Malaysian Police Officers' View on Vehicle Theft Through the Concept of Z Number

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Abstract—**The expert's view is an important aspect to be considered in vehicle theft since the crime has contributed to the magnificent proposition in property crime. In vehicle theft police officer is considered an expert since the authority is directly involved in solving the problem. The difficulty to understand the vehicle theft criteria because of ambiguity, uncertainty and vagueness of criteria are unavoidable among human. As a result, different interpretations occur toward particular vehicle theft criteria because of the difference of the level of understanding and experience among police officers. Therefore, the problem has allowed an obvious difference of interpretations by officers toward vehicle theft criteria. Thus, police officers are required to distinguish the degree of importance among the vehicle theft criteria. Therefore, a Z number which an extension of the fuzzy set theory is a tremendous method to tackle such problem related to the reliability of information which consists of ambiguity, uncertainty and vagueness aspect of vehicle theft criteria. The advantage of Z number concept implemented in the assessment of vehicle theft criteria is each of information given by police officers will be reliable, secure and preserved. Based on the result it seems that the vehicle theft been manipulated by a male juvenile who usually has problems with education, unemployed, originated from the particular race and influenced by drug addiction.**

Index Terms—**Fuzzy; Police; Subjective Weight; Vehicle Theft; Z Number.**

I. INTRODUCTION

An activity that can lead to injury and create chaos atmosphere to the public is against the law. Therefore, these behaviours are known as criminal conduct and may be barred by the provisions of the existing law. Crime is defined as an act that is conflicting towards the law and is punishable according to the provisions of existing law in a particular place [1], [2]. Additionally, the crimes are also subjected to the lawmakers who are responsible for prosecuting, punish and declare the offender's action that can hurt others and can be punished under existing provisions [3].

Generally, crime can be divided into two parts; namely the crime index and non-index crimes. Index crimes can also be divided into two parts, the property index crime and violence. Undoubtedly index crime in Malaysia is a tool to measure the increase in crime and concurrently as the benchmark of the commitment to control crime [4], [5]. [6] reported that property crime index was the biggest contributor to the increase in crime in Malaysia. In the category of property crime index, vehicle theft is a property which has most frequently reported compared to other [7], [8]. In fact, in Malaysia in 2004 about 49% of property crime index was recorded by vehicle theft, while 42% and 38% in 2008 and 2009 respectively [5].

Usually, vehicle theft is boosted by the value of the vehicle. Besides, the opportunity to file insurance claims is an encouragement for victims to lodge a police report of missing vehicles which resulted in the obvious increase compared to other property crimes. Indeed, each vehicle in Malaysia has a document of registration to aid reporting process [9].

Reportedly, the vehicle theft cases have dropped by 20 percent after the Government Transformation Policy introduced [10]. However, 13,407 cases were reported in 2014 is still considered as high and this caused major concern among society. The claim can be supported when Malaysia was reported to be in the second place on the basis of the highest crime index with a value of 68.55. It is 0.01 less than Bangladesh and among 38 Asian countries including Japan, Singapore and South Korea, which have three lowest crime rates in the Asian region with a score of 19.34, 15.81, 14.31 respectively [11].

Therefore, research shall be conducted to seek for other criteria which may influence the increase in vehicle theft in Malaysia. In term of searching for the criteria of vehicle theft, a brief literature review would be conducted in order to identify the issues which have been discussed and argued among researchers of cross knowledge disciplines such as sociology, education, economy, and law. Hence the discussed topic will become the main criterion to be assessed by the group of police officers.

In this paper, the authors proposed a subjective weight based on Z number to measure the police officers' assessments on vehicle theft criteria. The Z number has the capability to measure and filter the reliability of police officer's views which finally provide a relevant and authentic reference. Lastly, the assessments of police officers on each identified criteria will be transformed into numerical value known as weightage which illustrates the degree of importance of criteria for vehicle theft. As far as authors realise, no research has been conducted to reveal the police officers' views on vehicle theft based on criteria identified from literature review which employs the concept of Z number in order to validate the reliability of information. The significance of this paper is to provide the reliable preference related to vehicle theft given by police officers which consider the aspect of ambiguity, vagueness and uncertainty of information. In addition, as a contribution, the result of this research will reveal the truth behind the vehicle theft treat in order to rectify the public perspective since the method of Z number has the promising quality of reliability, confidence, sureness and the strength of police officers' information.

In this paper, the requirement of research on vehicle theft is described since this criminal activity is endless. Section 2 elaborates the criteria for vehicle theft which is related to property theft briefly based on literature review while the Z

number is available in section 4. In section 5 some concepts and definitions would be discussed while the method employed in the paper is revealed in section 6. Section 7 and section 8 is the result and discussion respectively. Lastly, the term of 'officer' and 'police officer" in this paper are utilised interchangeably.

II. CRITERIA FOR VEHICLE THEFT

Based on the literature review various criteria should be identified to understand the direction of vehicle theft. In fact, vehicle theft criteria are closely related to several criteria of property crimes. It is because the vehicle theft is the main component of property crime [7]. To illustrate the claim, let the universal set ξ as a set for property crimes which consists of all components of property crime criteria, while c is a set of vehicle theft consisting of a component of vehicle theft criteria, therefore, $c \subseteq \xi$. As a result, logically the criteria of property crime are automatically becoming the criteria of vehicle theft.

As [12] claimed that there is a significant relationship between drug and activities of property crimes such as car theft. Indeed, the rate of property crime is increasing critically as drug prices increase [13]. Therefore, the property crime problem could be solved if the drug addiction is being curbed [14]. Next, is a criterion of unemployment which might lead to property crimes [15], [16]. One of the main reasons for unemployment problem arise is the failure of an individual to complete their study which results in the difficulty to get a job [17], [18]. Consequently, education plays an important role as a criterion associated with the rise of property crimes. Hence [19] stated that youngsters who do not spend their time in study tend to commit crimes. Due to an ample time that should be spent in schools, however, is wasted on activities which geared towards property crimes [20].

[21] stated that the presence of immigrants who are working in a particular sector such as labour in construction and industrial has a potential to affect the growth of property crime. This problem probably caused by lower salary received compared to the local employees which cause the immigrant to live in poverty. The effect could be worst if the immigrant lives in big cities such as Kuala Lumpur. Thus, living in big cities requires a considerable expense because the cost of living in such place is high. Hence, the possibility for property crime to occur in the big city is very high because of the criterion of poverty [22], [23].

Thus, according to [6], the urbanisation could affect significantly towards property crimes such as vehicle theft. Also, most of the branded luxury vehicles are available in a big city compared to the rural area which could become a seductive aspect to criminals. Another criterion which is being discussed by researchers is natural phenomena or extreme weather such as floods and drought. [24] said that extreme weather could affect significantly towards property crime. The weather has the potential to influence the behaviour of people psychologically. People tend to be more aggressive and threatening when their needs are insufficient. Thus, the extreme weather has the capability to create a frightening situation due to an inadequate essential substance such as food which will result in chaos and unbridled. The problem could relate to vehicle theft. For instance, in flood disaster, the flood victim will attempt to search for higher ground to rescue their vehicle before the flood gets worse. So, the situation of locating the vehicle in the higher ground could create an opportunity for a criminal to react due to lack of observation and regulation by the owner of the vehicle because usually, the safer higher ground is far from the owner's home. [25].

The next criteria discussed by the researchers are gender and age which are weakly related to property crimes. Committing property crimes such as vehicle theft obviously requires a quickness, sharpness and energetic movement. Therefore, vehicle theft is commonly committed by youngsters aged between 16 to 25 [26], [27]. The racial criterion in criminal behaviour is also discussed by the researchers.

However, most of the research revealed that the racial variable and property crime especially in vehicle theft is insignificant [28]. Nevertheless [27] claimed that usually the criminals who an involved in vehicle theft commonly originate from the race which is economically poor. Family background such as parent criminal record also plays an important criterion since it might influence their child behaviour towards crime [29]. Finally, according to [30] there is an insignificant correlation between social classes in crime. However, [3] believes there is a difference in social class level regarding the quality of education and economic strength which distinguish the social group along the social class ranging from the lowest to the higher level. Therefore, the level of social class indirectly has a connection in crime positively since the education and the economic strength are capable of influencing people to commit a crime. Lastly, the criteria for vehicle theft summarised in Table 1.

Table 1
Summarized of Vehicle Theft Criteria.

No	Criteria
1	Drug
2	Unemployment
3	Education
4	Immigrant
5	Urbanization
6	Poverty
7	Natural disaster/extreme weather
8	Young age
9	Male gender
10	Races
11	Family background
12	Social Class

III. SUBJECTIVE WEIGHT

The degree of importance of criteria could be determined by weight. The weight shows the difference of criteria in term of the degree of importance commonly through numerical value in the interval [0 1]. Basically, according to [31] the weight originated from two types, which are objective and subjective weight. Then the combination of objective and subjective is known as aggregation weight [32].

The concept of subjective weight is a value showing the degree of importance of criteria which is derived based on the judgment, view, and opinion of the decision maker or expert through a subjective method such as analytical hierarchy process. On the contrary, the objective weight is mainly produced by solving a mathematical model (objective methods) such as entropy method. The objective weight usually originates from a set of data problem without any preferential of expert or decision maker [33].

Notably, the weight is the values which determined the degree of importance of criteria which is commonly shown in

the interval [0 1]. Hence the weight values are different among the criteria that show a different degree of importance [34]. For example, suppose weights are given in interval [0 1], and the weight of criteria A is 0.8, while the weight for criteria B is 0.5. Let assume that the value of weight that is closer to 1 is better. Based on the example, it is obvious that criteria A is better than criteria B.

So according to the objective, this paper mainly focuses on subjective weight, since the weight of the criteria of vehicle theft is solely an assessment of the decision maker (police officers). However, in step to determine the weight of vehicle theft criteria, the problem of vagueness and ambiguity related to vehicle theft criteria is unavoidable. To overcome the problem of vagueness and ambiguity on the assessment of the implementation of the fuzzy number will ease the officers through decision process by the concept of the membership function. The level of vagueness and ambiguity in decision problem will be illustrated by the degree of membership function commonly in the interval [0 1] through a triangular fuzzy number or trapezoidal fuzzy number [35].

Notably, opinion or view given by officers should be precise without any doubt and suspicion. Nevertheless, the difference between interpretation and view is unavoidable since it depends on the level of understanding and experience officers in particular criteria. So, the degree of confidence and reliability should be measured and considered in their assessment to ensure the quality information by the officer is conserved. Thus, the concept of Z number has an ability to strain the confidence and reliability aspect in the decision-making process [36].

IV. Z-Number

A decision from decision maker against a particular subject depends on the quality of understanding regarding the problem. Thus, opinion among of decision makers would differ since it is influenced by their experience and their knowledge level. Therefore, it is unavoidable to have a difference of interpretation, assessment and decision by the decision makers since human unable to provide a proper justification on particular problem quantitatively due to ambiguity, vagueness and uncertainty on the problem.

Consequently, it varies in reliability and confidence level of the information given by decision makers. Hence, the level of reliability and confidence level should be measured to ensure the quality of a decision by decision makers. So, the implementation of the concept of Z number in the decision process will ensure the given information by decision maker might be observed [37].

According to [38] the Z number is the concept of paired fuzzy numbers. The combination of fuzzy numbers is combined in sequence $(\tilde{A}, \tilde{B})$. $\tilde{A}$ is a component of restriction for an uncertainty value of variable X, where X is able to achieve, while the component $\tilde{B}$ is probability of $\tilde{A}$ will occur, regularly the components $\tilde{A}$ and $\tilde{B}$ is expressed linguistically such as 'agree' and 'confidence'.

Some of the utilisation of Z number is in the engineering field. [39] use the concept of Z number to overcome uncertainty and ambiguity to assist the group of manager of petrochemical plants to evaluate and analyses the resilience engineering principles' impacts on the integration of health, safety, environment and ergonomics factors.

[40] utilised the Z numbers in the earned value management (EVM) model to assess the cost and schedule progress of a project which considering the degree of the judgment of decision makers related to reliability in an uncertainty environment.

However, the adoption of a Z number in solving a real-world problem is fewer than classical fuzzy numbers due to the exploration of arithmetic of Z number becoming a priority of researchers [41]. Recently, to the best of authors' knowledge, more research performed in arithmetic compared to solving the real-world problem. [42] adapting the concept of trapezoidal fuzzy numbers to represent the element $\tilde{A}$ while the triangle fuzzy numbers representing the element $\tilde{B}$ in decision making. Next, the Z number is expressed in the form of a decision matrix and is solved by using the kernel-Mendel algorithm. In addition [41] use the triangular fuzzy number to illustrate both elements. [43] introduced the Choquet integral in decision making process under Z information.

A. Z-Valuation

[44] states Z valuation is an assessment based on the Z information. The Z valuation is illustrated with three elements in sequence, namely; X variables, the fuzzy numbers of A and the fuzzy numbers of B. Briefly the notation of Z valuation is (X, A, B). An example of Z valuation is (Unemployment encourage crime, agree, very confident)

V. Concept and Definition

At first, the method to be utilised in this paper is a subjective method to produce subjective weight since it solely involves the decision from decision makers. Thus, the subjective weight is determined by a subjective method with an approach to the concept of Z numbers will be used. The decision maker will express their views on each identified criteria X_{ij} on the interval [0 1] and decide the possibility (degree of reliability) for each of the following identified criteria to meet $Z_{ij}(\tilde{A}_{ij}, \tilde{B}_{ij})$ where, $\tilde{A}_{ij} \rightarrow$ value [0, 1] which the identified criteria X_{ij} can accomplished. The value of $\tilde{A}_{ij}$ is in interval [0 1] where 0 = completely X_{ij} is not included and 1 = completely X_{ij} is included and similar applied to the element of $\tilde{B}_{ij}$ as well. However, in order to obtain the decision from decision makers, both elements will be expressed in linguistic variable such as 'agree', 'disagree' or 'sure'. The related definitions of concept explained in following section.

A. Definition 1

Fuzzy numbers are defined on the set X as universal:

$$A = \{ \langle x, \mu_A | x \in X \rangle \}$$

where $\mu_A : X \rightarrow [0\ 1]$ is membership function for A. $\mu_A(x)$ is the degree of approximation $x \in X$ in A.

B. Definition 2

Triangular fuzzy number (TFN) can be represented by (a_1, a_2, a_3) as shown in Figure 1.
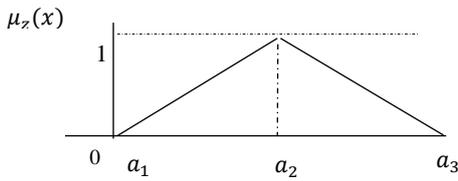
Figure 1: Triangular Fuzzy

$$\mu_z\,(x) = \begin{cases} 0, & ; x \in (-\infty, a_1) \\ x - a_1/a_2 - a_1 & ; x \in (a_1, a_2) \\ a_3 - x/a_3 - a_2 & ; x \in (a_2, a_3) \\ 0 & ; x \in (a_3, +\infty) \end{cases}$$

C. Definition 3

The Z number is a paired of consecutive fuzzy number $Z = (\tilde{A}, \tilde{B})$. $\tilde{A}$ is a restriction of X and $\tilde{B}$ is reliability of $\tilde{A}$. This study employed triangular fuzzy numbers to illustrate the components $\tilde{A}$ and $\tilde{B}$ [41]. Figure 2 shows the triangular of the degree of membership function. $\tilde{A}$ and $\tilde{B}$ represented by TFN in Figure 1.

$$f_{disagree}(x) = -4x + 1,\ 0 \leq x \leq 0.25$$

$$f_{less\ agree}(x) = \begin{cases} 4x, & 0 \leq x \leq 0.25 \\ -4x + 2, & 0.25 \leq x \leq 0.5 \end{cases}$$

$$f_{somewhat\ agree}(x) = \begin{cases} 4x - 1, & 0.25 \leq x \leq 0.5 \\ -4x + 3, & 0.25 \leq x \leq 0.75 \end{cases}$$

$$f_{agree}(x) = \begin{cases} 4x - 2, & 0.5 \leq x \leq 0.75 \\ -4x + 4, & 0.75 \leq x \leq 1 \end{cases}$$

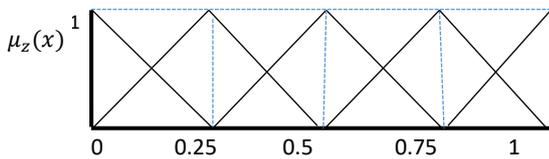$$f_{strongly\ agree}(x) = 4x - 3,\ 0.75 \leq x \leq 1$$

Figure 2: Degree of membership

D. Definition 4

Lastly, the defuzzification will be the product of two fuzzy numbers (element of $\tilde{A}$ multiply element of $\tilde{B}$) [46].

$$P(\tilde{A}) = 1/6\,(a_1 + 4a_2 + a_3) \tag{1}$$
$$P(\tilde{B}) = 1/6\,(b_1 + 4b_2 + b_3) \tag{2}$$

Hence,

$$P(\tilde{A} \otimes \tilde{B}) = 1/36\,(a_1 + 4a_2 + a_3)(b_1 + 4b_2 + b_3) \tag{3}$$

VI. METHOD TO DETERMINE THE SUBJECTIVE WEIGHT OF VEHICLE THEFT

The process to determine the subjective weight of vehicle theft started with the distribution of a questionnaire to the selected police officers of Royal Police Malaysia who and highly experienced in cases of vehicle theft. The selected officers are directly involved in criminal investigation,

arresting the suspect of vehicle theft and interrogation. The police officers were required to respond to the related statement of vehicle theft in the questionnaire, and they were compulsory to state their sureness of each of responses. This paper has utilised a proposed method by [45] to determine the weight of vehicle theft criteria through the officers' assessment. Questionnaire: In order to represent the officers' assessment, the questionnaire constructed based on Z number concept. The questionnaire is constructed based on a linguistic variable which is relevant and eases the officers to assess the statement report of vehicle theft. The linguistic variable provided in the questionnaire is practical in order to illustrate a fuzzy measurement [47].

The questionnaire is constructed according to Figure 2. There are two parts in each statement of questionnaire to be answered by officers which represent the components $\tilde{A}$ and $\tilde{B}$. The officers would give rea sponse on the level of agreement for $\tilde{A}$ part and the $\tilde{B}$ part is about the level of sureness and reliability toward the statement in the questionnaire. Table 2 is a list of criteria of vehicle theft.

Table 2
Identified Criteria for Vehicle Theft

Criteria for vehicle theft	
x_1	Drug
x_2	Unemployment
x_3	Education
x_4	Immigrant
x_5	Urbanization
x_6	Poverty
x_7	Natural disaster/extreme weather
x_8	Young age
x_9	Male gender
x_{10}	Races
x_{11}	Family background
x_{12}	Social Class

Decision matrix construction: Suppose $Z_{ij}(\tilde{A}, \tilde{B})$ is the basic elements of officer's assessment which consist component of $\tilde{A}$ which is a restriction on the value which the criteria of vehicle theft is allowed to take and component $\tilde{B}$ is the measure of the reliability of $\tilde{A}$ as shown on table 3. Both component of $\tilde{A}$ and $\tilde{B}$ is illustrate in triangular fuzzy number. Then decision matrix constructed to illustrate the officer assessment in well arrangement, where $Z_{ij}(\tilde{A}, \tilde{B})$, $i = 1,2,\ldots,m$; $j = 1,2,\ldots,n$ as the basic officer's assessment element in decision matrix which shows the assessment of jth criteria by officer$_i$ (respondent$_i$).

Table 3
Decision Matrix based on Z Number

	C_{11}	...	C_{1j}	C_{1n}
R_1	$Z_{11}(\tilde{A}, \tilde{B})$	...	$Z_{1j}(\tilde{A}, \tilde{B})$	$Z_{1n}(\tilde{A}, \tilde{B})$
R_i	$Z_{i1}(\tilde{A}, \tilde{B})$	...	$Z_{ij}(\tilde{A}, \tilde{B})$	$Z_{in}(\tilde{A}, \tilde{B})$
.	.	.	.	.
.	.	.	.	.
R_m	$Z_{m1}(\tilde{A}, \tilde{B})$	...	...	$Z_{mn}(\tilde{A}, \tilde{B})$

Crisp value: Next in order to obtain the crisp number, the basic element of decision matrix, $Z_{ij}(\tilde{A}, \tilde{B})$ would undergo the defuzzification in Equation (3).

Weight of vehicle theft criteria: The final weight of vehicle theft for each criterion is a summation of all the defuzzification value of each criterion.

For better understanding, the authors show an example, suppose the respondent₁ (R_1) assess the first three of criteria of vehicle theft based on Z number concept as shown in Table 4.

Table 4
Example of Converting the Z Number into Crisp Values

	C_1		C_2	
	$\tilde{A}$	$\tilde{B}$	$\tilde{A}$	$\tilde{B}$
	agree	Confident	agree	strongly confident
R_1	(0.5,0.75,1)	(0.5,0.75,1)	(0.5,0.75,1)	(0.5,1,1)

Therefore, the crisp values for C_1 by R_1 are;

C_1: $1/36\,[(0.5 + 4(0.75) + 1)(0.5 + 4(0.75) + 1)] = 0.5625$
C_2: $1/36\,[(0.5 + 4(0.75) + 1)(0.5 + 4(1) + 1)] = 0.6875$

This paper utilised the concept of Z number to determine the weight of vehicle theft criteria. To determine the weight of vehicle theft criteria, a total of 15 Royal Police Malaysia officers have cooperated to answer the questionnaire. The elected officers are those who have served more than three years in the criminal investigation unit. They have sufficient experience in the interrogation of vehicle theft suspects and well understand the criminology theories of vehicle theft cases. The elected officers are also directly involved in intelligence operation and arresting. Therefore, with their knowledge of theory and experience, they can assess the criteria for vehicle theft properly.

According to the results in table 5 in vehicle theft, the involvement of male is undeniable since the male is aggressive and energetic compared to female. According to the result, the education criterion should play an important role to overcome the crime. Undoubtedly, education could create and stimulate the awareness of crime especially vehicle theft, which can begin in young age through learning of values. Typically, an educated person infrequently commits property crime such as vehicle theft because of awareness and effect of good values lies in himself/herself since the objective of education itself to produce good mankind.

The other criteria which were significantly assessed by the police officers were young age and unemployment. The criterion of young age is a compliment for criterion gender male. Therefore, the feature of young age such as vigorous and active is fit to syndicate such as vehicle theft. Unemployment is one of the typical problems among juvenile. There are a few factors which result in the unemployment problem such as criminal record and incomplete education, as a result, create difficulty to be employed by the employer.

Racial criterion has been assessed as a significant criterion in vehicle theft by the officers, the discussion regarding the significant value about race toward vehicle theft is the officers' belief that there is a dominant race that controlled the vehicle theft syndicate. The assessment regarding the racial criterion is probably based on arrest record which had categorised criminal in term of race, age, etc. Although the threat of drug addiction has become the most feared threat as speculated by the public probably influenced by media however the officers believed that drug has a weak influence to escalate the vehicle theft crime.

Next, the criterion of poverty probably could affect the other property crime, but insignificantly in vehicle theft, it is due to a large numerical difference between the drug criterion in table 4. Next, the criteria of urbanisation, natural disaster and family background delivered relatively similar toward the degree of importance. Lastly, the criteria of the immigrant and social class have been decided truly insignificant by police officers.

Table 5
The weight of Vehicle Theft Criteria.

Criteria	Ranking	Weight
Male gender	x_9	9.46
Education	x_3	7.84
Young age	x_8	7.81
Unemployment	x_2	7.44
Races	x_{10}	7.28
Drug	x_1	7.09
Poverty	x_6	4.26
Urbanization	x_5	3.58
Natural disaster/extreme weather	x_7	3.49
Family background	x_{11}	3.25
Immigrant	x_4	2.93
Social Class	x_2	2.00

VII. CONCLUSION

As a conclusion, Z number has provided a magnificent idea in assessment process which relies on uncertain and incomplete information. The advantage of using the concept of Z number in assessment especially involving a view of police officers is the level of reliability of information is taken into account. Hence, the quality of the assessment is improved compared to the previous method which involved the fuzzy environment. As a result, the findings of the assessment of vehicle theft based on identified criteria from literature review which implements the concept of Z number effectively might avoid the doubtful which can degrade the quality of the research finding.

Therefore, the reliable assessment of vehicle theft conducted by police officers based on the concept of Z number should be a guide for law enforcement and policymaker. The result of table 4 successfully illustrates the actual factor of vehicle theft problem in numerical value which visualises the degree of importance that could be a direction for further action to be taken by a responsible body such as the ministry of education. Education plays an essential role even the criterion of education assessed in the second position in table 4 since the criterion of education has an ability to be improved. Hence effective effort should be geared in order to ensure that none of the youngsters was left outside of national education agenda.

This paper only discusses the 12 main criteria of vehicle theft. Whereas, each criterion of vehicle theft consists a few of sub-criteria which is not considered in this paper, so this could be the limitation of the paper which can be considered in future research.

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