I.T. Transport Ltd.

DFID Department for International Development

How to Manual

The Valuation of Rural Travel Time Savings in Least Developed Countries

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This is one of the outputs of the UK Department of International Development (DFID) supported studies under its Knowledge and Research (KaR) Programme on the valuation of rural travel time savings in Least Developed Countries. The first study was conducted in Bangladesh in 2001-02 (Contract No R7785) and the second one was conducted in Ghana and Tanzania in 2004-05 (Contract No R8307).

Preface

The manual is designed to bring out issues that are relevant in the valuation of rural travel time savings in Least Developed Countries (LDCs). It is one of the outputs of DFID supported studies on the valuation of travel time savings in Least Developed Countries (LDCs). It should also be relevant for other developing countries which do not have LDC status but have rural economy features typical of low income developing countries. The manual elaborates step-by-step procedures on how to design and execute studies to estimate the value of time (VoT) savings of rural travellers.

Professionals who are involved in the economic appraisal of transport/access projects, especially rural projects, in developing countries are the main target group of the manual. Researchers, academics, and students may find this manual useful in understanding issues related to travel time savings in developing countries in general and rural travel time savings in particular. Transport planners/engineers/economists may find the guidance on VoT values to be used in project appraisal provided at the end of the manual useful when time and resource constraints do not permit local empirical studies to estimate VoT.

There are six chapters in this manual. Chapter 1 justifies the importance of including travellers' time saving benefits in rural transport project appraisal in developing countries and briefly explains the theories underlying valuation of travel time savings. Chapter 2 presents alternative methods for measuring travel time saving values, discusses important issues related to valuing travel time saving values in developing countries and identifies factors that may influence the rural travel time saving values. While Chapter 3 sets out the step by step procedures for designing a VoT study, Chapter 4 outlines the use of qualitative methods in VoT studies. Chapter 5 explains the analysis of the preference data that are generated from 'willingness to pay' (WTP) surveys. Chapter 6 summarises the suggested methodologies to be used for valuing travel time savings and includes guidance on values to be used where local VoT estimates are not available and conducting VoT studies is not feasible.

Abbreviations

BVoT	Boundary Value of Time
DFID	Department for International Development
FGD	Focus group discussion
HL	Hierarchical Logit
hr	Hour
IVT	In-vehicle time
KaR	Knowledge and Research
LDC	Least developed country
min	Minutes
MNL	Multinomial logit models
PLA	Participatory learning and action
PRA	Participatory rural appraisal
RP	Revealed preference
RRA	Rapid rural appraisal
SCF	Standard conversion factor
SP	Stated preference
SWR	Shadow wage rate
Tk	Taka (Bangladeshi currency)
TZS	Tanzanian Shilling (Tanzanian Currency)
VoT	Value of time
WTP	Willingness to pay

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1. Introduction

Why value rural people's time savings?

In developed countries, travel time savings can account for a large proportion of benefits (as much as 80% in some cases) from transport infrastructure investment. However, in Least Developed Countries (LDCs) and in many other developing countries, especially in rural areas, such savings are either not included in transport project appraisal or they are valued based on questionable assumptions and methods. Although the importance of travel time savings is now recognised, the practice of including the value of travel time savings in the appraisal of rural transport projects in developing countries is not widespread.

A number of somewhat interrelated reasons have contributed to the exclusion of travel time saving benefits from rural transport project appraisal in developing countries. The first reason is an objection to using conventional models of VoT estimation used in developed countries in the rural context in developing countries where the work patterns, particularly of the poor, are diverse and the formal part of the economy is limited. Low rural incomes and underemployment also underlie the assumption of very low or even zero value of time of rural people at the margin and therefore a justification for ignoring time saving benefits. Consequently, vehicle operating cost savings are typically assumed to be the most important economic benefits of rural transport investment projects.

In the last two decades, a number of studies in Asia and Africa that dealt with the transport needs of rural people, time allocation in rural households and time requirements for meeting basic needs have demonstrated the importance of the time constraints faced by rural people. The travel and transport activities undertaken by rural people in general and the poorer people in particular in LDCs take place on local roads, tracks and paths and involve walking or headloading. Therefore, if the local transport infrastructure and services are improved, they are likely to bring about substantial time saving benefits from improved speeds and modal shifts. In the context of global efforts to reduce poverty, including the value of rural travel time savings in investment decisions in LDCs would lead to more pro-rural and pro-poor allocation of resources.

IT Transport, with financial support from DFID, undertook two studies to address the issues related to valuation of rural travel time savings in three LDCs (Bangladesh, Ghana and Tanzania). The studies demonstrated that with some adaptation and understanding of the rural context, conventional methods for estimating VoT can be applied in developing countries. This manual is one of the outputs of the two studies.

What is the meaning of VoT?

Time spent in travelling has an opportunity cost. Conventionally, a distinction is made between travelling in the course of employment and in travellers' own time. Travel time spent in the course of work is expected to affect the productivity of travelling employees. Therefore, the value of work related travel is linked to the value of production foregone. Travel time outside work may have been utilised in

other activities, including leisure. Therefore, saving travel time is generally preferred and brings about increased satisfaction or "utility" on the part of the traveller. The value of non-work travel time is represented by the "willingness to pay" to save travel time.

What are the underlying theories of VoT?

Economic theories provide the conceptual models for valuing travel time savings. For time savings while travelling during work, marginal productivity theory which explains allocation of resources for production is the relevant model. For travel time savings when not working, the theory of consumer welfare maximisation is relevant.

The value of working time savings for a travelling employee is assumed to be the value of the employee's saved time to the employer. Marginal productivity theory states that an employer seeking to maximise profit will hire labour up to the point where the marginal value of an extra unit of labour is equal to the cost of that unit. The cost to the employer of employing a person is the wage rate and other employment related costs such as employment taxes and social security contributions. The wage rate and the additional employment related costs are also referred to as 'the augmented wage rate'.

According to marginal productivity theory the value of output produced by an employee in the last unit of time used in production (the marginal productivity of labour) is equivalent to the augmented wage rate paid for that unit of time. It is assumed that an employee's saved travel time can be allocated to production and the value of the additional output will be equivalent to the augmented wage rate[1].

Consumer welfare maximisation is the conceptual model for valuing non-work travel time savings. The model assumes that each rational individual attempts to maximise the satisfaction or utility derived from the consumption of a range of goods and services permitted by the budget. For deriving the value of time saving, the model has to be modified to incorporate the allocation of time to various activities and recognise that time available for leisure or other discretionary activities also provides utility (or value) for which the individual is willing to pay.

In this modified model, welfare is maximised subject to two constraints: (i) a certain amount of time must be devoted to work to earn income to spend on consumption of goods and services, and (ii) work, leisure and travel compete with each other as the number of hours in a day is limited. By devoting more time to work an individual may earn more and increase spending on goods and services. However, he/she has to sacrifice time for leisure and discretionary activities. Similarly an individual may also extend work and leisure time by reducing travel time (e.g. by choosing faster transport modes). The choices made by an individual depend upon the relative utilities (or levels of satisfaction) derived from

[1] A number of simplifying assumptions have been made in arriving at this result. These are briefly discussed in the next chapter where the application of the result in valuing time in a developing country is considered.

more time available for leisure compared with the cost of faster transport. Conditions for choices which maximise welfare can be derived mathematically (see Appendix I). However, the empirical evidence required for estimating the value of non-work time savings can only be derived from observing actual choices made or asking travellers to state their preferences.

2. Valuation of Travel Time Savings

How saved travel time is differentiated?

As noted in the previous chapter, a distinction is made in the conventional approach to valuing travel time savings between:

- travel time saved in the course of work (on employer's business), and
- travel time saved for non-work travel (which includes commuting).

In applying the model in the rural context in developing countries, it is necessary to consider whether such a distinction is valid, how work trips are defined and whether non-work travel time savings can be assumed to be transferred to leisure. These issues are considered below.

What are work trips?

The typical definition of a work trip is a trip that is undertaken while a person is engaged in work for an employer and is being paid during the trip. Although such a definition may be relevant in an urban or a developed country context, it may not be applicable in the rural economy in a developing country where a large proportion of the population is engaged in a combination of formal and informal employment, subsistence production and other basic household activities such as fetching water and fuel. Thus there is a need to modify the definition of a work trip.

IT Transport (2002, 2005) proposed that in the rural context of a developing country, in addition to trips made in the course of work for an employer, work trips should include trips made in the course of work as a self employed person and trips made for purchasing/selling of goods for profit. In Bangladesh and Ghana, less than 1% of trips were work trips according to the conventional definition. According to the modified definition, about 21% and 14% respectively of trips were work trips. In Tanzania, the proportion of conventionally defined work trips was 6% because of high formal employment in tourism in the study area.

How working travel time savings are valued?

The model most commonly used for valuing working time savings is the wage rate or cost saving approach. As noted in the previous chapter, the wage rate or cost saving approach is based on the classical economic theory of marginal productivity. According to the theory, the value of travel time savings during work should be equal to the augmented wage rate (i.e. the wage rate plus employment related costs such as employment taxes, other compulsory contributions and employment related overhead costs).

It was also noted in the previous chapter that the cost saving approach is based on a number of simplifying assumptions. The assumptions found to be most questionable are: (i) the employee makes a full transfer of travel time saved to work; (ii) the employee does not use any of the travel time for productive purposes, and (iii) the employee gets similar utility of time spent working and

travelling. The Hensher model which removes these simplifying assumptions has been briefly described in Appendix II (Hensher, 1977). However, the Hensher model is difficult to use in practice and most VoT studies in developed countries use the cost saving approach.

The simplifying assumptions are more acceptable in the less sophisticated work and travel conditions in rural areas in developing countries. It is therefore recommended that the cost savings approach should be used for estimating value of time savings during work trips for rural people in developing countries. In practice this means that for trips in the course of work for an employer, the augmented wage rate is the appropriate measure of VoT. For other work trips (i.e. trips made in the course of work as a self employed person and trips made for purchasing/selling of goods for profit), VoT should be at least equal to the relevant wage rate (see I T Transport, 2002 and IT Transport, 2005). Other important references on this issue are: (i) World Bank (2005); (ii) Gwilliam (1997), (iii) Mackie et al (2003), and Institute for Transport Studies (2003).

How non-working travel time savings are valued?

Chapter 1 introduces the theoretical basis for valuing time savings for non-work travel and Appendix I provides an interpretation of non-work VoT based on marginal utilities of leisure and travel. The empirical evidence required for estimating the value of non-work time savings can only be derived from observing actual choices made or asking travellers to state their preferences.
The behaviourally revealed choices or stated preferences when an individual is offered choices between varying levels of travel time and travel time and other attributes can be used to estimate the willingness to pay to save travel time and transfer the time to leisure or other discretionary activities. For example, if a rational person chooses, either by showing behaviourally or by stating the intention (under carefully controlled experimental conditions), an expensive but faster mode over a cheap but slower mode of transport, it is evident that he/she is prepared to make a trade-off in favour of saving time at the expense of money. The most common theoretical framework for empirical measurements of non-working time savings is based on the discrete choice models that are again based on the framework of the random utility theory (Ortúzer and Willumsen, 1996).

How Willingness to Pay (WTP) can be estimated?

The willingness to pay for a preference can be identified in two major ways: Revealed Preference (RP) and Stated Preference (SP). The RP approach estimates the values of time from actual choices travellers make or have made. Conversely, the SP approach presents respondents with hypothetical choices and seeks their preferences.

What are advantages and disadvantages of RP and SP approaches?

Both RP and SP methods have advantages and disadvantages. A comparison between the two methods is presented in the following table.

Revealed Preference	Stated Preference
Descriptions	
• Based on actual choices rather than stated intentions	• Based on hypothetical choices on which individuals state their preferences
Advantages of RP	
• As RPs represent actual choices, the question of discrepancies between stated intentions and actual behaviour does not arise. • Easier to design a study as they do not involve a complicated design process.	• There may be biases because of discrepancies between stated intentions and actual behaviour. • May involve a complicated experimental design process.
Advantages of SP	
• Direct evidence only on the alternative selected. No direct evidence on the alternatives rejected • Unsuitable for use in potential transport improvement situations • Expensive to undertake this type of survey as it can generate only one decision per respondent.	• A variety of choices can be offered which enable the construction of statistically valid models. • Suitable for use in existing or potential situations. • Multiple observations per individual can be generated. Therefore number of interviews and survey costs are lower.

In the Bangladesh, Ghana and Tanzania studies (I T Transport, 2002 and I T Transport 2005) the RP approach was found to be unsuitable. The main difficulty appeared to be the absence of credible alternative modal choices available to travellers.

In many cases a combination of RP and SP results can provide a more robust measure of VoT. However, this approach is technically difficult requiring the correction of the "scale factor" problem within SP.

In principle, the RP approach is considered to be superior to the SP approach because observation of actual behaviour is more robust evidence than statement of intentions. In practice, the RP approach suffers from a number of weaknesses and difficulties (see below). In addition, Wardman (1997) found close correspondence between the results of RP and SP studies indicating that discrepancies between stated intentions and actual behaviour are not a serious problem if SP studies are designed well and properly implemented.

Based on the above assessment, it is recommended that the SP approach should be the main approach for estimating VoT. Ideally, small RP studies should be undertaken to test the robustness of the results of SP studies.

What are the main issues in the valuation of travel time savings in LDCs?

- **Relevance of division of time savings into working and non-working categories in rural areas in LDCs** : This is one of the main

conceptual issues which needs attention. The problem arises because as there is a marginal formal employment in rural areas of developing countries. Also a question frequently been asked whether the working trips need defining differently in the rural context of developing countries in comparison to their developed country or urban counterparts? The Bangladesh and African studies concluded that it was valid to divide travel time saving values into work and non-work related trips, although only a small proportion of total rural trips could be defined as working trips using the conventional work trip definition. The studies also concluded that there was a need to redefine working trips depending on the nature of the rural economy of the developing country.

- **Preference approaches in a subsistence context:** Time savings during non-working trips are assessed empirically using preference approaches. The Bangladesh and Africa VoT studies (I T Transport, 2002 and I T Transport, 2005) demonstrate that preference approaches can be used in rural areas in developing countries.

- **Use of SP vs. RP approach for the measurements of WTP:** Studies in Bangladesh and Africa showed that the SP approach was more suitable for WTP estimation than the RP approach. However, although the RP approach was found to be problematic, it should not be totally excluded because it provides a check on SP evidence based on the actual behaviour of people. More limited RP studies using observers to collect information on individual travellers' behaviour on a small scale could be used.

- **Nominal values of time vs. resource values of time:** Working and non-working time saving values represent the financial (or nominal) values. The issue is whether there is a need to adjust the nominal values to correct market distortions caused by unemployment, underemployment, taxes and subsidies. The adjusted values represent economic (or resource) values. Studies in Bangladesh and Africa highlighted the importance of taking such corrective measures.

What factors may influence rural travel time saving values in LDCs?

- **Income of travellers:** This may be one of the major sources of variation of WTP to save travel time as confirmed by the Bangladesh and Africa studies (I T Transport, 2002 and 2005).
- **Other personal attributes:** Empirical evidence from Bangladesh and Africa suggests that rural travellers' personal attributes other than income (e.g. gender, age and source of income) can significantly influence WTP to save travel time.
- **With and without load travel:** This is considered to be an important factor since a load may make travelling conditions more difficult and there may be a greater urgency to get the load to market or to other destinations. The Bangladesh study suggests that travellers with loads

are willing to pay more. However, this was not the case in Ghana and Tanzania.

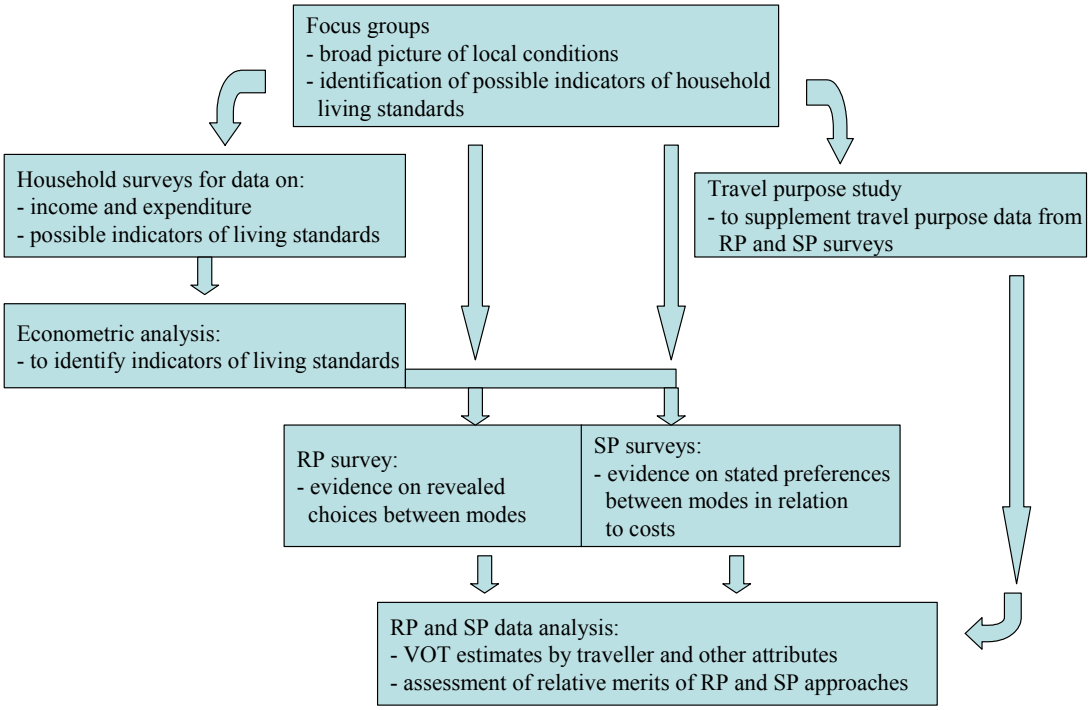
- **Seasonal variation:** Time values in rural areas may vary between seasons because time requirements in farming vary between seasons. The Bangladesh, Ghana and Tanzania studies found no seasonal variations in VoT.
- **Daily variation:** WTP to save travel time may vary between days (e.g. WTP may be higher on a market day than on a non-market day). This was found to be the case in Bangladesh but not in Ghana and Tanzania.
- **Modal variation:** Travel time saving values may differ between different transport modes (e.g. between the values of in-vehicle and walking time saved).
- **Variation due to infrastructure conditions:** WTP to save travel time may vary depending on the condition of the infrastructure on which the journey takes place (e.g. WTP may be higher to save travel time on a poor compared to a non-poor road). Studies in Bangladesh, Ghana and Tanzania provided mixed results. While in Tanzania it was found to be a significant factor, it was not the case in Bangladesh and Ghana.
- **Travel conditions:** Travel conditions (e.g. comfortable vs. uncomfortable travel) may be an important factor influencing WTP. Evidence from Bangladesh and Africa suggests that respondents were willing to pay more to avoid uncomfortable travel conditions.

In principle, the SP approach can be used to estimate the effects of a range of factors. In practice, the more factors are included, the more complex the design of the study becomes and the longer the questionnaire, leading to interview fatigue (see Chapter 3). In research it may be necessary to investigate the effects of a range of factors. However, for project appraisal, typically a small number of average VoT values will be required. Therefore, if the objective is to produce estimates for use in project appraisal, the study design should be kept simple and only a minimum number of factors influencing VoT should be included.

3. Design of a VoT Study

How to design a VoT study?

Evidence for estimating VoT comes from SP and/or RP surveys. The design of the surveys to ensure that the appropriate data are collected and the computations required to estimate the value of time savings clearly form the core of the SP and RP procedures. Guidance for conducting these has been provided in the rest of this chapter. For effective design of RP and SP studies and to interpret the RP and SP study results, it is necessary to conduct qualitative assessment of the socio-economic context (see next chapter). The following diagram shows the overall design of a VoT study in which the qualitative studies provide the essential context and the SP and RP surveys are used to collect data for estimating VoT.



What are the main steps in the design of an SP study?

The five main steps in the design of an SP study are described below.

Step 1: Identification of the set of attributes

This step involves making decisions about which trip attributes need to be included in the experimental design. The selection of attributes is clearly determined by the objectives and scope of the study. The selection of attributes normally takes account of the travel options respondents are familiar with.

Step 1 Illustration: Identifying the set of attributes

The objective in one of the SP studies in Bangladesh was to value in-vehicle time (IVT) and walking time values. The attributes identified were: bus fare, bus journey time and walking time to access the bus.

Step 2: Selection of the measurement unit for each attribute

Many attributes are measurable with clearly definable units. For example, cost is expressed in currency units and time in minutes. However, some attributes cannot be defined and measured objectively. 'Level of comfort' while travelling is one such generic attribute which cannot be defined unambiguously and respondents will have their own subjective views of it. In such cases, it is necessary to define the levels of comfort within the local context as clearly as possible and communicate the levels clearly to the respondents (see the Step 2 Illustration below). For clarity, the number of different levels of attributes should also be kept small.

Step 2 Illustration: How to determine levels of generic attributes and communicate them to respondents?

SP studies in Bangladesh, Ghana and Tanzania included the level of comfort during travel as a variable to assess what travellers were willing to pay for improved comfort. To reduce complexity, only two alternatives were offerd – comfortable and uncomfortable travelling conditions. In Bangladesh, interviewers explained the two options verbally to the respondents using the context of crowded buses vs uncrowded buses or private hire of a small vehicle. In Ghana and Tanzania, visual aids (photographs on cards representing comfortable and uncomfortable situations) were used to represent comfortable and uncomfortable conditions. An advantage of visual aids was to reduce the subjective element since all respondents were being shown the same depiction of the level of comfort.

Step 3: Specification of the number of attribute levels

This is the most important step in the design of an SP experiment. The first part of this step involves defining the attribute levels and their magnitude. First the attribute levels for each of the attributes are to be defined (see Step 3 Illustration below).

The next step is to combine the attribute levels to set up an experiment. An important decision in setting up an experiment is the number of 'scenarios' – combination of attribute levels – to be presented to respondents. In most cases, the 'full factorial design' (i.e. offering every possible combination of attribute levels) is avoided given its impracticality and to reduce response fatigue and the

resulting increase in response errors. The fractional factorial design developed by Kocur et al (1982) which reduces the number of scenarios to be offered to respondents to a reasonable level without compromising the results is normally used (see Step 3 Illustration below).

Step 3 Illustration: Fractional factorial design to reduce number of scenarios

There were three attributes (fare, in-vehicle time (IVT) and walking time) in one of the Bangladesh SP studies. The researchers decided to use three levels of values for each attribute (difference between fares, difference between IVT and difference between walking times) for each variable. Therefore, the full factorial design (presenting all possible combinations of variables) would have required a total of 27 (i.e. 3 x 3 x 3) scenarios to be presented to respondents. The researchers decided against presenting all 27 scenarios because of concerns about response fatigue and time required to conduct surveys. A fractional factorial design (Plan Code 16a, Master Plan 3) from the catalogue of Master Plans for fractional factorial design provided by Kocur et al (1982) was used. The study used a total of 9 scenarios, the minimum requirement for three attributes with three levels each as shown in the table.

Alternative	Cost difference[1]	Walking time difference	In-vehicle time difference	Alternative
1	0	0	0	1
2	0	1	2	2
3	0	2	1	3
4	1	0	1	4
5	1	1	0	5
6	1	2	2	6
7	2	0	2	7
8	2	1	1	8
9	2	2	0	9

The values 0, 1 and 2 in the table represent levels of differences from the current situation with 0 representing the most favourable situation for each option (i.e. lowest cost increase and largest time saving). The establishment of attribute values and their use in calculating the implied values of time are considered in the next step.

Step 4: Specification of values for attribute levels and statistical design

This step involves the establishment of attributes values to be presented to respondents. This has to be done systematically with the help of boundary values for different scenarios and the setting up of a boundary value equation. The concept of the boundary value is explained below with an illustration.

An individual is faced with two choices for going from A to B – travelling by train, which is faster but more expensive or travelling by coach, which is slower but cheaper. If the times and costs for travel are T_t and C_t, and T_c and C_c for train and coach respectively, the time and cost differences are (T_c-T_t) and (C_t-C_c) respectively. In this case, the boundary value of time (BVoT) is {(C_t-C_c)/ (T_t-T_c)} implying that any individual with value of time equal to {(C_t-C_c) / (T_t-T_c)} will be indifferent between the train and the coach. All else equal, an individual with value of time higher than {(C_t-C_b)/ (T_t-T_b)} would choose the train and vice versa.

<u>Step 4 Illustration: How to calculate boundary values</u>

One of the SP studies in Bangladesh included three attributes – bus fare, IVT and walking time. Therefore, the boundary value equation was:

$$\lambda = (C_2 - C_1) / ((T_1 - T_2) + a * (W_1 - W_2))$$

Where λ is the boundary value of time (BVoT); C_1 and C_2 are bus fares under Options 1 and 2 respectively; T_1 and T_2 are travel time within bus (in-vehicle time or IVT) under Options 1 and 2 respectively; W_1 and W_2 are walking times under Options 1 and 2 respectively, and a is value of walking time as a proportion of in-vehicle time.

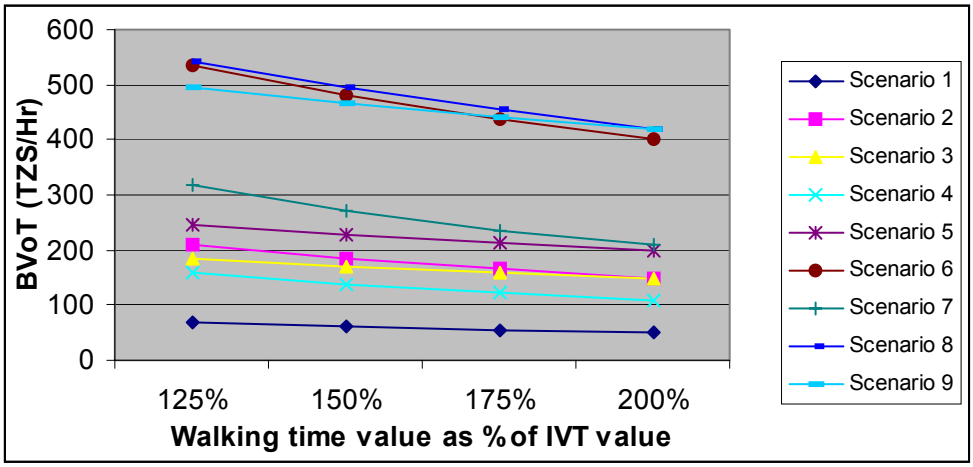
Clearly, the BVoTs depend on the values chosen for cost and travel time differences. The cost and time differences for the nine scenarios were chosen by a trial and error method to produce a range of BVoTs taking account of the following considerations:

- *BVoTs should be capable of capturing the time values of respondents representing the range of socio-economic conditions (represented by estimated expenditure levels of respondents' households in the Bangladesh study).*
- *BVoT should be roughly evenly distributed over the range (as the following table shows, in the Bangladesh study, the BVoT values ranged between 1.71 Tk/hour and 18.00 Tk/hour with reasonable intervals between (see table below).*
- *BVoTs should be realistic taking account of prevailing transpoprt costs and local price levels, incomes and wage rates.*

Step 4 Illustration: How to calculate boundary values (Contd.)

	Cost difference (Tk)	*Walking time difference (Min)*	*In-vehicle time difference (Min)*	*BVoT (Tk/hr)*
	2	*30*	*25*	*1.71*
	2	*20*	*10*	*3.00*
	2	*10*	*20*	*3.43*
	6	*30*	*20*	*5.54*
	6	*20*	*25*	*6.55*
	6	*10*	*10*	*14.40*
	12	*30*	*10*	*13.09*
	12	*20*	*20*	*14.40*
	12	*10*	*25*	*18.00*

To facilitate this exercise visual simulation in the form of graphs may also be constructed to understand the experimental design procedure. The following graph plots BVoTs for each of the nine scenarios in the Tanzania study against proportion of walking time to IVT.



Step 5: Setting up the scenarios in the questionnaire

Once the statistical design is completed, i.e. the numbers and levels of attributes, number of options to be presented to the respondents, and the values of the attributes are decided, the next step is the incorporation of this design into the questionnaire. In offering the scenarios to respondents to elicit realistic responses, they should be related to current fares and travel times (see Step 5 illustration below).

The travel attribute values may also be subjected to seasonal variations due to changed travelling conditions in different seasons. In such cases, there is a need to change the attribute values in a choice exercise depending on the time of survey in a year.

Step 5 Illustration: Setting up scenarios in questionnaires

In the Bangladesh SP study used in illustrating the earlier steps, the attributes selected were fares, IVT and walking time. The procedure for determining the differences in the values of these attributes to be used to represent a range of BVoTs has been set out in Step 4. In Step 5, the differences are translated into actual fares and travel times to be included in the questionnaire.

Scenarios	Option 1				Option 2			
	Cost Bus (Tk)	Time Bus (Min)	Walk Time (Min)	Choice	Cost Bus (Tk)	Time Bus (Min)	Walk Time (Min)	Choice
1	12	60	40		14	35	10	
2	10	50	40		12	40	20	
3	14	50	30		16	30	20	
4	12	60	40		18	40	10	
5	10	50	50		16	25	30	
6	14	40	30		20	30	20	
7	14	50	40		26	40	10	
8	12	60	30		24	40	10	
9	14	45	20		26	20	10	

When setting up the scenarios in the questionnaire, care was taken to ensure that the presented values corresponded with typical fares and travel times in the study area. Local inquiries showed that buses were the most common means of transport over the transport link and the fare and journey time respectively at the time of the study were 12 Tk and 50 minutes. The table above shows the scenarios offered to respondents.

The complete SP questionnaire which also includes questions to identify the socio-economic attributes of respondents and questions on trip purpose is shown in Appendix III. Steps 1 to 5 provide a framework and a template for studies elsewhere with appropriate modifications.

Step 5: Administration of SP questionnaires

There are two main options for administering the SP questionnaires: (i) administered by interviewers, and (ii) "self completed" by respondents. The factors likely to influence the choice of a specific option are: (a) respondents' familiarity with and complexity of stated preference experiments; (b) level of education of respondents; (iii) details with which the alternatives need to be described (i.e. trained interviewers preferred when more explanation has to be provided). Each of the options may be administered with the help of visual aids to improve respondents' understanding and choices.

In the Bangladesh and Africa studies interviewers were used. Visual aids were used successfully in the Africa studies (I T Transport, 2005). In future studies in rural areas, administering questionnaires through interviewers with the help of visual aids, where necessary, is the recommended option. See Pearmain and Kroes (1990) for more detailed discussion of issues relating to presentation and administration of SP questionnaires.

What are the main steps in the design of an RP study?

RP studies are easier to design than SP studies. They involves three main steps.

Step 1: Identification of the main modes
The first task is the identification of the relevant modes that operate on the link/route on which the studies are to be undertaken. They may include motorised and non-motorised modes in rural areas of a developing country. An RP study is only applicable if more than one modes offering realistic alternative means of travel operate on the selected link/route.

Step 2: Defining the variables that need to be captured
The next step is to define the variables that need to be captured in the RP study. The variables will include, among others, time (IVT, waiting time, walking time) and fare variables. It is necessary to capture the variables for both main and access[2] modes as a journey may involve the use of a main mode (e.g. bus) and one or more access modes (e.g. walking and bicycle).

Step 3: Design of the RP questionnaire
Once the modes are identified and the variables defined, the final step involves the design of a questionnaire to capture the travel and personal attribute

[2] The 'access mode' is the normally the means of travel to get to and from the origin and destination to the route on which the main part of the journey is undertaken. For example, a person may walk from home to the main road to take a bus on which the longest part of the journey is undertaken.

variables. In rural areas of developing countries the actual journey undertaken can be quite complex and may involve the use of several modes (e.g. walking and use of non-motorised and motorised modes). The rejected options may also involve a number of modes. The following table was used to capture RP data in the Ghana VoT study (I T Transport, 2005).

	Option used			**Options Rejected**		
	Mammy Wagon	Minibuses	Bicycle	Mammy Wagon	Minibuses	Bicycle
Fare - **main mode** (Currency Unit)						
Fare - **access mode** (Currency Unit)						
Fare load – **main mode** (Currency Unit)						
Fare load – **access mode** (Currency Unit)						
Waiting Time – **main mode** (min)						
Waiting time- **access mode** (min)						
In-vehicle Time - **main mode** (min)						
In-vehicle time - **access mode** (min)						
Comfort [*]						
Safety [**]						
Walking time (min)						

Notes: [*] – tick [✓] if comfortable; cross [x] if uncomfortable
[**] – tick [✓] if safe; [x] if unsafe

How factors that may influence rural people's VoT be incorporated in VoT study design?

Chapter 2 identified several travel and personal factors that might influence VoT. If the effects of these factors on VoT need to be verified, then they should be included in the study design. Information about them is collected during the SP and RP questionnaire surveys. Information on personal attributes (e.g. sex and age) can be collected directly from respondents during the survey. , travel factors (e.g. comfort, safety) related information may be collected either by directly asking the respondents about them or by incorporating one or more of them in the SP experiment.

Why travel purpose information of rural travellers is important in the valuation of travel time savings?

In Chapters 1 and 2, the distinction between valuation of time savings during work and non-work trips is explained. An important issue in valuing rural travel time savings in LDCs is the definition of work trips. The proportion of

conventionally defined work trips (i.e. those undertaken during the course of formal employment) is expected to be low in rural areas of LDCs. The Bangladesh and Africa studies confirmed this expectation (IT Transport, 2002; IT Transport 2005). However, the studies also found that there were other trips (e.g. trips made in the course of work as a self employed person and trips made for purchasing/selling of goods for profit) which should be defined as work trips. Time saving values for these trips should be the marginal value of income of travellers.

Travel purpose information is required to proportion of work and non-work trips and to determine the nature and breakdown of work trips.

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4. Use of Qualitative Methods in a VoT Study

How qualitative methods are used in a VoT study?

The term 'Qualitative methods' is used in this manual to mean any methods which collect data that is not numerical. Qualitative methods are used in a VoT study in two ways:

- **Informing the design of questionnaires.** This includes:
  - selection of roads, tracks or other infrastructure for conducting the preference surveys;
  - selection of indicators for household surveys;
  - development of visual aids for the preference studies, and
  - determining preference survey timing to reflect seasonal and other differences in questionnaires and choice of SP additional variables.
- **Validating and in depth research of quantitative data results.** This would involve looking at the results of data analysis and investigating especially unexpected results.

What types of qualitative method can be used in a VoT study?

The term 'qualitative methods' is rather broad and could include tools which are used as part of Rapid Rural Appraisal (RRA), Participatory Rural Appraisal (PRA) or Participatory Learning and Action (PLAs). The range of tools may be used by outsiders (e.g. researchers and policy makers) for improving understanding of the situation by communicating interactively with local people (extractive and consultative modes) or by local people with outside assistance if necessary to make decisions and take initiatives (empowering mode).

For VoT studies the participatory tools are used in extractive and consultative modes rather than the empowering mode. Therefore, the objectives of the exercise should be made clear to the key informants, contacts and participants when conducting interviews, group discussions and other investigations to avoid raising the expectations of local people. The rest of this chapter describes the processes and participatory tools useful in VoT studies. The section is written for someone who has some training or experience of using participatory tools. For more detailed discussion on participatory techniques such as attitudes and behaviour, adult rapport building, group dynamics, and the use of various tools and techniques, please refer to the relevant work of institutions such as the IIED (International Institute for Environment and Development, London) and IDS (Institute for Development Studies, University of Sussex, UK). Two references including practical guidance are Pretty et al (1995) and Mukherjee (2002).

What are qualitative methods planned and implemented?

Planning and design

As part of planning a VoT study, the team should sit down and discuss the overall methodology and the role of qualitative techniques within it. As noted above, qualitative methods will typically be required for informing the study design and for validating the quantitative results. The requirement for qualitative

investigations occurs at different stages of the study. Before the study starts it is recommended that the whole team get together to decide on the qualitative methods to be used, their purpose and how the qualitative studies are to be conducted. The qualitative investigations should be programmed into the overall VoT study and flow alongside the quantitative work. Further consultations on the progress of the qualitative work and how it fits into the overall study will be required through the course of the study.

Review

When designing the questionnaire, pilot testing in the field is essential to check whether the questionnaire is fit for the purpose and is likely to produce the required the data. Pilot testing also has an essential role in assessing the capabilities of interviewers and highlighting the need for training. Throughout the study it is important to review the progress of qualitative data collection. It is recommended that the team get together at the end of each day to review their work and plan for the following days.

What methods and tools can be used?

Methods used

There are a number of qualitative methods which can be used. The ones used for design of the questionnaires are quite set. However those used for validating have to be flexible. The designer of this methodology has to be creative and use a range of tools to investigate the quantitative results in more depth. Therefore this section sets out a range of tools that should be used for questionnaire design and a set of tools that could be used for validating results.

Tools for questionnaire design.

The following table sets out the qualitative methods that should be used to inform the design of questionnaires. It also gives an indication of who should participate. They are in the recommended order of execution.

Collection aim	Techniques that can be used
Preliminary road data - To have background data for the design of SP and RP questionnaires.	▪ Semi structured interview. Focused on establishing a pattern of travel and transport in the area, the costs and modes involved. Interview road users, local government officials including the engineer
Perception of time and daily activity - To have a better understanding of perceptions and methods of measuring of time. Secondly to inform the results on interpreting time budgeting from daily activity data.	▪ Focus group discussion (FGD). Focused on how people measure time and identifiable time intervals. ▪ Daily routine map. To establish common tasks and their duration. Secondly how and why they change through the month and year. Conducted sessions with at least two male and two female groups from a mixed social classes.
Community Travel and Transport - To give context to the SP and RP design in the types of trips people make and the reasons why.	▪ Area mapping In group focus on mapping out the transport network in the area. Followed by discussion, using the above map to discuss the modes and fares and other variables when choosing a journey. Conduct sessions with at least two female and two male groups from a mixed social classes.
Wealth and poverty - To inform the design of the household survey and indicators used in SP and RP questionnaires.	▪ Wealth and poverty indicator ranking Focused on identifying indicators of wealth or poverty in the community and then ranking them for significance. Conduct with at least two mixed groups from different backgrounds.

Tools for validating results

As discussed above the designer of the validating qualitative methodology will have to be creative and flexible to develop a more detailed understanding of the results of the quantitative analysis, especially where the quantitative results are unexpected. A selection of methods that have been used in the Bangladesh and Africa VoT studies have been described briefly in the following table. They illustrate a good range of methods which could be used in VoT studies elsewhere (also see IT Transport, 2005).

Method	Use in Bangladesh and Africa VoT studies
Semi-structured interviews	Semi structured interviews were used most extensively in situations where people could not be easily organised into groups. For example they were used to interview petty traders in markets.
Focus Groups	Focus groups were used as a way of gathering people for focused discussions usually based on a visual aid developed during the course of the discussion. For example in Tanzania household financial control was discussed with men's and women's groups.
Ranking	Ranking was used extensively in focus groups. For example journey choice variables were discussed in groups. Then ranked to decide which was the most important.
Mapping	Mapping was used mainly to investigate transport routes and modes. In Ghana participants were asked to draw an outline of their community and asked to use symbols or markings to represent various places in their community (i.e. schools, water points and markets) on the map.

5. Analysis of Preference Data

What type of data a preference survey generates?

A preference study data set will contain both dependent and independent variables. Again the independent variables may contain both continuous (e.g. travel time, cost etc.) and discrete variables (e.g. respondent's sex, social class, travel conditions etc.). The independent variable will usually have values that are either zero or one (indicating the choice of a certain option). Appendix IV presents a sample data set generated from a VoT study in Africa.

What are the main theories behind the preference survey data analysis?

If an individual faces a choice between two modes of transport (say bus and car), he will choose the car if only:

$U_c > \underline{U_b}$

Where, U_c is the utility of using the car and U_b is the utility of using the bus

Again utility has two components, a deterministic component and a random component. The utility of using a mode can be disaggregated into:

$U_i = V_i + e_i$

Where, V_i is the deterministic utility and e_i is the stochastic utility (also called the error term). The error term represents the idiosyncrasies and particular tastes of each individual, and measurement and observational errors made by the modeller (Ortúzer and Willumsen, 1996).

As e_i is unobservable, the analysis of travel behaviour is conducted on the basis of observed utility (V_i) only. The probability that an individual will choose alternative 1 from i available alternatives can be presented as:

$P_1 = \text{Prob}\ [(V_1+e_1) > (V_i + e_i)]$ for all i, $i \neq 1$

Now with an assumption on the probability distribution of the component e_i, the probability of choosing alternative 1 can be specified solely on the basis of deterministic utility, V_i.

The basic choice model, commonly known as multinomial logit (MNL) model, takes the following form:

$$P_1 = \frac{\exp^{V_1}}{\sum_i \exp^{V_i}}$$

The assumptions underlying the model are that the random parts of utility:

(i) follow a extreme value type 1 (EV1) distributions (referred to by a number of names, including Weibull, Gumbel and double-exponential);
(ii) are identically distributed; and
(iii) are uncorrelated.

The most commonly used estimation method of MNL model coefficients is the maximum likelihood approach. Louviere, Hensher and Swait (2003) discusses the theoretical aspects of MNL model, statistical estimation procedures of the MNL model and maximum likelihood estimation in detail.

What types of software are available for analysis of preference data?

The most commonly used technique for the analysis of SP data is the logit method which is also one of the most advanced methods for estimation of discrete choice functions. The analysis is based on the statistical principle of likelihood maximisation. Another advanced method for analysis of SP data is the probit model. However, the probit model is less commonly used than the logit because it is more complex and easily accessible software is not available. A number of commercial software products for logit modelling are available. Among them are Alogit (developed by Hague Consulting Group) and Nlogit (developed by Econometric Software, Inc).

What are the steps in the analysis of preference data?

Development of a mathematical specification of the model

An SP experiment involves the use of a number of attributes. The objective of the analysis of SP data (as well as revealed preference where applicable) is to decompose the overall preference into part utilities attached to each of the attributes. The overall utility equation, a linear model of utility[3], may take one of the following forms:

$$U_i = c_i + \sum a_i * x_i + \sum b_i * d_i \quad \text{..... (1)}$$

$$U_i = c_i + \sum a_i * x_i + \sum b_i * d_i * x_i \quad \text{.....(2)}$$

Where U_i = utility of option i;

C_i = constants to capture effects of subtle attributes such as inclination towards the use of car;
x_i = travel attributes (e.g. like in-vehicle time, walking time, fare etc.)
d_i = dummy variables (e.g. male vs. female, poor vs. non-poor etc.);
a_i = model coefficients of continuous variables, and
b_i = model coefficients of discrete (dummy) variables.

[3] Although the linear models are popular, the utility equations may take non-linear forms as well.

The difference between the two equations is that in Eq. 2 the dummy variables interact with the continuous variables (e.g. fare, travel time etc.), whereas in Eq. 1 they are treated separately from the continuous variables. Eq. 2 is suitable when travel attribute (personal and travel) values are expressed in time units (e.g. monetary value of uncomfortable travel time per hour)

Assessment of goodness of fit

The goodness of fit of the MNL models is tested using rho-squared (ρ^2), a type of pseudo-R^2 measure of goodness of fit which roughly corresponds to R^2 for ordinary regression. ρ^2 is defined as:

$$\rho^2 = 1 - \frac{LL(M)}{LL(0)} \quad \text{.....(3)}$$

where, LL(M) is the maximised value of the log-likelihood and LL(0) is the initial (null) value of the log-likelihood. However, it is important to choose an appropriate null hypothesis. Ortúzer and Willumsen (1996) suggests to carry out the log-likelihood test with market share model that requires computing log-likelihood value at convergence, LL(C). With this adjustment, the model takes the following form:

$$\rho^2 = 1 - \frac{LL(M)}{LL(C)} \quad \text{.....(4)}$$

Values of ρ^2 can vary between 1 and 0. However, one should not expect to obtain ρ^2 values as high as R^2 values commonly obtained in an ordinary regression. A ρ^2 value between 0.2 to 0.4 can be considered to be an extremely good fit. Louviere, Hensher & Swait (2003) and Ortúzer and Willumsen (1996) provide theoretical discussions of the log–likelihood ratio test.

Evaluation of model coefficients

The robustness of model coefficients should be evaluated using the following two criteria:

(i) *Statistical significance*: T-tests should be carried out for each coefficient to check that their values are significantly different from zero. To be statistically significant a model coefficient should have a t-value grater than or equal to 1.96 implying a confidence level of 95 per cent.

(ii) *Correct signs and values*: The signs and values of the coefficients should conform with economic theories and/or findings of previous empirical studies.

How to calculate the value of time from model coefficients?

Practical example: If the statistical analysis produces cost and IVT coefficient values of -7.99E-04 and -2.03E-02 respectively, VoT will be (-2.03E-02/-7.99E-04)=25.4 currency units per minute. Similarly if the same analysis produced a dummy coefficient value for children (expressed in terms of time) at 4.59E-03, the additional value of children's time will be (4.59E-03/-7.99E-04)= - 5.7 currency units/min. This means that children's VoT is 25.4-5.7=19.7 currency units/minute.

How to pool SP and RP data sets?

Pooling SP and RP data can offer a number of advantages. It increases the amount of data available for analysis. In addition, it enables exploitation of the best features of SP and RP data. As noted in chapter 2, RP data are more credible because they are based on observed values while SP data cover a wider range of options which may not be directly observable.

However, the joint analysis of RP and SP data requires correction of the "scale factor" problem present within SP.

The process of pooling RP and SP data together and estimation of the model from the pooled data is called data enrichment (Louviere, Hensher and Swait, 2003).

Let us assume that the utility models associated with the RP and SP data sets are:

$$U_i^{RP} = C_{RP} + \sum \alpha_i^{RP} * X_i^{RP} + \omega Z_i + \varepsilon_i^{RP} \quad \text{..... (5)}$$

$$U_i^{SP} = C_{SP} + \sum \alpha_i^{SP} * X_i^{SP} + \delta W_i + \varepsilon_i^{SP} \quad \text{.....(6)}$$

where, C_{RP} and C_{SP} are the alternative specific constants (ASCs), α^{RP} and α^{SP} are the utility parameters for the common attributes and ω and δ are the utility parameters for the unique attributes in each data set.

If the error terms associated with the two data sources can be expressed with scale factors λ^{RP} and λ^{SP} then we require to estimate C_{RP}, α^{RP}, ω, λ^{RP}, C_{SP}, α^{SP}, δ, λ^{SP}. However, in practice both the scale factors cannot be estimated. In the case of joint RP and SP estimation, one is normalised. Usually it is common to assume RP scale factor as one (i.e. λ^{RP} =1). Hence the estimate of λ^{SP} represent a relative scale with respect to RP scale data scale.

Figure 1 and Figure 2 present the ideal hierarchical logit (HL)[4] RP-SP model structures of an RP and an SP data sets and multiple SP and an RP data sets respectively.

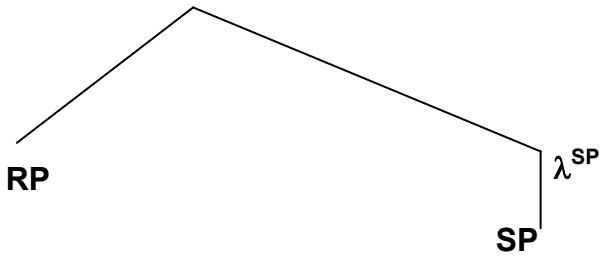

Figure 1: A hierarchical model structure for an SP and an RP data sets

[4] See Ortúzer and Willumsen (1996) for detailed discussions of the hierarchical logit model

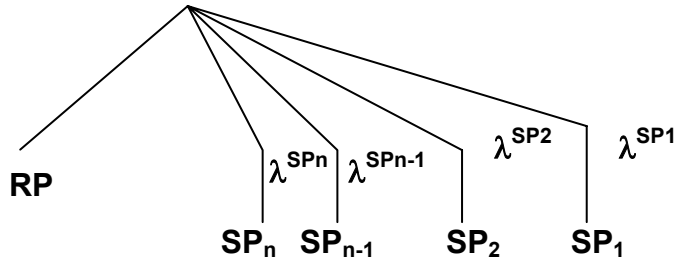

Figure 2: A hierarchical model structure for multiple SP and an RP data sets

Louviere, Hensher and Swait (2003) discusses in detail the theories underlying combining preference data from different sources.

Why do we need to convert nominal values to resource values?

The estimated time saving values (both working and non-working) are financial (nominal) values. For the inclusion of time saving benefits in project appraisal, there is need to adjust the financial travel time saving values into resource values where world price numeraire is used in economic analysis. Such adjustments are required to correct market distortions caused by unemployment, underemployment, taxes and subsidies.

How to convert the nominal values to resource values?

The working and non-working time saving values are adjusted using the Shadow Wage Rate (SWR) factor and Standard Conversion Factor (SCF) respectively. Asian Development Bank (1997) provides worked examples of how to calculate the SWR factor and the SCF.

6. Summary Approaches for Valuing Rural Travel Time Savings in Least Developed Countries

Table 1 and Table 2 respectively provide a range of approaches for valuing rural working and non-working time savings in least developed countries. The first column in each of the tables provides the ideal approaches for valuing travel time savings, generally based on the assumption that detailed studies specific to the country can be carried out. Table 1 also provides the second best and minimum approaches. They should only be used if it is not possible to undertake ideal approaches due to time and financial resource constraints.

Table 1: Approaches to Value Working Time Savings

Ideal approach	Second best approach	Minimum approach
• **Conventional work trips**: Average observed formal employment wage rate (adjusted by employment overheads and SWR factors)	• **Conventional work trips**: 1.33xadjusted average observed formal employment wage rate (adjusted by SWR factor)	• **Conventional work trips**: Average skilled labour wage rate (adjusted by SWR factor). Applicable only if the proportion of conventional work trips is thought to be small.
• **Other trips that have opportunity costs of lost time equal to marginal value of income:** Observed weighted average wage rate (adjusted by SWR factor)	• **Other trips that have opportunity costs of lost time equal to marginal value of income:** Observed weighted average wage rate (adjusted by SWR factor)	• **Other trips that have opportunity costs of lost time equal to marginal value of income:** Observed weighted average wage rate (adjusted by SWR factor)

Note: See notes to Table 2 for recommended SWR factor to be used if they cannot be estimated.

Table 2 shows that the ideal approach for estimating the value of non-working time savings is to conduct empirical studies, typically using the SP approach. Columns 2 and 3 in Table 2 recommend pragmatic approaches to be used if time and financial resources do not allow context specific studies. These recommended pragmatic approaches are based on the empirical findings from the Bangladesh and Africa studies.

Table 2: Methodology to Value Non-working Time Savings

Ideal approach	Practical approach 1	Practical approach 2
• Empirically derived travel time saving values for non-working time using preference approaches (using SP method) disaggregated by social, gender and age groups, modes, journey conditions etc. Also values derived for walking and waiting time. These values need to be adjusted by SCF.	• **Adult's IVT value (currency/hr)**: 0.55 x weighted average wage rate per hour (adjusted by SCF) • **Children's IVT value (currency/hr)**: 0.79x0.55x weighted average wage rate per hour (adjusted by SCF) • **Walking and waiting time value (currency/hr)**: 1.45x0.55 x weighted average wage rate per hour (adjusted by SCF)	• **Adult's IVT value (currency/hr)**: 0.37 x household consumption expenditure per hour (adjusted by SCF) • **Children's IVT value (currency/hr)**: 0.79x0.37 x household consumption expenditure per hour (adjusted by SCF) • **Walking and waiting time value (currency /hr)**: 1.45x0.37xhousehold consumption expenditure per hour (adjusted by SCF)

Notes: **SWR factor:** The estimated SWR factors for Bangladesh, Ghana and Tanzania were 0.75, 0.80 and 0.86 respectively. Where the SWR factor cannot be calculated, a value of 0.80 is suggested.
SCF: The SCFs for Bangladesh, Ghana and Tanzania were 0.88, 0.96 and 0.86 respectively. Where the SCF cannot be calculated, a value of 0.90 is suggested.
Consumption expenditure: should include expenditure in cash and in kind.

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Derivation of Marginal Valuation of Time Spend on an Activity, including Travel

The derivation of marginal valuation of time in this Appendix is principally based on the MVA, ITS and TSU (1987) analysis. However, an attempt has been made to explain it in comparatively simple terms.

The classical economic theory of consumer behaviour is based on the assumption of a rational person deriving utility from the consumption of commodities and attempting to maximise this utility subject to available resources. For example, if an individual earns income Y and consumes a vector of commodities x, whose prices are represented by the vector p, then the mathematical expression for constrained utility maximisation is:

$$\text{Max } U(x) \text{ subject to } p.x \leq Y \ldots\ldots\ldots (1.1.1)$$

The consequent Lagrangean expression for constrained maximisation will be:

$$L = U(x) + \lambda (Y - p.x) \ldots\ldots (1.1.2)$$

Differentiating with respect to x and setting to 0 for the first-order conditions will give:

$$\delta U / \delta x_i = \lambda . p_i \ldots\ldots\ldots (1.1.3)$$

In the aforementioned expressions λ is the Lagrangean multiplier. In case of constrained maximisation with inequality constraints, as here, if the constraint does not bind, then the associated Lagrangean multiplier has a zero value, i.e. in this case $\lambda = 0$. In the above case, if the individual does not use all the income available to him/her, i.e. if he/she would not like to consume more than what he/she earns, then the budget constraint is not binding and $\lambda = 0$. This effectively means that the marginal utility of an additional unit of income for him/her is zero. In the normal case, when the individual would like to consume more than he/she can afford, λ is the marginal utility of an additional unit of income.

This theory and its related interpretations can be extended to find a theoretical interpretation of the value of time while travelling. However, to do so, some simplifying assumptions are necessary. This is because the complete theory of time allocation embraces all aspects of human behaviour and taking all of them into consideration is unmanageable.

Let us consider that an individual's utility is composed of a vector of commodities x, and a vector of time spent in different activities, t. For convenience, let us also assume that one of the activities is work and time spent in work is t_w. His/her income may consist of two sources: work and non-work (e.g. remittances from relatives). His/her total income may be expressed as $w.t_w+y$; where, w is the wage rate and y is the income from non-work sources, both net of tax. Let us also

assume that he/she has to work a minimum number of hours (t_w^*) and requires minimum time for some other activities (t_i^*).

Given the aforementioned restriction, the formulation of the previous constrained maximization model will take the following form:

$$\text{Max}U(x_1, x_2, ...x_n, t_1, t_2, ...t_n, t_w) \ldots\ldots\ldots (1.2.1)$$

subject to the following constraints:

$$w.t_w + y \geq p.x \ldots\ldots (1.2.2)$$

$$T \geq \sum t_i + t_w \ldots\ldots\ldots (1.2.3)$$

$$t_w \geq t_w^* \ldots\ldots\ldots (1.2.4)$$

$$t_i \geq t_i^* \ldots\ldots\ldots (1.2.5)$$

The subsequent Lagrangean expression will take the following form:

$$L = U(x,t,t_w) + \lambda(wt_w + y - px) + \mu(T - \sum t_i - t_w) + \phi(t_w - t_w^*) + \sum_i \psi_i.(t_i - t_i^*) \ldots (1.2.6)$$

Differentiation with respect to w, t_j and t_w will give the following expression:

$$\delta U/\delta x_i - \lambda p_i = 0 \ldots\ldots (1.2.7)$$

$$\delta U/\delta t_w + \lambda w - \mu + \varphi = 0 \ldots\ldots (1.2.8)$$

$$\delta U/\delta t_j - \mu + \psi_j = 0 \ldots\ldots (1.2.9)$$

Now from eqs.1.2.8 and 1.2.9 we get the following equation:

$$(\delta U/\delta t_j)/\lambda = w + (\delta U/\delta t_w)/\lambda + (\varphi/\lambda) - (\psi_j/\lambda) \ldots\ldots (2.1)$$

Where:
$(\delta U/\delta t_j)$ is the marginal utility of time in activity j;
λ is the marginal utility of income;
$(\delta U/\delta t_j)/\lambda$ is the marginal valuation of time spent in activity j
(Φ/λ) is the marginal valuation of time for decreasing the minimum working time required;
(ψ_j/λ) is the marginal valuation of decreasing the minimum other time required

The marginal valuation of time in activity j may also be viewed in the following way (from Eq. 1.2.9):

$$(\delta U/\delta t_j)/\lambda = \mu/\lambda - \psi_j/\lambda \ldots\ldots (2.2)$$

When ψ_j is zero, i.e. when the time constraint does not bind, the marginal valuation of time in activity j is equal to μ/λ, also known as the 'resource value of time'. It represents a consumer's willingness to pay to have the total time budget increased, although in reality a complete relaxation of the time budget constraint is not feasible. This is interpreted as the marginal valuation of the 'pure leisure' time at the optimum.

The Hensher Model for Valuing Working Time Savings

However, there are several simplifying assumptions underlying the cost saving approach: The Hensher model (proposed by D A Hensher in the 1970s) seeks to address these issues specifying the value of travel time saved as:

$$VTTS = (1 - r - pq) * MP + \frac{1-r}{1-t} * VW + \frac{r}{1-t} * VL + MPF$$

where:

VTTS = value of travel time saved;
r = proportion of travel time saved which is used for leisure;
p = proportion of travel time saved at the expense of work done while travelling;
q = relative productivity of work done while travelling compared with the equivalent time in the office;
MP = the marginal product of labour;
VL = the value to the employee of leisure relative to travel time. Traditional behavioural value of time;
VW = the value to the employee of work time while in the office relative to travel time;
MPF = the value of extra output generated due to reduced fatigue; and
t = employee's personal tax rate.

Simple Stated Preference Questionnaire
THE VALUATION OF TIME: THE AFRICAN STUDIES

Interviewers Name:		**Date:**	dd/mm/2004
Journey Day	Market/Non-Market	**Interview Time:**	
Administered with the help of visual aids?			Yes/No

Travelling alone? Yes/No
Who was paying the fare? Traveller/Companion
Type of trip: Home-based/non-home-based
Direction of travel: to destination/from destination

1.0 Traveller's basic information

1.1 Sex: M/F/CM/CF

1.2 Age: ……. yrs

1.3 Occupation:

1	Farming		7	Teaching		13	Firewood charcoal production	
2	Agricultural labour		8	Domestic servant		14	Artisan/tailoring	
3	Construction labour		9	Transport operator		15	Student	
4	Fishing		10	Govt. employee		16	Housewife	
5	Trading		11	Permanent employment		17	Unemployed/ Retired	
6	Petty or seasonal trading		12	Temporary Employment		18	Other (Pl. specify)	

1.4 Wearing a watch? Yes/No **1.5 Is it a working watch?** Yes/No

2.0 Traveller's Household & Other Socio-economic Information

2.1 Cultivable Land: Amount Own and leased land: _____ acres

2.2 Family Size (nos.)

1. Children upto16		2. Adult over 16		3. Retired	

2.3 Sex of Household Head: Male/Female
2.4 Types of rooms in the household and their number:

1. Mud walls with thatched roof	
2. Mud wall with zinc roof	
3. Brick and cement walls with zinc roof	
4. Brick and cement walls with concrete roof	
5. Other (pl. specify) ……..	

2.5 No of Rooms: _____ Nos

2.6 No of Household member engaged in gainful income earning activities: _____ Nos

2.7 Occupation of the main income earner(s) in the household: _____

2.8 Ownership of transport mode with numbers: _____

2.9 Number of cattle: _____ nos.

2.10 Number of goats/sheep _____nos.

3.0 Traveller's Journey Related Information

3.1 Journey Purpose:

	Purpose	Primary	Secondary	Tertiary
	1. Travel to satisfy basic needs			
1a	Basic household activities: water collection, firewood collection, grinding mills,			
1b	Basic Agricultural activities: ploughing, planting, weeding, harvesting etc.			
	2. Travel to satisfy wider socio-economic needs			
2a	Wider agricultural activities: to buy farm inputs, to sell farm produce farm.			
2b	Business activities: to trade (buying/selling goods for profit)			
2c	Health facilities: health posts, local clinics, hospitals			
2d	Educational facilities: primary schools, secondary schools, colleges and tertiary educational institutions			
2e	Markets related travel			
2f	Other facilities and services: town/administrative centres, government offices, post office etc.			
2g	Economic facilities: e.g. like banks, credit institutions			
2h	Commuting : to go to work (any type)			
2i	Work related: while working for other employer			
2j	Work related: self employed			
2k	Other to satisfy wider socio-economic needs			
	Travel to satisfy social & recreational needs			
3a	Weddings			
3b	Funerals			
3c	Visiting friends			
3d	Visiting Relatives			
3e	Place of worship			
3f	Leisure activities (cinema, theatres, clubs etc.)			
3g	Sports activities			
3h	Other social and recreational			

3.2 Load type (Please write): _____

3.3 Load amount (to the nearest): _____ Kg

3.3 Approximate value of the load: _____ Cedis

4.0 Stated Mode Choice by the Traveller

	Option 1 (Trotro)			Choice	Option 2 (Trotro)			Choice
	Fare (Cedis)	**Time (min)**	**Comfort**		**Fare (Cedis)**	**Time (min)**	**Comfort**	
1	5,000	120	Uncomfortable		7,500	60	comfortable	
2	6,000	105	Uncomfortable		8,500	60	comfortable	
3	7,000	120	Uncomfortable		9,500	90	uncomfortable	
4	5,000	120	Uncomfortable		8,500	60	uncomfortable	
5	6,000	105	Uncomfortable		9,500	60	comfortable	
6	7,000	90	Uncomfortable		10,500	60	comfortable	
7	5,000	120	Uncomfortable		9,500	60	comfortable	
8	6,000	105	Uncomfortable		10,500	60	uncomfortable	
9	8,000	120	Uncomfortable		12,500	90	comfortable	

A sample Data Set

Option 1			Option 2			Dummy Variables				
Minibus Cost	Minibus Time	Walking Time	Minibus Cost	Minibus Time	Walking Time	Market day	Sex	Age	Use of Visual_aid	Choice
6000	120	60	9000	75	30	0	1	0	1	0
8000	90	30	11000	75	15	0	1	0	1	1
7000	120	60	11000	105	15	0	1	0	1	0
7000	120	30	11000	90	0	0	1	0	1	1
8000	90	45	12000	45	30	0	1	0	1	1
6000	120	60	7500	75	15	0	1	0	1	0
7000	105	30	8500	90	0	0	1	0	1	0
8000	90	45	9500	60	30	0	1	0	1	0
6000	105	45	9000	75	0	0	1	0	1	0

Note: Choice =1 (Option 1); Choice =0 (Option 2)