IN SEARCH OF THE VALUE OF TIME:
FROM
SOUTH AFRICA TO INDIA

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ABSTRACT

The charging of a toll fee for the use of road infrastructure has become a popular means of financing new road infrastructure or as a travel demand management strategy to reduce congestion on urban roads. A critical factor in the assessment of the feasibility of road pricing schemes is how the toll fee will impact on the demand for the toll route(s) as well as on the surrounding non-tolled routes. Quantifying the route choice behavior of road users is critical in modeling the user demand for a proposed toll road. This is fundamental in assessing the toll income stream and financial risks of the financiers of the toll road investment, as well as for the socio-economic evaluation of the toll road from the government’s and general public’s point of view.

International best practice recommends the use of Stated Preference (SP) techniques to develop individual choice or discrete choice models of users’ route choice behavior. With the use of these techniques the road users’ route choice behavior can typically be simulated with the use of a multinomial logit model incorporating a range of variables impacting on route choice, such as the toll fee, fuel cost, travel time, road safety and convenience. Market segmentation in terms of the road user profile, vehicle class and trip purpose is also important. The monetary value attached to travel time savings, or value of time, is a critical route choice parameter applied in the trip assignment routine of network transport models, such as EMME/2 or SATURN, which are typically used to model the traffic on the affected road network.

The paper draws on experience with various toll road feasibility studies in South Africa, and more recently in India, and also makes comparisons with other international experience. The paper emphasizes the survey and modeling methodology, factors impacting on route choice behavior, and interesting trends observed from the results. Various survey techniques to elicit information from road users on their actual (Revealed Preference) and intended (Stated Preference) route choice behavior are discussed, as well as the important considerations in the design of the survey and the SP experiment. Finally, recommendations are made with regard to further research to be conducted on various survey and model calibration techniques.

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1. INTRODUCTION

The route choice behavior of potential toll route users and their perceived value of time (VOT) which determines their choice of route are critical in modeling the toll income stream of a proposed toll road. This is also fundamental in assessing the financial risks of the financiers of the toll road investment.

Internationally the most acceptable approach is to use individual choice or discrete choice models calibrated on the potential users’ actual route choice behavior (revealed preference) as well their intended behavior (stated preference).

The VOT is subsequently used in network transport models such as EMME/2 and SATURN so that these models reflect the correct distribution of trips amongst alternative routes for each Origin-Destination pair of the trip matrix. The VOT is therefore a critical parameter in the trip assignment process and it is important that the VOT is accurately estimated.

This paper describes the value of time studies that were conducted for the purpose of two toll road studies in South Africa and one in India. These studies were most significant in contributing towards research knowledge:

- Scheme development of N4 Platinum toll road conducted by the Bakwena Platinum Corridor Concessionaire (BPCC) (This study will be refer to as the Platinum study)
- Scheme development of Gauteng freeway network as toll routes conducted by the Gauteng Super Highways Consortium (Referred to as the Gauteng study)
- National Highway Corridor PPP Project conducted by DHV for the National Highways Authority of India (NHAI) (Referred to as the India study)

The paper emphasizes the survey and modeling methodology, factors impacting on route choice behavior, and interesting trends observed from the results. Various survey techniques to elicit information from road users on their actual (Revealed Preference) and intended (Stated Preference) route choice behavior are discussed, as well as the important considerations in the design of the survey and the SP experiment. Finally, recommendations are made with regard to further research to be conducted on survey techniques and values of time studies.

2. BACKGROUND

2.1 Estimation of Values of Time From Discreet Choice Models

Discreet choice models, or individual choice models, are very popular worldwide to simulate the choice behavior of transport users for policy testing and travel forecasting purposes.Traditionally, most of these models were developed for mode choice studies. With the international trend to finance new high order roads by means of tolling, route choice studies have become more popular. Discreet choice models are specifically used to estimate values of time of road users as the models accurately capture the underlying choice behavior of the specific target market of the planned toll road. The models also allow the impact of any factor influencing the VOT to be estimated such as the trip purpose, income, road standard, etc.

The VOT is estimated as follows from the formulation of the logit discreet choice model:
Consider the simple route choice situation between a toll road and its alternative, or parallel, non-tolled road. The utility that the road user derives from each route can be formulated in terms of toll fee and travel time:

\[ U_{\text{toll}} = c^*C_t + t^*T_t + M_t \]  \hspace{1cm} \text{Equation 1}

\[ U_{\text{alt}} = c^*C_a + t^*T_a \]  \hspace{1cm} \text{Equation 2}

Where:

- \( U_{\text{toll}} \) and \( U_{\text{alt}} \) are the utilities of the toll road and alternative road respectively
- \( C_t \) and \( T_t \) are the user cost and the travel time on the toll route respectively
- \( C_a \) and \( T_a \) are the cost and time on the alternative route
- \( c \) and \( t \) are the cost and time coefficients which are estimated on survey data of road users’ perceived travel times and costs by means of special logit model calibration programs
- \( M_t \) is the constant, attached to the utility of the toll road, which captures any factor not related to the variables in the model, cost and time in this case, which may relate to safety and convenience of using the toll road relative to that of the alternative road.

In general terms, the value of time is defined as the rate of change of utility relative to the rate of change in travel time, divided by the rate of change of utility relative to the rate of change in the cost. For a linear utility function such as equations 1 and 2, the VOT is simply the ratio of the time coefficient to the cost coefficient:

\[ \text{VOT} = \frac{t}{c} \]  \hspace{1cm} \text{Equation 3}

If time was measured in minutes and cost in cents, the VOT is given in cents per minute.

Any variable in the utility function can be expressed in terms of monetary values by taking the ratio of that variable’s coefficient to the cost coefficient. By taking the ratio of the toll road constant \( M_t \) to the cost coefficient, one gets the value of the safety and convenience that road users attach to the toll road. This is often referred to as the motorway bonus by international literature.

By making the utility functions more complex one can derive more information from the model. For example, by breaking up the cost variable into running cost and toll fee cost, one can estimate the values of time related to running cost and to toll fee. The surveyed data can also be segmented by trip purpose and/or income level to estimate the VOT’s for different trip purposes and income levels.

Louviere and Hensher (2000) derived a value of time function by introducing quadratic and multiplication cost and time terms in the utility function. In this way they could estimate how the VOT would vary by the level of the toll fee and the travel time.

Various market research techniques can also be used to obtain information from targeted road users. Revealed preference surveys obtain road users’ current route preferences, costs and times, for existing toll route corridors. Stated preference surveys present potential toll road users with hypothetical choices between the proposed toll road and the alternative road and request their stated choices between the routes.
Stated preference (SP) models normally perform better than revealed preference (RP) models, as RP data often lacks variation and suffers from empirical correlation’s and interactions which hides the underlying choice behavior. However, SP models suffers from various biases in responses, such as strategic/policy bias in which respondents try to influence the experiment to favor a certain strategy/policy, or errors between intended as opposed to real life choice.

The differences in RP and SP values of time are further discussed in the paper.

2.2 Review of International Experience

In order to learn from overseas experience a literature search was conducted on SP surveys for route choice and toll road modelling. Limited information was found as most SP studies dealt with mode choice. Useful information extracted from overseas literature are summarised below:

- The following are important factors influencing road users route choice in the urban environment: (Abdel-Aty, TRC 1493)
  - Travel time
  - Road Type
  - Congestion
  - Occurrence of stops and traffic signals
  - Uncertainty/unreliability of travel time

- The heterogeneous nature of routes, with varying characteristics along the length of the route, makes route choice modelling more complicated than urban mode choice modelling (Bony, TRC 1037).

- Values of time may vary by trip purpose, income group, mode, occupation group, varying personal circumstances, amount of leisure time available and travel conditions (Bradley, TRC 1285).

- Market research amongst users of the SR91 toll road in California during 1996/97 indicated that many commuters overestimate their actual time savings i.e. 20 minutes perceived versus 13 minutes actual.

- A major research study conducted by the Institute of Transport Studies at Leeds University (England) makes available the net outcome of a very large amount of British empirical evidence regarding the impact of a large number of travel attributes on Values of Time (Wardman). The relevant key findings of the study are:
  - Not only do the money values vary across different circumstances, but there can also be considerable variation in the valuations expressed in units of in-vehicle time.
  - Business values are, as expected, the highest, followed by commuting values, which in turn tend to be higher than leisure values.
  - The effect of distance on the money values was in most cases positive and very similar although not particularly strong. This is in addition to higher values for inter-urban trips of 30 miles or more.
There is a reasonable degree of correspondence between RP and SP values of in-vehicle time. However, this correspondence is progressively weakened for out-of-vehicle time, headway and interchange. Indeed, the divergence between the RP and SP values for headway and interchange is a cause for some concern.

There is evidence that the money value of an attribute will vary with the monetary unit used. Valuations expressed in units of toll fee are the lowest whilst those expressed solely in terms of car running costs are highest.

2.3 Historic Review of South African VOT Studies

At the time of the bidding phase of the N4 Platinum toll road scheme, it was found that there was no recognised database in South Africa in respect of the values of time for traffic and transportation studies. However, there were different sources of information, which permitted a value judgment to be made. These sources of information were:

a) Values of time as ascertained by the Central Economic Advisory Service in the late 1980’s were based on income rates. These values are normally used in economic evaluation studies, but are not sufficiently accurate to explain route choice behavior of road users in a particular road network context.

b) Revealed Preference survey work conducted for the N3 toll road and which concluded that the attraction to this toll road is best defined in terms of a cumulative monetary value (i.e. inclusive of time, safety, comfort and convenience costs) for light (Class 1) vehicles of R80.00 per hour (1997 Rand value).

c) Stated Preference survey work conducted on the N4 Maputo Corridor, between Maputo in Mozambique and Witbank in Mpumalanga, which concluded relatively low values of time, but in conjunction with high motorway bonuses (i.e. to account for safety, comfort and convenience factors and a preference for higher standard routes).

The BPCC subsequently recommended that the South African National Roads Agency (SANRAL) develop a values of time database for South Africa as this would greatly assist in the various future toll road studies. When appointed as Preferred Bidder, the BPCC and its traffic auditors decided to conduct comprehensive RP and SP studies in order to refine the VOT’s for use in the final traffic model. This initiated a number of SP and RP value of time studies in South Africa.

3. RP AND SP SURVEY METHODS

3.1 Overview of Toll Road Studies

A brief overview of the three selected toll road projects for the purpose of this paper are given here in order to put the surveys into perspective.
3.1.1 N1/N4 Platinum Toll Road

The N1/N4 Platinum Toll Route project consists of some 100 km of the existing national road N1 between Pretoria and Warmbaths, running south north, and some 380 km of the existing national road N4 from Pretoria to the Botswana border, running east west. The N1 North links Gauteng province with Zimbabwe to the north, while the N4 West links Gauteng to Botswana to the west. The N4 Platinum route forms part of the coast-to-coast Maputo – Walvisbay Spatial Development Initiative linking Mozambique, South Africa and Namibia. This was one of a number of Build Operate Transfer (BOT) Toll Road Concessions that the SANRAL had put out to tender on a concession basis. The project involved the upgrading of the existing road, construction of toll plazas at various strategic locations, including provision of Electronic Toll Collection (ETC) gates at toll plazas. The toll route has recently been completed, except for one bypass near Rustenburg, a major town along the route.

Parts of the route are urban freeways in the vicinity of Pretoria, one of the three metropolitan areas in Gauteng province, while the other routes are inter-city rural roads. The urban / rural nature of the toll routes made the traffic model very complex, and the route choice surveys had to distinguish between urban and rural traffic.

The Bakwena Platinum Corridor Consortium (BPCC) was appointed by SANRAL as scheme developer, and the BPCC subsequently won the bid to implement the project. A SATURN traffic model was build of the toll routes and parallel main roads, as well as part of the urban network in Pretoria. The traffic model was used to determine the toll traffic attraction, yearly toll income over the next 30 years, and impact of the toll route on the main road network. Accurate values of time were critical for the correct estimation of the toll attraction and toll income stream estimation for the financiers of the BPCC.

3.1.2 Gauteng Toll Freeway Network

The primary corridor forming part of the Gauteng province’s freeway network is the two freeways linking greater Johannesburg and greater Pretoria, which is the busiest inter-city corridor in Africa with current traffic volumes in the order of 200 000 vehicles per day. SANRAL, together with the Gauteng Department Public Transport, Roads and Works, conducted a feasibility study to develop the freeway network in Gauteng as an integrated toll route network. The high traffic volumes, acute congestion, and complexity of the network demanded best practice solutions for the technical, financial and environmental challenges faced by the project.

The Gauteng Super Highways Consortium was formed and appointed by SANRAL to develop the scheme as a potential PPP project. The main toll road strategy was to upgrade freeways to four lanes per direction, with two outer lanes acting as toll express lanes, while the inner two lanes are un-tolled. A SATURN traffic model was build of all the main roads in Gauteng to test the impact of tolling the freeways and to estimate the toll income streams for the next 30 years. Numerous network scenarios consisting of the upgrading of existing freeways and construction of new freeways were tested. The results of the traffic model were also used in a financial model to determine the financial feasibility of the project. A micro-simulation model was developed for critical sections of the network to test the performance of urban toll plazas, using ETC methods, and to test the toll express lane concept.

To test the toll express lane concept very accurate values of time for various market segments were required as the level of traffic congestion and travel times savings between the parallel
un-tolled and tolled lanes were the determining factors for road users’ choice to use the tolled lanes or not. Various congestion-pricing strategies were also tested including higher toll fees during peak periods than during off-peak times.

### 3.1.3 India PPP Corridor:

The corridor is situated in the state of Gujarat, linking Porbandar in the south to Radhanpur in the north. The length of the National Highway along the corridor is 507 km. The corridor forms part of the Golden Quadrilateral road network, which the National Highways Authority of India (NHAI) is in the process of developing as part of a 30-year programme. Commercially viable sections of the network will be funded through tolling under Public Private Partnership (PPP) contracts.

The main purpose of the study to determine values of time was to evaluate funding models for the Porbandar- Radhanpur corridor, including funding from tolling.

### 3.2 RP VERSUS SP SURVEYS

Earlier value of time studies in SA indicated RP values of time to be much higher, in a more realistic range, than SP values. This is in contrast to experience overseas, where RP and SP surveys indicated very similar values. This was a major concern as SP models provided better model fits compared to RP models, but SP models suffer from various biases, such as negative emotions towards tolling, especially in urban areas, and differences between stated and actual preferences.

In spite of international traffic auditors’ insistence to rely only on SP studies, the bidding Consortiums preferred to conduct RP surveys as well to confirm the SP values. The studies reported here all made use of both RP and SP surveys.

Apart from the normal problems associated with RP surveys and models, another problem was to find an existing toll route with a viable parallel main road close to the proposed toll route. Both in SA and India toll roads are not that extensive and the RP surveys did not cover the target market of the SP surveys, which were conducted amongst the potential toll road users. This provided another source of unknown error.

In the case of the Platinum study, the RP and SP studies were conducted independently by two study teams and market research companies. The background questions were made compatible to compare the sample profiles.

The RP surveys conducted for the Platinum study were also relevant to the Gauteng study, which only required additional SP surveys.

In India, the RP and PS surveys were conducted by different companies, both managed by the same consultant team. The RP surveys were done by a traffic survey company and the SP surveys by a market research company. The South African consulting firm also managed the surveys in conjunction with a local transportation engineering consulting firm, which was crucial for the success of the surveys.

The comparison between RP and SP values of time found in these studies are discussed in section 4.
3.3 SURVEY METHODS

The early SP studies in SA all made use of pen and paper interview methods, which was also the case in the Platinum study. One market research company in SA introduced computer aided personal interviews (CAPI) using laptop PC’s, and transferring data via the Internet on a daily basis during surveys. CAPI was therefore used for the first time in a route choice survey during the Gauteng study, with great success.

CAPI provided major benefits as this allowed real time validation of responses, direct computerisation of data, and presenting the SP levels as percentage deviations from respondents’ current personal travel characteristics. The greater variation in the data obtained in this way improved the performance of the models. SP levels could also be adjusted during the survey – fieldworkers down loaded revised questionnaires by dialing in via modem to headquarters when uploading the survey data after the day’s work. This opportunity was indeed used during the Gauteng study, when daily monitoring of responses indicated that too many respondents did not change their choice between the toll route and the alternative route.

The later study in India used pen and paper, as CAPI was not available amongst the local market research companies. Being unfamiliar with local conditions and in view of the fact that this was a first for all the teams involved in the study, it was considered important to keep methods and designs as simple as possible.

Past experience with SP studies in SA indicated that face-to-face interviews is crucial to ensure good results. Another reason is that among low-income groups, telephone ownership and postal services are limited, which ruled out telephone and postal surveys. Postal surveys also suffer from low response rates and require higher literacy of the respondent. All the studies therefore employed face-to-face interviews.

3.4 RECRUITMENT TECHNIQUES

To ensure that only potential toll road users are interviewed for the SP studies, Road Side Interviews were conducted at filling stations on existing roads that were proposed to be tolled. For the RP surveys, Road Side interviews were conducted at existing toll plazas, which was ideal, while road users on the alternative routes were pulled off by traffic police for interviewing, or users were intercepted at filling stations on the route. The drawback of Road Side Interviews is the limited time available to interview road users, especially in case of the SP surveys, for which it is not an ideal interview environment.

In the case of the Gauteng surveys, the freeway users were recruited at so called ultra cities, filling stations adjacent to the freeway with their own interchange, and interviewed at a convenient location afterwards. It proved to be difficult to make appointments with willing respondents at suitable times and locations, especially business people, and various incentives had to be used to make successful appointments. Incentives included gift vouchers or a light meal at a restaurant where the interview could be conducted.

In India the interviews were conducted at roadside cafes, or dhabas, which were conveniently located at short intervals. Recruitment went much faster, even amongst business people.

Heavy vehicle users posed a different a problem, as drivers are not always making the route choices, but rather their managers. In such cases the managers were phoned in the SA studies.
In India, a sample of drivers was interviewed, as well as a sample of managers of freight transport companies owning large fleets.

### 3.5 Market Segmentation

Market segmentation was critical as trip purpose and income generally indicate significantly different values of time. The following typical segmentation was used, with minor differences depending on the local context:

- **Light vehicles** - low and high income of following trip purposes:
  - Business
  - Commuter
  - Social / other

- **Heavy vehicles**:
  - 2 axles
  - 3-4 axles
  - 5 and more axles

A stratified random sampling strategy was adopted to achieve certain minimum quotas according to location, trip purpose and vehicle class, with random selection of respondents within each quota.

Market segmentation posed a challenge in India as a result of the many socio-economic and cultural / religious groups, as well as many vehicle classes. Vehicles such as two- and three-wheelers, and three-wheel trucks occur in significant numbers. Light vehicles such as jeeps are often rented with a driver, and in these cases the client was interviewed and not the driver.

In India, it was also attempted to distinguish different categories of freight to test the impact of different types of freight on the value of time.

The Gauteng survey focused on commuters and business light vehicle trips as these were the most critical for the estimation of the toll express lane attraction rates. These users were also most likely to experience unacceptable congestion in view of work requirements.

### 3.6 Survey Locations and Sample Sizes

A guideline of between 75 and 100 interviews per market segment were used for the SP surveys, suggested by international experience (Ortuzar and Willumsen, 2000). Survey locations and sample sizes are briefly described below

#### 3.6.1 Platinum Study

In total 869 respondents were interviewed in the RP survey, consisting of 619 light vehicles, 97 commercial LDV’s and 153 heavy vehicles. The sample on the N1 north covered the Kranskop and Nyl toll plazas and the R101 alternative route. The N17 sample in the East Rand covered the Gosforth and Dalpark toll plazas and alternative metropolitan routes. The Platinum sample in Pretoria West covered the Quagga toll plaza and R104 alternative route.
For the SP study, 500 light vehicle users and 100 heavy vehicle users were interviewed on the N1 North at the Petroport, adjacent to the freeway, and on Zambesi drive (Pretoria North), a main road running parallel to the proposed N4 West route.

3.6.2 Gauteng Study

The SP survey targeted light vehicles only including a sample of 150 commuters and 150 business users.

The most viable and efficient method was to intercept people at the Ultra-City filling stations adjacent to the Ben Schoeman freeway between Johannesburg and Pretoria, and the Engen filling stations adjacent to the R21, between Pretoria and the Johannesburg International Airport.

No special RP surveys were conducted as comprehensive RP surveys conducted at the rather limited number of existing toll roads in Gauteng province were available from the Platinum surveys.

3.6.3 India Study

The existing toll road corridor between Nadiad and Ahmedabad to the east of the proposed toll road was the closest location for the RP survey. Roadside interviews were conducted at Randhavanj on the toll route and at Barsola on the parallel non-tolled route.

The SP surveys were planned to the south and north of Rajkot, covering the Porbandar-Gondal link and Bamanbore-Samakhiali-Banaskantha link along the total PPP corridor. The roadside interviews were supplemented by large freight operator interviews in these locations, i.e. Ahmedabad, Rajkot and Junagadh.

A total of 1375 SP interviews were conducted during a 10 day period, while 2504 RP interviews were conducted during a 6-day period.

4. DESIGN OF SP EXPERIMENTS

4.1 CHOICE CONTEXTS

Careful consideration was given to the choice context in the SP experiments in order to present realistic route choice scenarios to respondents, yet keeping it simple to obtain reliable choices. Both the Platinum and the India projects involved the upgrading of a road to be tolled, or building a new road, and the availability of one viable alternative route. This context was simply described as choosing between a high standard toll road and a lower standard alternative road with the toll road offering a saving in travel time, better and well maintained road surface, improved safety and security.

Road users were in general familiar with the concept of toll roads and bridges and they could relate to the experimental context. However, the toll express lane concept in the Gauteng study was unfamiliar to respondents, and raised many questions during the Focus Group discussion and the pilot test. It was subsequently decided to simplify the presentation of the toll express lanes by presenting it as two parallel freeways of the same standard, the one being tolled and the other one un-tolled. The tolled freeway was presented as having much less congestion, offered shorter travel times, and only allowed light vehicles to use it.
In this way the choice context was still realistic, but it avoided possible confusion about the toll express lanes.

### 4.2 SP VARIABLES AND LEVELS

As the main purpose of the SP studies was to determine the value of time, the toll fee, fuel cost and travel time variables were the most important to include in the experiments. The roadside interviews also did not allow time for lengthy interviews, and the number of variables had to be limited.

The complexity of the Gauteng study required additional variables to be tested such as the reliability of predicting travel time, and hence departing earlier to allow for unexpected congestion. To determine the most significant factors impacting on route choice along the Johannesburg – Pretoria corridor and to test road users understanding of the toll express lane concept, focus group discussions were conducted prior to the SP surveys.

A spreadsheet was used to determine boundary arrays in order to define the SP levels such that the boundary values of time with respect to toll fees and fuel costs covered a wide range within plausible limits.

All questionnaire designs were pilot tested to ensure that respondents understood the experiment, did not get fatigued and would switch their choices between the toll and alternative route options.

#### 4.2.1 Platinum Study

Two variables, travel time saving and relative user cost, with 5 levels each were presented in the SP questions. The total number of combinations was too many and therefore respondents were randomly divided into 3 groups and each group was offered 8 to 9 choices to cover the whole range.

In view of the pen and paper method used, separate designs were developed for short and long distance trips.

#### 4.2.2 Gauteng Study

Apart from the travel time savings and toll fee, it was also felt important to include two additional travel characteristics that were important for the strategic and micro simulation models. Earlier departure for commuters on the existing freeway relative to the toll freeway as a result of congestion, and the number of incidents per month (commuter and business) were also presented as SP variables.

Two separate SP experiments were conducted. Travel time saving and toll fee were common to both of them, while departure time was included in one experiment and number of incidents in the other one.

Each experiment therefore consisted of 3 variables, each with 3 levels. This yielded 9 choices per experiment to obtain an orthogonal design estimating main effects only.
The use of CAPI allowed SP levels of the new toll freeway to be estimated in real time during interviews based on respondents reported travel times and departure times for their current trips.

4.2.3 India Study

In view of previous experience and the need to focus on travel time and cost variables in order to determine values of time, it was decided to adopt a simplified design.

The following variables and levels were selected:

- Travel time saving of toll route relative to alternative route (3 levels)
- Toll fee on toll route (4 levels)
- Fuel cost saving of toll route relative to alternative route (3 levels)

An orthogonal design, yielding 16 choices per respondent, was selected. Initial concerns that 16 levels were too many, were allayed during the pilot tests and the 16-choice design was also used for the main survey.

In view of the fact that a pen and paper method was used, four designs had to be formulated to cover short and long distance trips, with a 100 km cut-off point, for light and heavy vehicles.

4.3 Inertia To Change

A typical phenomenon, “inertia to change”, was encountered similar to that found during mode choice SP studies in SA. See van Zyl, Lombard and Lamprecht (2000). In the toll route studies, the added problem of sensitivities to paying toll worsened the problem. The result was that some respondents only chose the non-tolled route, no matter how attractive the toll route levels were. Within limits this problem can be accepted as normal behavior, as long as the design allow for trade-offs that would test respondents’ boundary values of time.

The sensitivities of tolling the freeways in Gauteng, especially among commuters, resulted in too many respondents not switching their choices. Subsequently, the SP design had to be changed during the survey, which reduced the problem.

The Platinum study and the India study did not experience this problem. Both these studies involved inter-city toll roads, although commuter traffic in the Platinum study was also targeted. The Platinum study included one level of zero toll fees for the toll route, which might have helped to reduce the problem.

The problem of “inertia to change” and how to deal with it was much debated during the Platinum and Gauteng studies. One solution is to present respondents with time vs. cost trade-offs in other non-emotional contexts. However, value of time is very context specific and one would not know what the error would be caused by the difference in context. Offering trade-off’s just between fuel costs and travel time savings in a route choice situation is a closely related context, but experience indicated that values of time based on fuel costs is higher than that of toll fees.
5. COMPARISON OF VALUES OF TIME BETWEEN STUDIES

5.1 Performance of Route Choice Models

Although a wide range of tests of the designs and questionnaires were performed, as well as checking and validation of responses during the surveys, the ultimate quality of the surveys were judged by the performance of the route choice models. Normal logit estimation procedures were performed, and values of time were only determined from significant models, and from cost and time variables that were significant and that indicated the correct signs.

Similar to international experience, SP models performed much better than RP models. Travel times and costs were often not well reported, which required extensive validation to be performed. Records with outliers were subsequently excluded. The large RP samples allowed the data bases to be reduced without yielding too low samples.

Interestingly, the SP models in India performed better than those in SA. The problems experienced with the sensitivities surrounding tolling of urban freeways might have been the cause of the lesser performance of the models in the Gauteng study. No such sensitivities were encountered in India. On the other hand, the RP data of the India study did not allow any models to be calibrated, due to high correlations between travel times and costs of the tolled and alternative routes, amongst others.

5.2 South African Studies

The following patterns in the VOT’s were observed from the results of the Platinum and Gauteng studies:

- For light vehicles, business trips display the highest VOT’s followed by commuters, while social/other trips indicating the lowest VOT’s. This is similar to international experience.

- Low-income road users have lower VOT’s than high-income users, which may be a combined income and cultural effect.

- For heavy vehicles, the larger vehicle classes that pay higher toll fees, display higher VOT’s.

- Similar to the findings in earlier studies, the VOT’s are much higher than the average income rate across all market segments, i.e. some 80 per cent higher.

- Motorway bonuses indicating the value of safety and convenience offered by toll roads were valued at approximately 20 per cent of the time value.

The Platinum study found very good similarities between the RP and SP VOT’s, with a few minor exceptions. The different target populations of the RP and SP surveys could explain these differences. The similar results produced by two independent study teams following
different survey approaches generated a lot of confidence in the values of time for the toll income modelling purposes.

In contrast, the Gauteng study indicated lower SP values of time than the RP values, confirming the results of an earlier study in Gauteng. It is evident that the VOT is sensitive to the route choice context and that road users have more negative perceptions regarding paying toll on urban roads, which are used on a more regular basis compared to inter-city toll roads.

Combined SP and RP models were subsequently estimated and a scale factor determined for the toll fee, and estimating separate RP and SP coefficients for the travel time savings. This provided more plausible results. Comparison of the final VOT’s indicated that VOT’s of Business and Commuter trips from the Gauteng study were 20 percent lower than those of the Platinum study, while the VOT of “Other” trips were found to be much lower, i.e. 20 per cent of that of the Platinum study. This seemed plausible, as the “Other” trips in the Platinum study would consist of mostly long distance holiday/weekend trips, which would indicate higher VOT’s, compared to the mostly Social and Recreational trips in the case of the Gauteng study.

5.3 Comparison of India and South African results

The following results were obtained for light vehicles. The India results are mentioned first and then compared to the South African results:

- Values of time related to toll fees and those related to fuel costs were fairly similar in India. Other studies indicated that road users are more willing to pay in terms of fuel cost rather than toll fees, and therefore values of time in terms of toll fees are generally lower than those for fuel costs. This pattern was observed in the case of some user segments.

- In general there was not much variation in VOT’s of different trip purposes. The VOT of business trips was somewhat higher than for other trip purposes. This trend was similar to the South African studies. The VOT of holiday trips was the lowest, with that of commuter and other trips the same and somewhat higher than that of holiday trips. This pattern differs from other studies, which indicates higher VOTs for commuter trips than for social/recreational trips.

- As expected, higher income users indicated a higher VOT compared to lower income users, although this difference is not as large as found in SA.

- The highest difference between user segments was found between short and long travel time trips, with the VOT of long trips more than double that of short trips. Short trips were probably made more frequently and time savings were less, and therefore users were likely to be less willing to pay toll for short trips. This trend was similar to that of SA studies.

- The goodness of fit of the RP models in India was very poor and RP values of time could not be estimated. Instead average RP boundary VOT’s were determined, which was found to be double the average SP VOT. When comparing the RP and SP VOTs, one must also consider that the surveys were done in different locations and different techniques were used. Other studies also found higher RP VOTs compared to SP VOTs.
• In contrast to SA studies, the VOT’s in India were much lower than average income rates, just opposite to the results indicated by SA studies.

The following results were obtained for heavy vehicles:

• The overall average VOT of heavy vehicles in India was roughly similar to that of light vehicles, although the maximum VOT of different heavy vehicle classes was much higher than the maximum VOT of different light vehicle segments. In the SA studies, heavy vehicles indicated a much higher VOT than light vehicles across all market segments. The lower than expected VOT of heavy vehicles supported the responses on the importance rating of route choice factors by respondents, which indicated costs to be much more important than travel time.

• In terms of vehicle classes, the VOT of larger (3 and multiple axles) was lower than that of smaller vehicles (2 axles). This pattern was opposite to that of found by the SA studies, and might have been due to measurement errors.

• The highest difference in VOT between user segments was indicated among low and high value loads. This pattern was also evident among time-sensitive / high-value commodities (perishable and manufactured goods) compared to low-value / non-time sensitive goods (bulk commodities).

• Long trips indicated a higher VOT than shorter trips, which was similar to the trend shown by light vehicles, but not to the same extent.

• The interest on the average value of loads offered a benchmark VOT for heavy vehicles as capital locked in transit is unproductive and the owner would value this at the cost of borrowing money. Assuming interest of 16 percent per annum, the average financing cost per hour was much lower than the VOTs of heavy vehicles. Other factors that place a premium on travel time savings, such as customer service and delivery of food products in a fresh state, were therefore more important than financing cost.

• Similar to the SA studies; the motorway bonus factor of toll roads in India was found to be significant for both light and heavy vehicles. This result supported the attitudinal responses on important factors such as road safety, driver comfort and safety from crime.

• The motorway bonus was between 16 and 17 per cent of the average value of time, only slightly lower than for SA studies.

6. CONCLUSIONS AND RECOMMENDATIONS

The two SP studies in SA and one in India that were reviewed, produced well performing models and values of time for different market segments, with interesting similarities and differences. A reliable set of values of times for various trip purposes and user segments were established from the Platinum and Gauteng studies that can serve as a useful benchmark for future studies in South Africa. For a first study, good results were achieved in India, although more research is needed to establish a reliable benchmark of values of time for different market segments.
Various survey techniques were employed, and although some worked better than others, they can all be used with fruitful results. The following conclusions are drawn:

- Keep the SP experimental context simple but realistic, using binary choices as far as possible;
- Conduct RP surveys for a back up, but these need to be as close as possible to the target market and the socio-economic profile of the target market;
- Use focus groups for new concepts unfamiliar to road users;
- Where possible use of CAPI should be made;
- In view of possible problems such as “inertia to change” sample sizes should preferably be more than 100 per market segment;
- Although road-side interviews are the most practical and cost-effective, road side recruitment and interviews at home or work provides a more ideal SP environment;
- Testing of boundary arrays is important to ensure a range of cost vs. time trade-off’s.
- Use 8 to 9 choice scenarios, although up to 16 can also work;
- Use at least three levels of each variable and preferably more, by segmenting the sample.

VOT’s governing the route choice behavior of road users were found to be much different than the average income per working hour for light vehicles, or financing costs of freight locked in transit, that is normally used in economic evaluation studies. For the purpose of toll road feasibility studies, it is therefore important that VOT’s are estimated for each toll road context using SP and RP survey techniques.

Various factors that significantly impact on the value of time were quantified:

- Market segments in terms of passenger versus goods, trip purpose and vehicle class
- Income and socio-economic status of light vehicles drivers
- The level of congestion experienced, and number of incidents causing delays
- Urban versus rural toll roads, also related to the frequency of trips,
- Departure time,
- Length of the trip,
- Factors relating to the standard of the road, safety and convenience.

It is recommended that further research be conducted on the following aspects:

- Including more variables impacting on route choice as a result of tolling, in addition to time and cost, as well as interaction with other choices such as ride-sharing, mode choice, and even changing location of residence and work location.
- Solutions to the problems experienced with SP biases relating to the sensitivities towards urban toll routes in SA need to be investigated.
- Evaluating alternative methods to obtain more reliable RP route choice data from road users. It is expected that face-to-face interviews, in an unhurried environment, would give better results. The use of aids to assist the respondent, such as maps indicating route distances and travel times, should also be evaluated.
- Direct comparison of RP and SP values of time by applying both methods on the same sample of road users in the context of an existing toll road.
- It is recommended that the national roads agencies in SA and India continue to support comprehensive SP and RP studies for all future toll road studies in order to build up a comprehensive data and knowledge base.
- The completion of the N4 Platinum toll route provides a unique opportunity to conduct after surveys and testing both RP and SP models on the same target market.
- It is appreciated that the technique used to estimate values of time was based on the assumption that road users display compensatory, utility maximization route choices.
This assumption should be tested to determine whether non-compensatory models do not yield better results. However, this will require a similar toll traffic modelling approach as well.

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