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DEVELOPING A METHOD FOR MEASURING THE QUALITY OF A SAMPLE BASED TRIP LENGTH DISTRIBUTION FOR URBAN TRIP

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Abstract

Trip Length Distribution is an important part of Transportation Modelling. This distribution is normally gotten from a sample. Thus, the Quality of the Sample Based Distribution must be able to be measured. This paper present the result of an attempt to develop a method to measure this quality. The research gave the following result. Basic common measure related to the sampling is a maximum acceptable error at a certain minimum confidence level. It has been found that the Quality Measuring Method can not incorporate the error, since it deals with a distribution pattern in which there is no single parameter value and the error probability density function is not yet known. The proposed Sample Quality Measuring Method is by calculating its Confidence Level based on the Goodness of Fit Statistical Inference method, by using a χ^2 test. The Confidence Level is equal to $P(\chi^2,\upsilon)$; where $\chi^2 = \Sigma (O_i - E_i)^2 / E_i$ and $\upsilon = k - r - 1$.

Keywords : transport modelling, trip length distribution, sample, sample quality.

1 INTRODUCTION

Transportation Planning must incorporate Transport Modelling to produce the desired lines, trafic and passenger flow in the network. These three are needed for Transportation Planning, and are calculated based on Origin-Destination Matrix (OD Matrix). The OD Matrix itself is a product of the Trip Generation, the Network Data and a Deterrence Function. While the Deterrence Function is a modelization of a Trip Length Distribution (TLD). Generally, the Deterrence Function can be modeled in three forms : a negative power, a negative exponential, and a multiplication of negative power and negative exponential. So having a correct TLD is an obligation in Transport Modelling (Ortuzar-2004, Suprayitno-2015, Suprayitno-2016, Tamin-2000).

Non Conventional Modelling is becoming more popular and more widely used. It is about developing an OD Matrix based on Traffic Volume Data. But normally, the TLD is normally still needed to validate and calibrate the OD Matrix (Ortuzar-2204; Suprayitno-2015; Suprayitno-20016, Tamin-2000).

TLD is always built based on a Sample. Thus, its quality must be able to be verified. A sample is considered qualified if the Sample Property is close enough to the Population Property. In this case means that the Sample Based TLD cannot be much difference to the Populaton Based TLD. A method to verify is therefore needed and important. The method cannot be found in classical Transportation Modeling handbook and article (Ortuzar-2004, Suprayitno-2015, Suprayitno-2016, Tamin-2000). The guidance which can be found is only from the US Bureau of Public Road, which is a Guidance on Sample Size according to the Region Population, for developing an Urban Transport Model (O'Flaherty, et al – 2006).

Basically, to be practical, Sample Quality is directly determined by a Minimum Sample Size. Example of formula on Minimum Sample Size can be found several. But normally, these formula deal with a single value of population parameter. The TLD as Population Parameter have a series of values. A single formula to determine Minimum Sample Size for developing a TLD can not be found (Blank-1982; Burmeister & Aitken – 2012; Freedman – 2004); Gertsmann – 2003; Israel – 1992; Rose et al - 2015; Scott – 2008; Siegel - 1980) . Regarding Statistical Science, the Minimum Sample Size has a direct relation with Sample Quality Measuring Method and this is part of Statistical Inference technic. The basic Statistical Inference discusions normally cover the parametric and the

non parametric cases, and this deals with verifying the following statistics parameter : mean, variance, and proportion (Blank-1982, Siegel-1980). Apart from those three, methods to verify the Goodness of Fit is also discussed in Statistical Inference. The Goodness of Fit Test for a Discrete Distribution can be done by using a χ^2 test, while for a Continous Distribution by using a χ^2 test or Kolmogorof-Smirnov test depend on the case (Blank-1982).

A method to measure the Sample Based TLD Quality must be developed. This paper presents the result of an attempt to develop the method.

2 RESEARCH METHOD

The Research was executed by following these steps : identification of TLD main characteritics, research problem statement, formulation of the Sample Quality Measure (SQM), identification of the existing minimum sample size formula, method development, method trial, conclusion.

3 DEVELOPMENT OF TLD SAMPLE QUALITY MEASURING METHOD

3.1 TLD and Problem Statement

It is known that TLD – Trip Length Distribution follow a certain principle, the number of long trip is less than the number of short trips, more than that the number of very short trips is also less. The TLD follow a certain general distribution pattern which is started from low value, increase steeply to reach the peak value and than gradually decrease until it reach the minimum value at the maximum trip length recorded. It must be noted that it deals with a distribution, it means a series of parameter values, and not a single parameter value. As an illustration an Example of a a TLD is presented in Table 1 and Figure 1 below.

Table 1 Example of a Trip Length Distribution

No	Trip Length	Distribution	
	km	Trip	%
1	0-2	28	23
2	2-4	48	40
3	4-6	26	22
4	6-8	12	10
5	8-10	6	5
Total		120	100

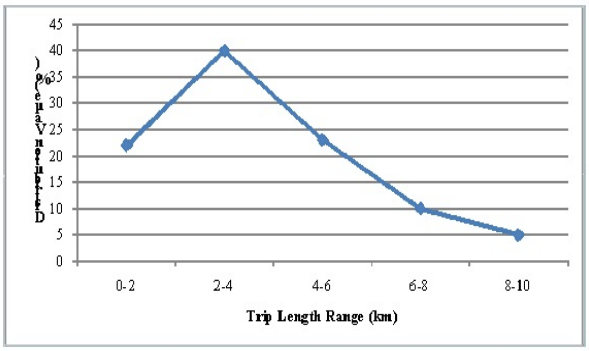

Figure 1 Example of a Trip Length Distribution Graph

3.2 Problem Statement

Since the TLD is normally built based on a Sample, this TLD must be correct enough, means that the Sample based TLD value must not be very different from the Population based TLD value. A Method to Measure the Sample Quality must be developed.

3.3 Formulation of the Sample Quality Measure

Sample main function is to represent Population Attribut Value by Sample Attribut Value. Thus the Main Sample Quality is its ability to produce the Sample Attribut Value which is as close as possible to the Population Attribut Value. Therefore, the most appropriate Sample Quality Measure is having a certain Maximum Acceptable Error (%) at a certain Minimum Confidence Level (%) (MAE at MCL). In certain case, the Minimum Sample Size Formula can be derived directly from the Population Probability Density Function.

3.4 Statistical Formula for Minimum Sample Size

A litterature review to find the Statistical Formula to calculate the Minimum Sample Size and Transport Modeling Sample Size has been done. The study results are presented as follow.

In certain case the Sample Quality Measure is controlled by the Minimum Sample Size. Several methods have been developed to etablished formula or method to determine the Minimum Sample Size (MSS) (Blank – 1982; Burrmeiser & Aitken – 2012; Gertsmann – 2003; Israel – 1992; Rose – 2015; Scott – 2008; Sevilla – 1992). In order not to be too extensive, only several examples are mentioned below.

MSS for the Estimate of Mean : $n = (z\,\sigma / \delta)^2$

MSS for the Estimate of Proportion : $n = z^2\, p\, (1 - p) / \delta^2$

MSS for the Estimate of Variance : $n = (\chi^2\, \sigma^2 / s^2) + 1$

where :

n	:	minimum sample size
z	:	z value related to the confidence level
χ^2	:	χ^2 value related to the confidence value
δ	:	maximum acceptable error
σ	:	population standard deviation
s	:	sample standard deviation
p	:	proportion

Those three are excellent formula of Minimum Sample Size for those three common cases. But these formula are not appropriate to be used for the TLD case, since the case is a different case.

Another MSS formulae has ever been developed, very often cited as Slovin Formulae, to cope with a general problem in which the population probability density function is not known and the parameter measured can be varied from the usual mean, proportion and variance. The Slovin Formulae is presented below (Sevilla – 1992; Israel – 1992).

Slovin Formula : $n = N / (1 + Ne^2)$

where :

n	:	minimum sample size
N	:	population size
E	:	accepted error level

Refering to its principal the Slovin Formulae can be used for this case. But this formulae is not able to indicate the quality of the sample, in terms of the MAE at MCL (Minimum Acceptable Error at a Minimum Confidence Level).

In Conventional Method, Transport Model is developed based on Household Interview Survey (HIS) Data. For that purpose, the US Bureau of Public Roads in circa 1960 published a Guidance of HIS Sample Size for developing a Transport Model (O'Flaherty – 2004). It must be noted that this is only a Guidance, a discussion on the related aspects of Maximum Acceptable Error at a Minimum Confidence Level (MAE at MCL) were not published. The Sample Size Guidance is presented Table 2 below.

Table 2. Sample Size for Household Interview Survey

No	Population	Sample Size
1	< 50.000	1 in 5 households
2	50.000 - 150.000	1 in 8 households
3	150.000 - 300.000	1 in 10 households
4	300.000 - 500.000	1 in 15 households
5	500.000 - 1.000.000	1 in 20 households
6	> 1.000.000	1 in 25 households

Those three categories of methods mentioned above, either is not appropriate because of from different case or is not appropriate because the accuracy and its confidence level is not guaranteed. Hence, a Special Method to measure TLD Sample Quality still need to be developed. It is still very needed.

3.5 Method Development

The common Sample Quality Measure is a Maximum Acceptable Error (%) at a certain Minimum Confidence Level (%). Therefore, two methods has to be thought i.e : first a method to test the Maximum Acceptable Error (%) and second a method to test the Minimum Confidence Level (%).

Maximum Acceptable Error (%)

The case is about a TLD – Trip Length Distribution statistical test. The TLD does not deal with only a single parameter value. The

values are the distribution value, so it incorporate several data values. Thus, several error values must be investigated. Each error, the population value minus the sample value, can be either a positive or negative error. The Sample Quality then must be measured in terms of the total summation of each error or better in terms of the mean value of the all errors. A simple direct summation of each error can lead to a wrong answer, since negative error and positive error can eliminate each other. Therefore, several error forms must be investigated and the most appropriate one must be selected. Several error forms and its main characteristics are presented in Table 3 below. The most appropriate one is the form of |e|. But this error form can not yet be used, since its statistical distribution form is not yet known.

Table 3. Variety of Error Forms

No	Error Form	Error Rate	Error Mean	Remarks	Note
1	e	e_i/y_i	$\Sigma(e_i/y_i)/n$	eliminate each other among the positive and the naegative error	can not be used
2	e^2	e_i^2/y_i^2	$\Sigma(e_i^2/y_i^2)/n$	not very natural	better not to be used
3	|e|	$\|e_i\|/y_i$	$\Sigma(\|e_i\|/y_i)/n$	very natural	can be used

Minimum Confidence Level (%)

The nature of the problem is to verify wether the Sample Distribution Pattern fit to the Population Distribution Pattern. It means that this problem can be considered as an problem of Goodness of Fit. Therefore, in this attempt, two types of confidence level are investigated. One is related to the Confidence Level related to the Error and the other one is related to the Goodness of Fit of the Sample based TLD against the Population based TLD.

Confidence Level of Error Means

Confidence level of mean error must be measured in terms of the Means of Error Absolute Values. The statistical distribution of absolute error must be known first, before the test can be defined. Since the Statistical Distribution is not yet known, the Confidence Level related to the Error Absolute Value can not be developed here.

Confidence Level of Goodness of Fit

Statiscal Inference Technics indicate that the Confidence Level of Goodness of Fit of a certain a Curve Fitting can be measured by using a χ^2 Statistical Test.

H_0: sample is from a specified distribution
H_1: sample is not from a specified distribution

$$P(\chi^2 \le \chi^2_0) = 1 - \alpha$$

Confidence Level = $P(\chi^2,\upsilon)$

$$\chi^2 = \Sigma (O_i - E_i)^2 / E_i$$
$$\upsilon = k - r - 1$$

where :
χ^2 = observed χ^2 value
O_i = observed parameter value
E_i = expected parameter value
υ = degree of freedom
k = number of different values of variable
r = number of parameters of the hypothesized distribution

Maximum Acceptable Error at a Minimum Confidence Level

The method to measure this type of measurement can not be developed in this attempt, since the Statistical Distribution of the Error Absolute Value is not yet known.

3.6 Summary

So, the proposed Sample Quality Measure is the Confidence Level of Goodness of Fit, by using χ^2 test. The Confidence Level value is equal to $P(\chi^2,u)$, where $\chi^2 = \Sigma (O_i - E_i)^2 / E_i$, and $\upsilon = k - r - 1$.

4 METHOD TRIAL

4.1 Trial Case

To examine the proposed method, two different cases were taken, one for working trip and the other for schooling trip. The two cases are mentioned below.

- BRI Kertajaya Office - working trip
- SMA 9 Wijaya Kusuma - schooling trip

The working trip length and the schooling trip length are the distance from employes home to the office and the distance from students home

to the school. A number of employee's and student's addresses were noted. The distance from home to the the cases addresses are measured. These can be considered as morning working and schooling trips. For each case, a sample of minimum 50 trips were taken and considered as a reference, from which a 80% samples were taken as the sample of the reference population. Reference sample of 50s individus has been taken in order to have a Reference Sample with number of individu more than 30. The number of 30 is considered as a number at which a certain group start to have a clear statistical distribution pattern.

4.2 Trial Case 1 – BRI Kertajaya Office

BRI Kertajaya Office is a branch office of the Bank Rakyat Indonesia (BRI), a state owned bank. The office main data is as follow.

Name : BRI Kertajaya Office
Status : A branch office of a state owned bank.
Address : Jl. Kertajaya 78, Surabaya
Number of Staff : 78
Reference Sample : 50
Sample of Reference : 40 (80%)

Afterward, a Trip Length Distribution was constructed for the Reference Sample and for the Sample of Reference. The Confidence Level has been calculated, and gave a value of 50,5%. The distribution is presented in Table 2 and Figure 2 as follow.

Table 4. Case 1 – Trip Length Distribution and Confidence Level of 80% Sample

No	Trip Length km	Number		%		χ^2_i
		Reference	Sample	Reference	Sample	
1	0-3	20	15	40,0	37,5	0,156
2	3-6	21	16	42,0	40,0	0,095
3	6-9	8	8	16,0	20,0	1,000
4	9-12	1	1	2,0	2,5	0,125
Total		50	40	100	100	
				Total χ^2		1,376
				υ		2
				Confidence Level (%)		50,5

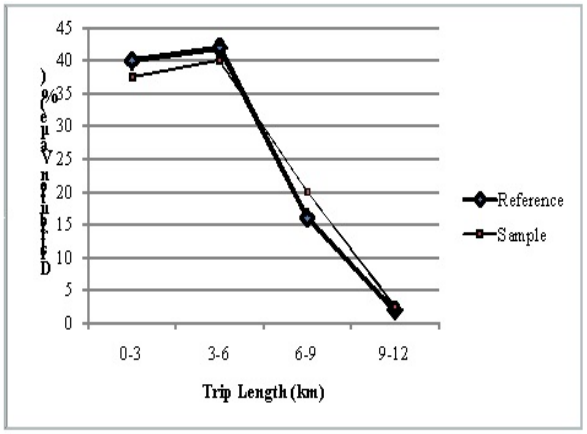

Figure 2 Case 1 – Trip Length Distribution Graph

4.3 Trial Case 2 – SMA 9 Wijaya Kusuma

The SMA 9 Wijaya Kusuma is a favourite High School in Surabaya. The high school main data are as follow :

Name : SMA 9 Wijaya Kusuma
Status : A state owned favourite High School
Address : Jl. Wijaya Kusuma 48, Surabaya
Number of Student : 879
Reference Sample : 54
Sample of Reference: 44 (81,5%)

Afterward, a Trip Length Distribution was constructed for the Reference Sample and for the Sample of Reference. The Confidence Level has been calculated, and it gave a value of 89%. The distribution is presented in Table 5 and Figure 3 as follow.

Table 5. Case 2 – Trip Length Distribution and Confidence Level of 80% Sample

No	Trip Length km	Number		%		χ^2_i
		Reference	Sample	Reference	Sample	
1	0-3	3	2	5,6	4,5	0,2
2	3-6	12	10	22,2	22,7	0,0
3	6-9	21	16	38,9	36,4	0,2
4	9-12	5	5	9,3	11,4	0,5
5	12-15	5	5	9,3	11,4	0,5
6	15-18	7	5	13,0	11,4	0,2
7	18-21	1	1	1,9	2,3	0,1
Total		54	44	100	100	
				Total χ^2		1,6
				υ		5,0
				Confidence Level (%)		89,0

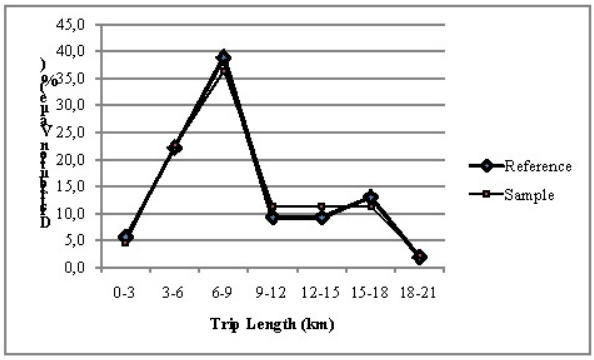

Figure 3 **Case 2 – Trip Length Distribution Graph**

4.4 Remarks

A Method to Measure Sample based TLD Quality has been developed and has been proofed that it can be used and it provide the Confidence Level value. But the Method, by itself, is not able to give a Minimum Sample Size Formula directly. The experiment also indicated that the TLD main characteristics may vary across different trip attribut : subject, purpose, region, mode, etc.

5 CONCLUSION

The research objective has been attained. Main conclusions and reflexion on following researches are written below.

A method based on "The Minimum Acceptable Error at a Minimum Confidence Level" (MAE at MCL) cannot be developed, since the error probability density function is not yet known.

A Method to Measure the TLD Sample Quality has been developed. The method is based on Goodness of Fit Statistical Inference by using a χ^2 Test. The Sample Quality is expressed by the Confidence Level.

Confidence Level = $P(\chi^2,\upsilon)$

$\chi^2 = \Sigma (O_i - E_i)^2 / E_i$

$\upsilon = k - r - 1$

where :

χ^2 = calculated χ^2 value

O_i = observed value

E_i = expected value

υ = degree of freedom

k = number of values of distribution

r = number of parameter

The conclusions leads to following couriosity. The first is to make an experiment to try to investigate the Confidence Level Value Variation due to the Sample Size Variation. The second is to find the error statistical distribution. The third is to develop a Quality Measure based on the "MAE at MCL" principle, after the error probability density function will be known.

ACKNOWLEDGEMENT

This small research is a part of the main research in trying to find the Trip Length Distribution Quality Variation across Different Sample Size. The data are collected by Nina Saraswati and Citto Pacama Fajrinia as part of their thesis work.

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