ESTIMATION OF VALUE OF TRAVEL TIME IN TRINIDAD AND TOBAGO

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Abstract*:* The value of travel time is a key component in evaluating the potential impacts of projects aimed at improving the transportation system. In particular, the evaluation of the feasibility of projects such as toll roads is often premised on the assumed benefits that drivers perceive from saving travel time and their willingness to pay for such benefits. In Trinidad and Tobago there is no historical information which could inform valuation. This study utilized stated preference methods to determine the local value of travel time. A questionnaire was developed that incorporated a stated preference survey involving binary choices between faster, expensive travel options and slower, cheaper ones and also captured socio – economic data and work trip characteristics of the respondents. It was administered using convenience sampling via the Whatsapp mobile messaging app. To develop the survey, a preliminary estimate of value of travel time was made based on both national Gross Domestic Product and average income data. A binary logistic regression model was developed utilizing the maximum likelihood method to determine the parameters of travel time and travel cost. Based on the analysis, the overall value of travel time estimate obtained was found to be 71% of the income wage rate and 48% of the wage rate calculated using Gross Domestic Product. The GDP base rate is consistent with estimates from other jurisdictions.

Keywords: *Binary logistic regression. Stated preference survey, Value of travel time.*

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1.0 Introduction

A robust and efficient transportation system enables the effortless movement of goods and people and is critical to economic development. Travel time is one of the most important attributes of any transportation system and influences the decisions made in the movement of goods and by passengers [4]. The value of travel time (VOT) is a key component in evaluating the potential impacts of projects aimed at improving the transportation system. In Trinidad and Tobago, the road network is essential to local transport. As such, VOT can be used to drive the decision-making process with respect to road infrastructure improvements through its use in deriving monetary estimates of the benefits of projects. In this way, VOT is critical to estimating the economic benefits of projects, which can aid the sustainable development of transportation systems.

Additionally, VOT is utilized in the determination of the feasibility of projects such as toll roads since its evaluation is often premised on the assumed benefits that drivers perceive from saving

travel time and their willingness to pay for such benefits. Tolled facilities were first proposed in Trinidad and Tobago by the then government in 2008 [31] and again in 2012 [12] but were never implemented. Despite the planned implementation of toll roads at these times and notwithstanding the study done by Egis during the development of the Port of Spain (POS) Northern Valleys Link (NVL) Project, there was little information to predict the proposed traffic volumes based on the public's value of travel time.

In Trinidad and Tobago, there is no historical information which could inform valuation and therefore, proper assessment that would determine the feasibility of road infrastructure improvement projects is difficult. This paper seeks to address this issue by determining the value of travel time in Trinidad and Tobago.

2. Literature Review

Value of travel time (VOT) can be defined as "the maximum amount of money that people are willing to sacrifice to save one unit of time, provided that all other trip–related attributes remain constant" [4]. The concept was first introduced by Becker (1965) where it was put forward that time can be converted to money based on the idea that savings in time can be freely allocated to work and hence, increased earnings. It is based on the neo–classical time allocation model which posits that an individual will maximize their utility by allocating their time within the constraints of time and budget [1][26][4]. The model implies that travel time can be valued at the wage rate based on the assumption that time can be easily reassigned between work and other activities i.e. any savings in travel time can be used to increase income through more work hours [26]. This is not usually the case and so more empirical methods have been used to determine VOT. Despite this assumption, due to lack of other empirical data, wage rate has been used to approximate VOT and can be determined based on the Gross Domestic Product (GDP) per capita and the working time per person [2] or be determined directly if the data are available. In the majority of developing countries and in some first world countries (Germany and Japan, for example), economic indicators such as GDP and wage rates are used for VOT [15].

It is recognized that demand for travel is a derived one; it is as a result of the demand of activities that exist at the start and end of a trip. Furthermore, it is also a negative demand, i.e. an individual is willing to pay to have less of it [6]. It is a result of this willingness that the concept of VOT arises. Though this view of demand is universally accepted, alternative views have been explored in recent years. Excess travel may be pursued due to the enjoyment of undirected travel (sense of speed, enjoyment of beauty) and as such, instead of travel being conducted pursuant to an activity, the travel itself becomes the activity [21].

The framework to measure willingness to pay to reduce travel time can be divided into two main categories: revealed preference (RP) and stated preference (SP) [3][7]. In the context of transportation, RP information is traditionally based on observations on or statements from individuals about their behaviour and is usually assumed to be reliable. Conversely, SP information is obtained from what individuals claim they intend to do in hypothetical situations [3][17]. As such, SP can be used in new situations and are therefore widely used in the introduction of new tolled facilities [16].

Despite the use SP survey in studies of this nature, there are experts who have reservations about this method [3]. The major downside in the use of SP surveys is the possibility that the stated

preferences by respondents are not the same as what occurs in actuality. Another reason for the inconsistency in stated and actual behaviour is that oftentimes scheduling constraints (allowing insufficient time for the journey) may result in persons using the tolled facility in order to arrive at their destination on time. It is also highlighted that there can be a regular misperception of travel times due to the toll facility only representing a portion of the trip. Therefore, travellers erroneously think that the delay faced on the entire trip will be eliminated and not only for the section where the new toll facility will be implemented [7]. It can be argued that in most SP studies the trade–off between money and time is assumed to occur over the entire trip, including free roads that lead to the tolled facility [23].

Despite these concerns regarding SP surveys, RP surveys provide a number of challenges and shortcomings as well. Since these types of survey can only generate one choice for each participant, they tend to be expensive to undertake. Secondly, they give no insight into the alternatives that were rejected since only the chosen option is revealed by the participant. Finally, they are not suitable in instances where there are new alternatives to transportation. SP surveys do not suffer from these limitations, and in fact, a variety of choices can be offered for each participant allowing for the development of statistical models [15].

SP methods can be subdivided into direct surveys and indirect surveys with the latter being further broken down into conjoint analysis and discrete choice experiments [24]. Direct surveys involve directly asking potential customers what price they will be willing to pay for a product [7]. In the case of road pricing, it would be the toll price. However, this can be particularly challenging for respondents for unfamiliar goods [8], as would be the case for a new toll road locally. An example of the difficulties for respondents was the direct survey used in the POS NVL Project which resulted in a large standard deviation for VOT [12]. Furthermore, this survey type can result in biases from respondents attempting to please the interviewer or influence the final outcome. It is also possible that for respondents' replies later in the questionnaire can be influenced by their initial ones [19].

Despite the importance of the use of VOT in transportation planning, it remains a concept heavily based in theory that is not easily measured and therefore, indirect methods of measuring VOT have been developed [3]. SP survey data allows for multiple responses to be obtained from each respondent since a number of choices can be made. Through the use of discrete choice surveys, discrete choice models can be developed and used to quantify VOT. In a VOT study done in Greece, multiple discrete model types were formulated and it was found that the other model types were superior to the binary logistic regression models developed [3]. However, it is also noted that the binary logistic regression models performed well and are mostly used in studies due to practical reasons.

3. Theoretical Framework

The logistic regression or logit model is used in the analysis of discrete choice data because the responses can only take values representing success or failure i.e. selecting or not selecting a particular choice. Unlike linear regression models where the dependent variable is some continuous output, for logit models the dependent variable is the probability that an outcome will occur. For binary logit models, the observations of the outcome can only take two values (usually 0 or 1) and are categorical with the 0 and 1 serving as dummy variables. The independent variables

are in the form of a linear function which is the logit function. In the case of VOT studies using binary discrete choice data, while other variables can be used, differences in time and cost between the choices are usually the independent variables. The logit model takes the form:

$$P_i = \frac{e^{U_i}}{e^{U_i+1}} \quad (1)$$

where P_i = probability of success of observation i
U_i = logit function
[22]

The model describes the probability that observation i will be a success ($P_i = 1$) based on the logit function U_i [22]. For VOT studies, the logit function, U_i, is the utility function for each alternative and has independent variables of changes in time and cost between the two choices given in the SP survey [3]. Subsequent sections describe what form the utility function takes, what the parameters of the said function are and how these parameters can be utilized to determine VOT.

For the binary logit model used, respondents had a choice between two options, a fast expensive option and a slow cheap one. The choice made between these options would depend on the perceived utility that one would gain from the selecting a particular option. Utility is a term used in microeconomics to measure the additional amount of satisfaction a person would derive from buying a service or commodity [13]. In the case of the stated preference survey the variables to consider are the time and cost differences for each option.

The utility function of each alternative has the form:

$$U_i = \beta_1 \Delta T + \beta_2 \Delta C + \varepsilon \quad (2)$$

where U_i = utility of alternative i
ΔT = Change in travel time (in minutes)
ΔC = Change in travel cost (in TT dollars)
[4][5]

The parameters β_1 and β_2 are the coefficients of the change in travel time and travel cost, respectively, and represents the sensitivity of a participant's utility toward variations in travel time and travel cost. As such, the ratio β_1 / β_2 would reveal the trade–off of travel time and cost, which is the value of travel time or VOT [3][5][9]. The ε term is an error term meant to capture any errors that cannot be explained by the model.

The coefficients β_1 and β_2 from the given data were estimated by maximizing the log–likelihood function, which is given by:

$$\ln L = \sum_{i=1}^{N} [y_i \ln P_i + (1 - y_i) \ln P_i] \quad (3)$$

where probability, $P_i = \frac{e^{\beta_1 \Delta T + \beta_2 \Delta C}}{e^{\beta_1 \Delta T + \beta_2 \Delta C + 1}}$
y_i = observation i [22]

4. Methodology and Data Collection

4.1 Research Design

This study was based on quantitative research and as such field data was required. It was collected via an indirect stated preference questionnaire using binary discrete choice methods. Secondary data, namely socioeconomic data about the respondents, was also captured by the survey. It was conducted online using the cloud–based survey development software, Google Forms, and was distributed via the mobile messaging app, WhatsApp.

4.1.1 Wage Rate

To ensure that the values for cost and time used in the options given in the stated preference survey were appropriate for the local population, a baseline value of travel time had to be established. This was done using the national wage rate, which is a measure of the amount of base wage to a worker per unit of time [20]. Wage rate is still utilized in some jurisdictions to estimate value of travel time [4][15] and so was chosen to establish the baseline value of travel time to develop the work trip scenarios in the questionnaire.

If the data is available, wage rate can be obtained directly. In Trinidad and Tobago, according to the Central Statistical Office (CSO), no wage rate data was collected for the last census [29] but income data was collected for the Annual Labour Force Report [30]. Data for 2016 (the latest data published), shows that the average income for the population was TT$6077 per month or TT$72,924 per year [30]. Calculating the average wage rate based on a typical forty hour work week over the course of fifty two weeks for the year (2080 work hours per annum) results in an average wage rate of TT$35.06. It should be noted however, the data revealed that the response rate from respondents was low. This could significantly impact the average wage rate calculated as it would not be a true representation of the population.

Therefore, the indirect method of calculating the wage rate from the Gross Domestic Product (GDP) was also employed. According to the most recent data from the World Bank for the year 2016, the GDP per capita for Trinidad and Tobago was US$16,334.52 [36]. Using the same typical 40 hour work week over the course of fifty two weeks for the year translates into an average wage rate of US$7.85 per hour or TT$53.38 per hour, which is approximately TT$18 more than the value obtained using income data.

4.1.2 Questionnaire

The stated preference questionnaire comprised a total of fifteen questions that were subdivided into three sections. The first section of the questionnaire consisted of two questions about the work trip characteristics, specifically whether public transport or private vehicles are used and whether dropping children to school forms part of the trip.

The second section of the questionnaire was the stated preference survey and was comprised of seven binary discrete choice games described in the survey as “work trip scenarios”. The number of attributes for each choice game was limited to two namely, change in travel time and travel cost, allowing for the data to be analyzed using binary logit models. This simple design allowed for a concise analysis that may not have been arrived at for more complicated designs, such as multinomial logit models, since for such designs there would be many variables which may make it very difficult to obtain firm conclusions [14].

The number of attribute levels was limited to three to ensure that there were not too many discrete choice games. The length of the survey was kept to a minimum since respondents can get fatigued if there are too many questions [23]. The cost per hour values that varied from $6.67 per hour to $120 per hour, resulting in a range in which the median was sufficiently close to the previously determined baseline value of $53.38 obtained from the wage rate.

Each game in the choice experiment was set up such that for each there is a choice between two alternatives, a fast, expensive option and a slow, cheap option. In this way, each game reveals if and to what extent the participant is willing to trade time for money [14]. The journey times were randomized and both shorter and longer times were used so that the values to travel time obtained would not be biased by the length of the journey. Studies have shown that the length of time of the journey can affect the value of travel time [26].

The final section of the questionnaire collected socio-economic information of the respondents. Prior to the distribution of the questionnaire, the process was tested and piloted with a smaller sample group and all shortcomings were addressed. Ensuring that the survey was simple and easy to complete obviated the need to conduct interviews and enabled the use of the stated distribution methods.

4.2 Data Collection

The stated preference survey data that was collected through Google Forms was distributed using the unique URL generated by the software via the mobile messaging application, Whatsapp. Respondents were encouraged to forward the survey upon completion in an effort to increase the chances of achieving the desired sample size. The data was collected from July 16, 2018 to July 24, 2018. In total, there were 462 respondents for the seven scenarios considered resulting in 3234 responses.

The sample consisted of 55.2% female respondents and the 26 – 35 and the 36 – 50 age brackets were prominent, representing 54.3% and 30.5% of the respondents, respectively. The data showed that 70.8% of the respondents had an education up to the degree level while the remainder did not. Out of the 70.8% that had attained a degree, the majority (35.1%) had attained a Bachelor's. With regard to average monthly earnings, approximately 70% of respondents indicated that they earned between TT$5000 and TT$20,000 per month with a larger portion (37.6%) earning between TT$5000 and TT$10,000 per month. The questionnaire also gathered information on trip characteristics which revealed that 16.7% of respondents used public transport versus private vehicles during their work trip and 24% of respondents had to drop children to school prior to proceeding to work while the remainder did not. Out of the respondents surveyed, the municipalities that had the greatest percentages of trip origins were the Tunapuna – Piarco Regional (19.7%), Chaguanas Borough (19.3%), Diego Martin Regional (10.2%) and San Juan – Laventille Regional (9.7%) Corporations. However, the Port of Spain City Corporation had the majority (39.0%) of the trip destinations when compared to other municipalities. The San Juan – Laventille and Tunapuna – Piarco Regional Corporations also had substantial percentages of trip destinations which were 14.1% and 13.4%, respectively.

5. Discussion

5.1 Data Analysis

The questionnaire and survey were structured in a manner to allow the use of a logistic regression (logit) model to analyze the data collected. Since the observations from the survey were categorical i.e. whether the fast, expensive option is chosen, this model type is suitable. For categorical dependent variables, linear regression models are unsuitable since they can generate outputs that are not measured on a ratio scale and can be any real number between negative and positive infinity [11]. Logit models have also been successfully used on many VOT studies done in Europe [3]. However, while some of those studies have applied multinomial and mixed logit models to analyze stated and revealed preference data [4], a binary logit model was used for this research since there were only two alternatives for each game in the stated preference survey.

As stated previously, the coefficients β1 and β2 were determined as those values that maximized the log–likelihood function. This was done using Gretl, a software package that is used for econometric analysis.

Taking into consideration the previous discussion, the data received from all 462 respondents that participated in the survey resulting in a total of 3234 data points. It should be noted that the data was compiled such that ΔT was negative. This is because the changes in time represent time reductions. On the other hand, ΔC values were recorded as positive since the toll paid would represent an increase in cost. The following table summarizes the parameters and results of the logit model analysis for all respondents of the sample group.

Table 2. Parameters and Results of Logit Model Analysis for All Respondents

Independent Variables	Coefficient	Std. Error	Z–score	P–value
ΔT	-0.0663	0.0024	-27.41	<0.0001
ΔC	-0.1608	0.0056	-28.96	<0.0001

From (2), the coefficients for ΔT and ΔC correspond to β1 and β2, respectively. The negative signs for both coefficients signify the negative correlation between the level of satisfaction and the independent variables. Therefore, as the cost increases there is a decrease in the level of satisfaction and a lower likelihood that the option would be chosen. The high value absolute values of the z–score and corresponding low p–values indicate that there is a low likelihood the results were random. As such, choosing the fast option is highly influenced by ΔT and ΔC. Based on the results of the survey, the model that was developed had a 77.4% success rate.

It should be noted that the independent variable for change in cost is based on minutes. Therefore, the ratio of β1 / β2 would give the value of time in TT dollars per minute. This ratio was converted

to dollars per hour as is the custom for studies of this nature. The analysis shows that the VOT for all respondents in the sample is TT$24.74 per hour which converts to US$3.67 per hour (US$1 = TT$6.74).

5.2 Interpretation of Results

Given the national wage rate using average income and GDP per capita of TT$35.06 and TT$51.76 per hour, respectively, the VOT to wage ratios were 71% using the income wage rate and 48% for the wage rate determined using GDP per capita data. These ratios indicate that the GDP per capita wage rate seems more reasonable given the theory and the plethora of studies done regarding the relationship between the two concepts. A reasonable estimate of average VOT is approximately one half of the wage rate [25]. This has become such a widely accepted approximation that Transport Canada and US Department of Transportation have recommended using a value of 50% to estimate VOT in relation to average wage rate [28][32].

Furthermore, a study of fifty-six VOT estimates within a sample of fourteen nations revealed that the average VOT as a fraction of gross wage rate was 48% [35], which is consistent with the value obtained in this study. The research further suggested that values between 35% and 50% of wage rate can be used approximate VOT for commuting by automobile. Two studies carried out in the UK in1998 and more recently in 2003 found that VOTs as a percentage of wage rate were 52% and 51%, respectively [18][33]. Use of the estimate is further supported by the most extensive meta–analysis of 389 studies conducted between 1963 and 2011 in European countries. It revealed that for all the years for which studies were evaluated, the VOT estimates for commuting, other travel and when no purpose for travel was stated were 42%, 48%, and 42%, respectively [34]. All these studies demonstrate that the 48% value obtained for this study was reasonable.

On the other hand, there have been studies done revealing that VOT is a higher percentage of wage rate as was seen when the income wage rate was used. A French study found the percentage to be an average of 59% [10] and one done in Japan found VOT to be as high as 84% of wage rate [27]. Despite these studies, there appears to be a lot more research supporting the notion that VOT is closer to 50% of wage rate and thus, the wage rate calculated using GDP per capita data appears to be more accurate.

It should be noted that there are some issues in the collection of average income data. As previously stated, the response rate for this type of data locally is very low. Review of the income data for one of the municipalities revealed that the response rate was only 40% [30]. It was not immediately apparent how this was treated with in the determination of the average income value. However, it cannot be denied that such a low response rate can significantly impact on the average value determination. It can be reasoned that security and safety concerns result in persons in higher income brackets being less willing to reveal their income leading to the lower wage rate value than the one obtained using GDP per capita.

6. Conclusion

The road network in Trinidad and Tobago forms the backbone of the local transportation system and therefore careful consideration must be made in deciding economic investments aimed at developing road infrastructure in a sustainable manner. Value of travel time (VOT) assessments form the basis of such determinations and are therefore the reason for this research being conducted, the aim of which was to estimate the value of travel time in Trinidad and Tobago.

The findings of this study indicate the estimation of the VOT for commuters locally. This was done using an online stated preference survey of 462 commuters. The wage rate was estimated using average income and GDP data for the country so as to be used as a baseline to develop the stated preference survey questionnaire. The survey was structured such that it enabled the use of a binary logistic regression model which was then developed to represent the data collected. Using least likelihood methods, the parameters and coefficients of the model were determined and used to calculate VOT. The analysis shows that VOT estimation was TT$24.74 which was deemed reasonable given its ratio to the national wage rate.

Overall, the results of the research mirror those of other studies done globally very well and have its place in building the knowledge base with respect to local VOT. It is hoped that this sheds some light into the potential of the use of toll roads locally and provides a foundation for the proper valuation of road infrastructure projects. In so doing, the potential for developing the local transportation system in a sustainable manner is greatly improved.

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