-	-	-	+	+	-	-	+	+	+	-	+	-
4	+	+	-	-	+	-	-	-	-	+	-	-	+	+	+
5	-	-	+	-	+	-	+	-	+	-	+	-	+	+	-
6	+	-	+	-	-	+	-	-	+	-	-	+	-	+	+
7	-	+	+	-	-	-	+	+	-	-	-	+	+	-	+
8	+	+	+	-	+	+	-	+	-	-	+	-	-	-	-
9	-	-	-	+	+	+	-	+	-	-	-	+	+	+	-
10	+	-	-	+	-	-	+	+	-	-	+	-	-	+	+
11	-	+	-	+	-	+	-	-	+	-	+	-	+	-	+
12	+	+	-	+	+	-	+	-	+	-	-	+	-	-	-
13	-	-	+	+	+	-	-	-	-	+	+	+	-	-	+
14	+	-	+	+	-	+	+	-	-	+	-	-	+	-	-
15	-	+	+	+	-	-	-	+	+	+	-	-	-	+	-
16	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Appendix B: Experimental Design

Following the notation of Box et al. (1978) the three variables and the combination variable are denoted as follows; $1 = t$ (travel time), $2 = c$ (travel cost), $3 = s$ (safety), $4 = ef$ (Environmental friendliness/Flexibility). All variables have two levels, a high level and a low level. As previously, we employ a plus sign (+) to indicate the high level and a minus sign (-) to indicate the low level. Furthermore, if the elements of any column are multiplied by themselves, we obtain a column of plus signs, **I**, i.e. **I**=11=22=33=44**.**

In the following description of the experimental design, it is important to distinguish between the concepts of alternatives, blocks, pairs and subsubsamples (denoted sss in Table B2). When we have four variables varying at two different levels and desire two pairwise comparisons in each subsubsample, we need three "block" variables to do the job. Therefore, let us introduce the block variables, B_1, B_2 and B_3, where $B_1 = 12$, $B_2 = 13$ and $B_3 = 34$ (see Table B2). Hence, B_1 is equal to the two-way interaction between t and

Table B2: Block variables and experimental design.

Alternative	B_1	B_2	B_3	Pair no	sss	Pair no	Alternatives	Questionnaire
1	+	+	+	8	1	8	1, 16	A and E
2	-	-	+	7				
3	-	+	+	6		7	2, 15	A and E
4	+	-	+	5				
5	+	-	-	4	2	6	3, 14	B and F
6	-	+	-	3				
7	-	-	-	2		5	4, 13	B and F
8	+	+	-	1				
9	+	+	-	1	3	4	5, 12	C and G
10	-	-	-	2				
11	-	+	-	3		3	6, 11	C and G
12	+	-	-	4				
13	+	-	+	5	4	2	7, 10	D and H
14	-	+	+	6				
15	-	-	+	7		1	8, 9	D and H
16	+	+	+	8				

c, B_2 is equal to the two-way interaction between t and s and B_3 is equal to the two-way interaction between s and ef.

Depending on the signs of the block variables, we assign "pair" numbers to the different alternatives. Hence, the two alternatives with all block variables at the high level (+ + +) constitute a pair (pair no 8) while alternatives with block variables minus, minus, plus (- - +) constitute another (pair no 7), and so on. The result of using the block variables is eight different pairs. These pairs are divided into four subsubsamples consisting of two pairs each. For example, subsubsample one consists of two pairwise comparisons, pairs number eight (8) and seven (7), where pair eight equals the choice between alternative one and 16 and pair seven equals the choice between alternative two and 15. For the other three subsubsamples the alternatives are given in Table B2. The two alternatives in each pair are complementary in signs, as the signs of the attribute levels of the first alternative are reversed in the second. Therefore, each pair is said to be a *fold-over* pair (Box et al., 1978). For example, in pair no 8 there is a choice between alternative one and 16. Regarding Table B1, we see that while alternative one is low on all variables,

alternative 16 is high on all variables.

This blocking arrangement is copied from Box et al. (1978, p. 347). Clearly, there are some, but not so many, other possible combinations of block variables. However, caution is called for, because the use of wrong block variables may lead to main effects being confounded with block effects. Using any other three *possible* (without confounding the block effects with the main effects) combinations of block variables leads to the same result as the ones we use; all two-way interactions and the four-way interaction are confounded with the block effects and the pairs consist of the same alternatives.

If the we use the notation and the multiplicative properties from above, we have; $B_1B_2 = 1213 = 23$, $B_1B_3 = 1234$, $B_2B_3 = 1334 = 14$ and $B_1B_2B_3 = 121334 = 24$, which means that interaction effects 12 (time-cost), 13 (time-safety), 14 (time-environmental friendliness/flexibility), 23 (cost-safety), 24 (cost-environmental friendliness/flexibility), 34 (safety-environmental friendliness/flexibility) and 1234 (time-cost-safety-environmental friendliness/flexibility) are confounded with the block effects and, therefore, not possible to estimate separately. However, none of the main effects are confounded.

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What Determines the Number of Alternative Travel Modes for Work Trips?*

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Abstract

Two different count data models are estimated in order to explain the number of alternative travel modes for work trips: a Poisson model and a polynomial Poisson model of order 1 (PP1). The PP1 model is estimated to allow for departures from the Poisson assumption of equidispersed data. Two significant determinants of the number of alternative travel modes for work trips are found: the individual's income and the distance to the workplace. As suggested by intuition, the individual's number of alternatives increases with income and decreases with distance to the workplace.

Key words: Value of Time, Count Data, Choice Set Size, Polynomial Poisson Model.

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1 Introduction

In order for a society to conduct optimal allocation of common, scarce, resources, it is important that *all* effects of proposed projects are identified and quantified. In project evaluations, such as benefit cost analyses some benefits and costs are relatively easy to find monetary values for (e.g. production costs), while other effects are, more or less, intangible and, therefore, harder to measure. When the Swedish National Road Administration (SNRA) perform road project evaluations, the most important benefit is the value of time savings. When estimating the value of time in economic transportation research random utility models are frequently employed (cf. Algers et al., 1995; Vredin, 1999). In such models only those who are not captives to their chosen modes, i.e. those who are free to make a choice among alternatives, are included in the estimations. That is, the individual's choice set, defined as the set of travel mode alternatives that are both known and feasible to the individual (Ben-Akiva and Lerman, 1985, ch. 3), has to contain at least *two* elements in order for the individual to be included in estimation. Consequently, if the captives (the excluded) differ in any substantial way from those who are more free to choose between travel alternatives (the included), the estimated value of time is likely to be biased. Only when we know the determinants of the individuals' modal choice set sizes, can we speculate about the direction of this bias.

This paper explores the determinants of the modal choice set size for individuals' work trips. Because our interest lies in explaining the *size,* not the *composition,* of the individuals' choice sets, we just look at the number of elements in each choice set and do not distinguish between, for instance, two-element choice sets composed of walk-bike and auto-bus.

The paper is organised as follows; the next section describes the data, section three provides the econometrics behind the model used, section four presents results from the estimation and considers an alternative model and, finally, section five compares the models and discusses the results.

2 Data

In the autumn of 1997, a combined revealed and stated preference mail questionnaire survey was performed in two Swedish municipalities; Borlänge and Falu (the survey is described at length in Vredin, 1999). Apart from stated

preference and socio-economic questions, the questionnaire contained questions about the respondents' actual and alternative travel modes for work trips. These data provide information about the respondents' modal choice set sizes, i.e. the number of travel modes that are both known and feasible to the respondents, including the chosen ones. Because the data were gathered by surveying only working respondents, "on-site" or "choice-based" sampling occurred. This kind of sampling is often employed in studies of recreational site demands to reduce survey costs (cf. Englin & Shonkwiler, 1995).

In our data, the most frequently chosen travel modes for work trips were (in decreasing order of magnitude); auto, bike and walk. Together these three travel modes accounted for almost 86 percent of all modes used. Other modes in the choice sets were bus, rideshare auto, train and an inclusive mode called "other".

The mean choice set size in our data is 2.18 (with standard deviation 1.05), assuming that both time and cost of an alternative have to be known in order for it to qualify as an element in the choice set (if the respondent is unaware of the either the time or the cost of an alternative, it is unlikely that the alternative is part of the respondent's choice set).

Due to the survey design[1], no choice set can contain more than four alternatives. Consequently, right censoring of the choice set size distribution occurred. Furthermore, because the survey focused on work trip travel modes we only surveyed working respondents. Each respondent's choice set, therefore, contains *at least* one element and there are no empty choice sets. In fact, when studying modal choice set size for work trips, empty choice sets are indeed implausible (although the data collection may still be classified as choice-based, truncating the data at zero). Hence, we define the choice set of individual i as $y_i \in [1, 4]$.

From Table 1 it is evident that a large proportion (34 percent) of the respondents are captives to their chosen travel modes. It is also evident that the data on the choice set size consist of discrete, non-negative integers. Hence we are dealing with count data. Count data are frequently studied using the Poisson regression model or, a generalisation of the Poisson model, the negative binomial model.

Table 2 shows the unconditional mean and variance of the choice set size and a transformation thereof, $y_i - 1$, which will be explained and used below. Simply by looking at Table 2, we see that underdispersion (i.e. the vari-

[1] After stating the employed travel mode, only three alternative modes could be given.

Table 1: Choice set sizes, frequencies and percentages.

No of alternatives	Frequency	Percent
1	85	34.0
2	69	27.6
3	63	25.2
4	33	13.2
n	250	
$\bar{y}$	2.18	
$\hat{\sigma}$	1.05	

Table 2: Descriptive statistics of the choice set size.

Variable	Mean	Variance	Min	Max	Cases
y_i	2.18	1.09	1	4	250
$y_i - 1$	1.18	1.09	0	3	250

ance smaller than the mean) is present for the untransformed variable, while equidispersion, or very mild underdispersion, is likely for the transformed variable.

We can expect underdispersion of our data for two different reasons. First, the choice based sampling induces underdispersion on the distribution. Second, censoring reduces, by necessity, the variance of y_i, so that the data may seem more underdispersed than if censoring is not present.

In contrast to overdispersion, underdispersion will not be reduced by inclusion of regressors. On the contrary, regressors will in fact enhance underdispersion if it is present because regressors can never increase variance (Cameron & Trivedi, 1998, ch. 3). Because the negative binomial model cannot accommodate underdispersion, we do not consider this model. Instead, we begin the modelling of the choice set size with a choice-based Poisson regression model due to Shaw (1988).

3 Econometric Issues

3.1 Truncation and Censoring

In a 1988 paper, Shaw developed a Poisson model that corrects for problems associated with choice-based sampling. One of these problems is truncation at zero. Another is endogenous stratification, which means that the likelihood of being sampled depends on the frequency of use.

In our survey, we have a special form of choice-based sampling where endogenous stratification is not a problem and empty choice sets are not observed. Hence, the distribution is truncated at zero. Because the surveyed population consists of working people, the respondent has to have at least one travel mode in her choice set in order to make a work trip. Thus, empty choice sets do not exist in the population of interest either. The interesting variable to model, therefore, is the *number of alternative* travel modes in the respondent's choice set, $w_i = y_i - 1$, rather than the complete choice set, y_i.

Specifying w_i to be Poisson distributed with mean and variance μ_i and $\mathbf{x}_i$ to be a vector of explanatory variables for individual i, we have $E[y_i \mid \mathbf{x}_i] = \mu_i + 1$ and $V[y_i \mid \mathbf{x}_i] = \mu_i$. The results in Table 2 seem to validate this specification of w_i being Poisson distributed whereas y_i is not. The mean and variance are the same as in Shaw (1988). However, the conclusions from our estimation are clearly different from Shaw's. In the case of zero truncation coupled with endogenous stratification, Shaw's approach gives inference to the *total* population, whereas our approach gives inference only to the *population who performs work trips*, i.e. the population of interest in our survey. This distinction is crucial. Deriving the *unconditional* number of alternative travel modes for work trips for people without work trips makes no sense at all.

Furthermore, in our data, w_i is right censored. This censoring, imposed by the survey design, now occurs at $c = 3$.[2] We define a regression model for the latent (unobserved) count variable as $w_i^* = \mu(\mathbf{x}_i, \beta) + u_i$, where $\boldsymbol{\beta}$ is a parameter vector and the disturbance term u_i has $E[u_i] = 0$. The latent variable w_i^* and the observed dependent variable w_i are related as follows,

$$w_i^* = \begin{cases} w_i \text{ if } w_i^* < c \\ c \text{ if } w_i^* \geq c \end{cases}.$$

[2] For y_i, the censoring occurred at $c = 4$.

Let $d_i = 1$ if $w_i^* < c$ and $d_i = 0$ if $w_i^* \geq c$ be an indicator of the latent count variable. Assuming independence of the n observations, the right censored log-likelihood function is

$$\ln \ell = \sum_{i}^{n} \left\{ d_i \ln f(w_i; \mu_i) + (1 - d_i) \ln(1 - F(c-1; \mu_i)) \right\}.$$

$f(w_i; \mu_i)$ is the probability density function (pdf) for w_i and $F(c-1; \mu_i) = \Pr[w_i^* \leq c-1]$.

If $\mu_i = \exp(\mathbf{x}_i'\beta)$, the parameterised log-likelihood function equals

$$\ln \ell(\beta) = \sum_{i=1}^{n} \left\{ \begin{array}{l} d_i \left[w_i \mathbf{x}_i'\beta - \exp(\mathbf{x}_i'\beta) - \ln w_i! \right] + \\ (1 - d_i) \ln \left[1 - \exp(-\exp(\mathbf{x}_i'\beta)) \sum_{j=0}^{c-1} \frac{\exp(j\mathbf{x}_i'\beta)}{j!} \right] \end{array} \right\} \quad (1)$$

The parameters are estimated with maximum likelihood (ML) in LIMDEP.

4 Model Estimation

4.1 The Poisson Model with Censoring

The results from maximizing the log likelihood function in Equation (1) are given in Table 3. The explanatory variables used are: SEX, an indicator variable with one for women; AGE, the age in years of the respondent; CHILDREN, the number of persons younger than 18 years in the respondent's household; LICENCE, an indicator variable equal to one if the respondent has a driver's licence; DISTANCE, the respondent's distance in kilometers (km) between home and workplace; EDUCATION, the respondent's years of education; WORKTIME, the respondent's worktime in percent and INCOME, the respondent's monthly household income before tax in thousands Swedish kronor (SEK).[3]

From the estimation it is evident that only DISTANCE and INCOME have significant impact on the number of work trip travel mode alternatives at any reasonable level of significance. As suggested by intuition, the number of alternative travel modes is reduced by longer distance but is increased by higher income. However, the numerical values of both effects are small

[3] US$ 1 is approximately equal to SEK 8.

Table 3: Results from the Poisson model.

Variable	Coefficient	St dev	t-value
Constant	0.510	0.808	0.631
SEX	-0.109	0.131	-0.834
AGE	-0.002	0.012	-0.194
CHILDREN	0.021	0.062	0.349
LICENCE	0.408	0.399	1.023
DISTANCE	-0.008	0.004	-2.391
EDUCATION	-0.015	0.022	-0.712
WORKTIME	-0.006	0.004	-1.395
INCOME	0.011	0.005	2.123
n	239		
χ^2	36.30		
ln ℓ	-316.86		

since the household's monthly income before tax would have to increase by approximately SEK 83,000 ceteris paribus for the number of alternatives to increase by one unit, while increasing the distance between home and workplace by 111 km ceteris paribus reduces the number of alternatives with one unit.

Furthermore, the overall model fit of the Poisson model is given by the chi-squared statistic, equal to 36.3 with eight degrees of freedom (likelihood ratio (LR) test for all parameters equal to zero). Thus, we cannot reject this model on the basis of estimation.

4.2 Model Evaluation

Without truncation or censoring and as long as the conditional mean is correctly specified, the Poisson ML estimator (MLE) is consistent even if data is underdispersed. In the more complicated cases of truncation and censoring the MLE becomes inconsistent (Cameron & Trivedi, 1998, ch.4). For these reasons it is desirable to perform model tests after running a Poisson regression.

Several tests for over/underdispersion exist (cf. Cameron & Trivedi, 1998, chapters 3 and 5) when data is uncensored. To the best of our knowledge,

no standard test exists for over/underdispersion when data are censored. Instead of testing for over/underdispersion with tests unsuitable for censored data, we take another approach and estimate a more flexible model, the polynomial Poisson model, capable of accommodating both over- and underdispersion. Because the polynomial Poisson model nests the Poisson model, we can perform an LR test between the two models.

4.3 The Poisson Polynomial Model with Censoring

To account for the departures from equidispersion of the data, we estimate a Poisson polynomial model based on squared polynomial expansions around the Poisson baseline density (the interested reader is referred to Cameron & Johansson, 1997, who derive general results and proofs, in addition to describing and estimating polynomial Poisson models of different orders). For simplicity, we use a Poisson polynomial of order 1 (PP1). The density for a PP1 model is given by the baseline Poisson density and a first order polynomial expansion:

$$g_1(w \mid \mu, a) = \frac{\exp(-\mu_i)\mu_i^{w_i}}{w_i!} \cdot \frac{(1 + a_1 w_i)^2}{\eta_1(\mu, a)},$$

where $\eta_1(\mu, a) = 1+2a_1\mu_i+a_1^2(\mu_i+\mu_i^2)$ is a normalising constant ensuring that the density $g_1(w \mid \mu, a)$ sum to unity.[4] The numerator of the expansion term, $(1 + a_1 w_i)$, is the first order polynomial, squared to ensure non-negativity of the density. Thus, the log-likelihood function with censoring equals:

$$\ln \ell(\beta, a) = \sum_{i=1}^{n} \left\{ \begin{array}{c} d_i \left[w_i \ln \mu_i - \mu_i - \ln w_i! + 2\ln(1 + a_1 w_i) - \ln \eta_1(\mu, a) \right] \\ +(1 - d_i) \left[\ln(1 - \frac{\exp(-\mu_i)}{\eta_1(\mu,a)} \cdot \sum_{j=0}^{c-1} \frac{\mu_i^j (1+ja_1)^2}{j!}) \right] \end{array} \right\}.$$

We estimate the model with mean specified as in the Poisson model, $\mu_i = \exp(\mathbf{x}_i'\beta)$. The result from the ML estimation conducted in LIMDEP is given in Table 4. The explanatory variables are the same as in the Poisson model, with the exception of the polynomial coefficient, a_1, defined above. Because

[4] The conditional mean and variance are, respectively, $E[w_i \mid \mathbf{x}_i] = (m_1 + 2a_1 m_2 + a_1^2 m_3)/\eta_1(\mu, a)$ and $V[w_i \mid \mathbf{x}_i] = \frac{m_2+2a_1 m_3+a_1^2 m_4}{\eta_1(\mu,a)} - \left(\frac{m_1+2a_1 m_2+a_1^2 m_3}{\eta_1(\mu,a)}\right)^2$, where $m_1 - m_4$ are the first four moments of the Poisson density, $m_1 = \mu_i$, $m_2 = \mu_i + \mu_i^2$, $m_3 = \mu_i + 3\mu_i^2 + \mu_i^3$ and $m_4 = \mu_i + 7\mu_i^2 + 6\mu_i^3 + \mu_i^5$.

Table 4: Results from the PP1 model.

Variable	Coefficient	St dev	t-value
Constant	0.510	0.905	0.563
SEX	-0.109	0.131	-0.834
AGE	-0.002	0.012	-0.194
CHILDREN	0.021	0.061	0.349
LICENCE	0.408	0.399	1.023
DISTANCE	-0.008	0.003	-2.391
EDUCATION	-0.015	0.021	-0.712
WORKTIME	-0.006	0.004	-1.395
INCOME	0.011	0.005	2.123
a_1	-0.000	0.203	-0.000
n	239		
$\ln \ell$	-316.86		

the PP1 model nests the Poisson model, the PP1 model cannot improve the Poisson model when $a_1 = 0$.

From Table 4 it is evident that the polynomial coefficient is insignificant, so that the PP1 model cannot improve the Poisson model. Consequently, both models give the same parameter estimates, loglikelihood values and predicted probabilities (see Table 5). Thus, the ordinary Poisson model cannot be rejected and can, therefore, adequately describe the data.

5 Model Comparison and Discussion

Two different count data models were estimated in order to explain the number of alternative travel modes for work trips. First, a Poisson model was estimated and then, in order to allow for departures from the Poisson assumption of equidispersed data, a PP1 model. Because the PP1 model could not improve the Poisson model, we conclude that an ordinary Poisson model is appropriate for estimations.

In Table 5, actual and predicted probabilities from the Poisson and the PP1 models are compared for the number of alternative travel modes for work trips. Evidently, there is a problem of excess zeros, i.e. the actual proportion of zeros is larger than the corresponding proportion in the Poisson parent

Table 5: Predicted probabilities for w_i from the estimated models.

Counts	Actual	Poisson/PP1
0	0.3222	0.2939
1	0.2887	0.3481
2	0.2510	0.2192
3	0.1381	0.1388
n	239	239
$\ln \ell$		-316.86

distribution.

Altogether, only the respondent's income and distance to the workplace can be shown to have significant impact on the number of alternative travel modes for work trips, where increases in income and decreases in distance increases the number of alternatives. It is interesting to think about the implications of these results. As mentioned in the introduction, when the value of time is estimated in random utility models, only those that are not captives to their chosen mode, i.e. with choice sets ≥ 2 (number of alternative travel modes ≥ 1), are included in estimation.[5] Our results imply that people with lower income have fewer alternatives, which means that they are more likely to be excluded from the value of time estimation. If lower income implies lower value of time, the value of time estimated in a random utility model is biased upwards and, thus, exaggerates the value of time.

Because explanatory variables such as income and distance frequently are used (and proved significant) in random utility models of travel mode choice, a holistic approach to estimating the value of time would be to *simultaneously* model choice sets *and* modal choice, instead of taking the choice set as given. Gensch (1987) estimated a two-stage model for the choice set generation and the subsequent choice where the first stage consisted of a non-compensatory maximum likelihood hierarchical (MLH) model and the second stage of a compensatory logit model. In order to estimate such a model, data must be available on the respondents' ratings or ranking of several different modal attributes.

In cases *un*like ours, where the exact size (and composition) of the in-

[5] In our sample, about one-third of the respondents are captives to their chosen mode (see Table 1).

dividuals' choice sets is unknown and, therefore, assumed to be identical across individuals, the parameterized logit captivity (PLC) model by Swait & Ben-Akiva (1987) can be estimated.[6] In the PLC model the propensity for being captive is accounted for by a function of the respondents' characteristics and/or modal attributes (which means that captivity can vary between respondents), so that there are separate functions for captivity and utility. Our results indicate that it is imperative to include income and distance in the captivity function. The resulting value of time from the PLC model could then be compared with the corresponding multinominal logit (MNL) value of time and the predicted number of captives from the PLC model could be compared with the actual number. Additionally, a likelihood ratio test between the two models could be performed because the PLC model nests the MNL model.[7]

[6] The PLC model is a generalisation of the dogit model by Gaudry and Dagenais (1979).

[7] Swait & Ben-Akiva (1987) found values of time from the PLC model to be two to 28 times *greater* than the corresponding values from a MNL model. The hypothesis of no captivity was rejected in an LR test.

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Economics Without Markets

Four papers on Contingent Valuation and Stated Preference Methods

Maria Vredin Johansson

Abstract

This thesis consists of four papers. The first two papers deal with the valuation of an endangered species, the African elephant. The third paper is on the assessment of attribute values for work trips. The fourth paper models the number of alternative travel modes for work trips.

Paper [I] reports benefit estimates from a Contingent Valuation (CV) survey of Swedish households' willingness to pay (WTP) for the preservation of the African elephant. Methodological aspects of the CV method are addressed, such as the method's susceptibility to variations in the payment vehicle and in the time-horizon of the payment obligation. None of the treatments have significant impact on the WTP.

Paper [II] analyses determinants of the WTP from Paper [I]. A double hurdle model for household choice is formulated where the household first decides whether to give to elephant protection or not and, then, decides on the size of the donation. The model is estimated with Heckman's two-step estimator. With one exception, the determinants significant for the decision to give are not the same as the ones significant for the decision on how much to give.

Paper [III] uses stated preference data to estimate the values of time and safety for work trips. In standard and random parameters logit models the respondent's modal choice is related to the perceived time, cost, safety, and environmental friendliness or flexibility of the alternatives. The perceived time, cost and safety are shown to significantly affect the choice of work trip travel mode. From the estimated models we assess attribute values for time and safety.

Paper [IV] estimates two count data models, an ordinary Poisson and a polynomial Poisson of order one (PP1), to explain the individual's number of alternative travel modes for work trips. The PP1 model, which allows for departures from equidispersed data, cannot improve the Poisson model. The individual's income and the distance to the workplace are found to affect the number of alternative travel modes for work trips.

Key words: Intertemporal Embedding, Discrete/Continuous Choice, Value of Statistical Life, Value of Time, Random Parameters Logit, Count Data, Choice Set Size.

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Uppsala in October, 1999

Maria Vredin Johansson

This thesis consists of this summary and the following four papers:

[I] Valuing a Peripheral Environmental Amenity. The Swedes' Willingness to Pay for the Survival of the African Elephant

[II] Determinants of Charitable Giving. Evidence from Hypothetical Data on Willingness to Pay

[III] Using Modal Perceptions to Determine Work Trip Travel Mode

[IV] What Determines the Number of Alternative Travel Modes for Work Trips?

1 Economics without Markets

The moon belongs to everyone,
The best things in life are free
The stars belong to everyone
They gleam there for you and me.
Song by Buddy De Silva and Lew Brown.

From the song we learn that "the best things in life are free", which implies that the things we value most in life are priceless and cannot be bought or sold on any markets. Even apart from the moon, the stars, and basic human rights and needs, such as freedom, friendship, health and love, there are other things such as, for instance, unspoiled nature and clean air, that positively affect the welfare of many people. Such "goods"[1] are frequently public, and their effect on people's welfare hard to measure. Nonetheless, it is sometimes desirable to quantify those effects.

For instance, when the provision of a public good depends on the amount of taxes raised for its provision, it is important to have an idea about the size of the benefits so that the taxes collected correspond to the benefits received. Information about the size of the benefits can, thereby, facilitate social decisions on provision.

When evaluating the social desirability of projects affecting the welfare of many people, cost-benefit analyses are frequently employed. In cost-benefit analyses, benefits are weighted against costs and, in order to simplify comparison, the effects are monetised. To be able to monetise effects that are not inherently monetary, we have to apply some kind of non-market valuation method. This thesis is about two different methods for economic valuation of non-marketed goods, the contingent valuation method and conjoint analysis.

2 Non-Market Valuation

There are basically two different approaches to determining the value of non-marketed public goods, the revealed preferences (RP) approach and the stated preferences (SP) approach.[2]

[1] Good is used inclusively, incorporating services.

[2] We do not aspire to completeness when describing some of the existing non-market valuation methods.

RP methods rely on preferences being conveyed through observable market behaviour. Therefore, RP methods can only be used to value goods whose values can be inferred from the behavior in another market, as in the travel cost method or the hedonic pricing method (cf. Hanley and Spash, 1993). Thus, RP methods are limited in application.

SP methods can be used if we want to estimate the value of a good for which there is no connected regular market, or, if we want to predict the market share for a new good. One of the most frequently used SP methods is the contingent valuation (CV) method. The CV method has predominantly been used in environmental economics, but there are also applications in transportation and health economics. Another SP technique, most common in marketing, is conjoint analysis (CA). CA is a technique for evaluating multiattribute commodities.[3]

In the literature, there appears to be some semantic confusion regarding the use of the term CA. In some applications, CA refers to the *elicitation procedure* in an SP study, while it in others refers to the *method for analysing SP data* (Johnson & Desvousges, 1997). From our point of view, CA is just one of several SP methods. However, we adhere to today's common practise and employ SP when referring to the specific *elicitation procedure* employed in conjoint analysis experiments. The methods for *analysing* SP data will henceforth be referred to by the conventional statistical terminology, like logit, probit and so on. Below follows a brief introduction and description of the CV and SP methods and their experimental designs.

2.1 Contingent Valuation

Even though Ciriacy-Wantrup as early as 1947 proposed the use of the "direct interview method" for measuring the value of natural resources, it was not until the 1960's that the contingent valuation method first came into use (Davis, 1963). In order to measure the benefits from a particular recreation area, Davis interviewed hunters and recreationists. Nearly all the following, early uses of the contingent valuation method involved valuations of recreational benefits or natural resources, such as hunting rights (Hammack &

[3]While RP methods depend on behaviour being observed in *real* markets, SP methods depend on *hypothetical* market behaviour. Between the polar cases of RP and SP, economic experimental methods are found. In an economic experiment the individual's behaviour is affected by *real* gains and losses, while still in an experimental context (cf. Kagel & Roth, 1995).

Brown, 1974) and clean air (Ridker, 1967). One exception was Acton (1973) who estimated the value of programs aimed at reducing the risk of dying from heart attacks. In 1974, the first volume of the *Journal of Environmental Economics and Management* published a paper by Randall, Ives and Eastman. In that paper, the contingent valuation method was introduced to a broader audience. Ever since the 1970's, the contingent valuation method has been frequently applied, and many of the surveys performed have been explorative, investigating the merits and demerits of the CV method. The CV method is now an established and well-known method for measuring project benefits, especially in environmental economics.

2.2 Experimental Design

In a contingent valuation survey the absence of a real market is circumvented by a carefully structured hypothetical market and, as the elicited willingness to pay (WTP) (or the willingness to accept, WTA)[4] are contingent on the particular hypothetical market constructed, the method is known as the contingent valuation method.[5] Through this surrogate market the researcher, via interviews (personal or telephone) or mail questionnaires, elicits the respondents' preferences for the amenity.[6] During the elicitation process, the respondent is asked to state her maximum WTP to achieve a welfare improvement.

The elicitation could be done in several different ways; in an open-ended question, in a single referendum question[7], or in the form of a bidding game. In an open-ended question the respondent is asked to state the maximum amount she is willing to pay while, in the referendum format, the respondent is presented with a posted price that she is asked to reject or accept. A bidding game is a repeated game where the researcher tries to bracket the respondent's maximum WTP by presenting her with higher and higher bids.

[4] The WTP format is by far the most widely used in CV surveys, as the WTA format (in many settings) cannot elicit valid data (Mitchell & Carson, 1989). Therefore, we make no further reference to WTA.

[5] During the years the contingent valuation method has been called the survey method, the interview method, the direct interview method, the direct questioning method, the hypothetical demand curve estimation method, the difference mapping method and the preference elicitation method (Mitchell & Carson, 1989).

[6] The interested reader is referred to Mitchell and Carson (1989) and Cummings et al. (1986) for much more on the CV method.

[7] Also known as the discrete choice or closed-ended format.

A lower value for the WTP is bracketed in a similar manner.

While Davis (1963) used an open-ended question (proposed by Ciriacy-Wantrup in 1947), Randall et al. (1974) implemented a sequential bidding question format (proposed by Bradford in 1970) in which the WTP was bracketed by a series of referendum payment questions. Although, the bidding format on several accounts was argued as being preferable, the most commonly used formats during the early 1980's was the open-ended (Green et al., 1998).

Bishop and Heberlein (1979) and Hanemann (1984) introduced the single referendum (discrete choice) questions in which the respondent had to accept or reject a single bid. The bids varied among the respondents according to an experimental design and the mean WTP was estimated parametrically or non-parametrically.

The single referendum format is claimed to be more akin to an ordinary market situation where the respondent is faced with a posted price. In 1993, the single referendum format was endorsed as the preferred procedure for CV analysis in the well-known NOAA-report (Arrow et al., 1993).

Notwithstanding the referendum format's official endorsement, open-ended responses are richer in information and statistically more efficient than referendum data. Moreover, the mean responses to single referendum questions have recently been shown to systematically exceed their open-ended equivalents (Green et al., 1998; O'Conor et al., 1999). Therefore, even in non-monetary valuation, discrete choice questions are prone to inflation. Inflated benefit values are by no means innocent because overprovision, at the expense of other desirable goods, will result when they are applied to cost-benefit analyses.

2.3 Stated Preferences

Building on mathematical and experimental psychology, the SP method was first applied in marketing as a devise for predicting market shares for new products (cf. Green & Srinivasan, 1978; 1990). The method was then picked up in travel behaviour research to make individuals' reveal their trade-offs between modal attributes in the choice of travel mode. Adamowicz et al. (1994) is one of the first applications of SP in environmental economics and there are also applications in tourism economics (cf. Louviere & Timmer-

mans, 1990).[8]

SP experiments deals with complex decision making and complex product evaluation, where the respondents systematically evaluate trade-offs between attributes. In an SP experiment a hypothetical choice situation is constructed where the respondent is confronted with different alternatives (real or constructed). The different alternatives are characterised by various attributes, for instance, in a travel mode choice experiment, time, cost and safety, and different levels of these attributes. The respondents is then supposed to rate or rank the alternatives, or to choose one of the alternatives. The number of alternatives for the respondent to evaluate may vary in different experiments, but the overall design of the experiment is constructed to control for the correlation between the attributes, which makes separate valuation of the attributes made possible. If *one* of the attributes is monetary (e.g. travel cost) marginal rates of substitution between this attribute and the other attributes (e.g. travel time and safety) result in an economic valuation of the latter. Such simultaneous valuations are useful in project evaluations performed by, for instance, the Swedish National Road Administration (SNRA).

2.4 Experimental Design

An SP experiment can be planned and performed by a step-by-step procedure. The following seven steps are adapted from Hensher (1994). Although the procedure might seem straightforward, one should not underestimate the considerations made at each step. We exemplify the procedure with a travel mode choice experiment.

In step *one* the experimenter decides which attributes to include in the experimental design. For example, there may be an array of attributes that may influence the choice of travel mode and the experimenter has to decide which ones that are important for the decision and which are not. Because the complexity and the size of the experiment grow considerably as more attributes are included, the gains from including one more attribute should be weighted against the cost.

In step *two* a measurement unit for each attribute has to be selected. Quantitative attributes like travel cost and travel time are probably most conveniently measured in their usual metrics - money or time, respectively.

[8] The 1988 Special Issue on Stated Preference Models in the *Journal of Transport Economics and Policy*, **20**(1), provides a good introduction to SP theory, methods and applications.

For qualitative attributes, such as safety, comfort and environmental effects, the measurement units have to be *invented* and *communicated* to the respondents. If, for instance, scales ranging from low to high are employed, the implications of each level must be carefully described. An alternative way for the experimenter is to *endogenise* the construction of a metric scale by letting the respondent decide on the current attribute level and then use variations from that level in the experiment.

In step *three* the experimenter has to specify the attribute levels to be employed, i.e. the number of levels and each levels magnitude. For existing alternatives, the recommendation is to use the current level as one of the levels while, for hypothetical alternatives, the recommendation is to keep the levels believable and deliverable. In this step the experimenter also has to decide on which attribute interactions that are important and how the respondent is going to be exposed to them. The overall complexity of the experimental design will be contingent on the number of levels for each attribute.

In step *four* the attribute levels are combined into an experiment. Each combination of attribute levels is produced with the aid of statistical design theory (a combinatorial problem) and describes an *alternative,* or *treatment*, or *profile*. Combinations of attribute levels for all attributes in the experiment are used to construct a *factorial* design. For example, if an experiment consists of four attributes (e.g. time, cost, safety and flexibility) with five levels each (ranging from very high to very low), there are $5^4 = 625$ combinations of attributes, resulting in 625 different alternatives in the *full* factorial design. Because no respondent arguably could be required to evaluate such an extensive number of alternatives, *fractional* factorial designs are often employed. In a fractional factorial design the number of alternatives is reduced to a "manageable" size. When reducing the number of alternatives, some of the alternatives are relatively easy to discard immediately, for instance, alternatives that are either dominant or dominated (superior or inferior on all attributes). The cost of reducing the number of alternatives is loss of statistical efficiency because we have to assume that some, or all, interaction effects between attributes (e.g time-cost and cost-safety effects) are statistically insignificant. The assumption of insignificance "[...] is a very reasonable and non-testable assumption for a large number of possible interactions, especially interactions of more than two attributes (e.g. three-way interactions), and indeed for many two-way interactions" (Hensher, 1994, p. 115-116). The most common fractional factorial design is the *main effects*

plan where only the main effects (time, cost, safety and flexibility) can be measured without confounding. Thus, a main effects plan only provides a sufficient number of alternatives to estimate attribute specific effects. The relevant number of alternatives in a main effects plan depends on the overall size of the experiment, i.e. on the number of attributes and attribute levels.

Nonetheless, there might still be too many alternatives for the respondent to evaluate in the main effects plan. A solution is to expose different subsamples of respondents to different subsets of alternatives. This could be done either through "blocking" (cf. Box et al., 1978) or through randomisation of the alternatives. When blocking is employed a subset of the respondents is presented with a fixed subset of the alternatives, while in randomisation, the subset of alternatives is random. In both blocking and randomising, the important thing is that all alternatives have equal representation in the overall experiment, and that different treatments are randomised over respondents.

In step *five* the design from step four has to be communicated to the respondent through a comprehendible survey design. This step is also the data collection phase. The survey instrument may be designed for in-person interviews (with or without the aid of computers), telephone interviews, mail questionnaires, or combinations thereof. Data collection on choices could be made in either one of three ways; through contingent rating, contingent ranking or through stated choices. Contingent rating generates the richest information on choices, producing both ordering and strength of preference for every alternative. The respondent is usually asked to grade each alternative on a rating scale with, for instance, ten or 100 points. In contingent ranking the respondent is asked to rank the different alternatives, e.g. if there are five alternatives the respondent is asked to give rank one to the one she prefers the most, rank two to the one she likes the next most, and so on. The procedure generates an ordering of alternatives but does not convey any information on the degree of preference. Because both the contingent rating and ranking approach might be too demanding for the respondent, an alternative approach, the stated choice technique, has been developed. In stated choice two or more alternatives are presented to the respondent who is asked to choose one of them (a status quo alternative, a "don't know" alternative or a "none" alternative may be included). The stated choice approach is assumed to be more similar to an ordinary choice situation for the respondent.

In step *six* the appropriate estimation procedure has to be selected depending on the kind of data collected. With ratings data, for instance, gen-

eralised least squares (GLS) or maximum likelihood (ML) for models such as logit, probit, or their ordered versions, may be applicable. With rankings data, multinominal or ordered logit ML procedures may be relevant and, with stated choice data, the ML estimator for logit, probit or multinominal logit models may be of use.

In the final step, step *seven*, choice probabilities for each alternative for each respondent is estimated using the parameters from the estimations in step six. These choice probabilities can, together with population weights, be used to predict market behaviour and market shares and/or total demand. In many cases, this is the ultimate end of an SP experiment.

2.5 Comparing Methods

In a typical single referendum format CV survey, only the price (bid) attribute varies over respondents (in some surveys also the quantity of the good varies, cf. Boman & Bostedt, 1995; Kahneman & Knetsch, 1992; Boyle et al., 1994). Thus, the single referendum CV format is a special case of the more general SP method, in which more than one attribute is varied. Compared with CV, the SP valuation process is less complicated, but also less transparent. Consequently, the existence of strategic bias is potentially smaller in SP surveys (Halvorsen et al., 1996). Furthermore, SP avoids problems with part-whole biases which may occur if the respondent values a more inclusive category of goods than the good itself (Hanley et al., 1998).

Whilst Halvorsen et al. (1996) suggest that CV and SP are complementary ways of valuation, Hanley et al. (1998) find that the CV and SP methods have different merits. Whereas CV is best suited to an overall evaluation of goods and policies, SP is better suited for attribute evaluation.

3 A Summary of the Papers

3.1 Paper [I] Valuing a Peripheral Environmental Amenity. The Swedes' Willingness to Pay for the Survival of the African Elephant

The first and the second of the papers in this thesis are based on a CV survey concerning the willingness to pay for the preservation of the African

elephant. A mail questionnaire (with two follow-ups) was sent to 1,500 randomly selected Swedish residents, aged between 18 and 75 years, during January-March 1996. The questionnaire contained socio-economic questions and questions regarding the respondent's interest in the natural environment in general and in the African elephant in particular. Furthermore, the respondents were asked an *open-ended* valuation question for a project aimed at preserving the African elephant.

The WTP stated by the respondent was in the form of an annual payment obligation and the overall response rate was 60.2 percent.

Apart from estimating the Swedes' annual WTP for the African elephant, we addressed some methodological issues associated with the CV method, such as its sensitivity to differential valuation stimuli. In order to accomplish the experiments, the total sample was split in four equally sized groups (A-D), where respondents were randomly assigned one of four different treatments. Small variations in the elements of the scenario regarding the time-horizon for the payment obligation and the payment vehicle, meant that each subgroup received a slightly different valuation question. Subgroup A's payment vehicle was an annual *voluntary* payment without specified time-horizon; subgroup B's payment vehicle was an annual *voluntary* payment made every year for *three* years; subgroup C's payment vehicle was an annual *voluntary* payment made every year for *ten* years and, finally, subgroup D's payment vehicle was a *tax* receipt without specified time-horizon.

Designing the valuation question this way had two purposes; first, we wanted to test whether the CV method is susceptible to intertemporal embedding and second, we wanted to examine whether there are differences in the WTP dependent on the type of payment vehicle used.

Intertemporal embedding results if the respondent is insensitive to the timing and the frequency of the payment obligation. While economic theory does not predict that the value of a good should depend on how often one has to pay for it, aggregated WTP estimates can be much larger when the payment is described as a continuous, long-term commitment rather than a lump sum fee. Because there is no agreed upon basis for how to choose between a one-time payment and a continuous payment scheme, the valuations could easily be manipulated by changing the payment schedule if there is intertemporal embedding.

We were able to test the hypothesis of differences in mean annual WTP by comparing the valuation resulting from subsample B's response to the valuation question with the response from subsample C. Furthermore, it was

possible to compare the time-specified commitments (B and C) with an unspecified commitment (A). Performing both parametric and non-parametric tests, we could not reject the hypothesis of equality of the means. Consequently, we conclude that respondents do not seem to discriminate between different payment schemes.

Because amenities valued in CV surveys are not market goods, the payment vehicle used in a survey is chosen on the basis of realism, i.e. what method of payment would most likely be used if the amenity was an ordinary market good. In our survey, we considered that two different payment vehicles were feasible - a voluntary donation and a tax payment. Based on results in economic theory, we tested whether the WTP resulting from being asked to pay voluntarily (A) is significantly larger than the WTP resulting from a tax payment (D).

However, as the mean WTP from the tax vehicle proved to be larger than that from the voluntary vehicle, we could immediately reject this hypothesis. In fact, using both parametric and non-parametric tests, we were unable to detect any significant differences in the mean WTP's resulting from the different payment modes. Therefore, we conclude that the respondents do not discriminate between different payment vehicles.

The overall annual mean and median WTP were found to be SEK 238 and SEK 100, respectively. Altogether, the median seems to be a robust measure of a Swedish household's WTP for the preservation of the African elephant.

3.2 Paper [II] Determinants of Charitable Giving. Evidence from Hypothetical Data on Willingness to Pay

The second paper analyses why people are willing to pay voluntarily for elephant protection. The purpose is to examine whether the factors contributing to the decision to give at the *extensive* margin (whether to give or not) are different from the factors influencing the decision to give at the *intensive* margin (how much to give).

Derived from utility theory, a two-step model is formulated in which the household first faces the dichotomous choice between giving and not giving and then, contingent on the decision to give, faces the decision of how much to give. The model is subsequently estimated using Heckman's two-step es-

timator (Heckman, 1979), where a probit model is estimated for the decision to give and a linear regression model for the size of the donation. We use the same set of regressors in both models, except for the Heckman correction term that is added to the regression model.

Significant determinants of the decision to give include household income and membership in environmental organisations. Determinants of the size of the donation are, among others, the respondent's age and whether the respondent had visited Africa prior to receiving the questionnaire. With one exception (the membership dummy variable), the determinants significant for the decision to give are *not* the same as the determinants significant for the decision of how much to give. For instance, household income is a significant determinant of the decision to give, but it is insignificant for the size of the donation. Moreover, the Heckman correction parameter is insignificant in the linear regression part of the model.

We test the assumption of bivariate normality between the two decisions by using a method devised by Pagan and Vella (1989). Because we are unable to reject the assumption of bivariate normality, the model's appropriateness is enhanced. Given bivariate normality, the insignificance of Heckman's correction term indicates that the discrete and continuous parts of the model may be estimated separately, which, in turn, implies that the decision to give at the extensive margin is independent of the decision to give at the intensive margin.

However, when estimating the different processes separately, significant heteroscedasticity is found in the linear regression model. This indicates that the two-part Heckman model, which is inherently heteroscedastic (cf. Greene, 1993, ch. 22), is the more appropriate choice of model, even though the correction term proved to be insignificant.

Overall, because the determinants of giving to elephant protection are reasonable, the reliability of the CV benefit estimates of paper [I] is enhanced.

3.3 Paper [III] Using Modal Perceptions to Determine Work Trip Travel Mode

The third paper in this thesis is based on a revealed and stated preference mail survey. A questionnaire (with one reminder) was sent to 480 randomly selected residents of two Swedish municipalities (Borlänge and Falun), aged between 36 and 55 years, during December 1997 - January 1998. The over-

all response rate was 66.8 percent. In addition to socio-economic questions and questions regarding the respondent's actual work trip travel mode, the questionnaire contained questions about the respondent's alternative travel modes. The experimental SP design used was constructed by selecting the smallest orthogonal main effects plan from the full factorial through blocking. Consequently, we are able to estimate all main effects, but none of the interaction effects. The two SP questions were in the form of stated choice where the respondent made pairwise comparisons between alternatives and chose the preferred one.

Based on the data from the stated choice experiment, we estimate standard and random parameters logit models of commuters' choice of travel mode. The choices are explained by the individual's perceptions of four modal attributes; time, cost, safety and environmental friendliness *or* flexibility. Depending on the attributes evaluated by the respondent, the sample was divided into an environmental friendliness and a flexibility subsample. The respondents' preferences were elicited by a novel approach in which the names of two modes (auto and bus) were used as attribute levels instead of objective levels. Based on the respondents' revealed preferences, we infer "perceptions-based" real values for the time and cost attributes. In the estimation the inferred values are used together with the perceptions of the other attributes. From the estimated model we derive a value of time for work trips and a monetary value for safety improvements, i.e. the value of statistical life. The value of time is found to be approximately SEK 40 per hour and a lower bound for the value of statistical life is found to be SEK 4.3 million. Time savings and saved statistical lives are the major benefits in project evaluations of the Swedish National Road Administration (SNRA). Whereas the SNRA use values derived from separate studies, we estimate the values in the same model.

3.4 Paper [IV] What Determines the Number of Alternative Travel Modes for Work Trips?

In the fourth paper, we use data from the SP survey described in Paper [III] and estimate two different count data models in order to explain the individual's number of alternative travel modes for work trips. First, a Poisson model is estimated and then, in order to allow for departures from the Poisson assumption of equidispersed data, a polynomial Poisson model of order

1 (PP1). Because the PP1 model could not improve the Poisson model, an ordinary Poisson model is found appropriate. Only the respondent's income and distance to the workplace can be shown to have significant impact on the number of alternative travel modes for work trips, where increases in income and decreases in distance increases the number of alternatives.

In economic transportation research, the value of time is frequently estimated by using random utility models. In such models only those that are not "captives" to their chosen mode, i.e. respondents with one or more alternative travel modes in their choice sets, are included in the estimations (in our sample about one-third of the respondents were captives). Our results imply that people with lower incomes have fewer alternatives, which means that they are more likely to be excluded from the value of time estimations. If people with lower incomes have lower values of time, the value of time derived from random utility models is likely to be overestimated.

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