What's the best car in the market? An Assistive Tool for New Car Buyers in Thailand

Kanchit Rongchai*, Phanuphong Pansri and Khachaphon Chueahan

Rajamangala University of Technology Isan, Khon Kaen Campus
150 Srichan Road, Nai Mueng, Mueng, Khon Kaen 40000
*Corresponding Author: kanchit.ro@rmuti.ac.th Tel: +66 (0)43 336370 ext. 3410

Abstract

Purchasing a car is one of the most important tasks for many people; for some it might only happen once in a life time. According to the Office of Industrial Economics of Thailand, there are currently more than 790 registered cars to choose from in the Thai market and many more available to be imported from abroad. Therefore, choosing a car which best satisfies the buyer's needs and wants can be challenging. This paper proposes new tool which can help users make a decision. The computer-based tool utilises a multi-criteria decision making method called Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). To create a reliable car database, official Eco-Sticker data were collected. A range of criteria were considered including: cost, tax, number of seats, fuel type, engine capacity, quoted horsepower, transmission, fuel consumption, weight, CO_2 emission and emission standards. The user can specify their requirements and how important (score from 1 to 5) each criterion is in the decision which is then converted into the weighting. Using the input and the database, a normalised decision matrix could be written. Ideal and non-ideal solutions were then created from beneficial and non-beneficial attributes respectively. Then Euclidian distances to the ideal and non-ideal solutions from each car candidate were calculated. Lastly, the best choice should have the shortest distance to the ideal solution and the furthest distance from the non-ideal solution, while the reverse is true for the worst choice. The proposed tool allows all cars to be compared against individual user's requirements. Not only it reveals optimal ("cheap, light, fuel-saving, green, powerful") cars in the Thai market, it could also give more insights into the Thai car industry, potentially useful for the public policy makers.

***Keywords**:* Automotive industry, Internal Combustion Engines, Decision making, TOPSIS

1. Introduction

The Thai automotive industry has been growing constantly over the past year. The statistics from the Thai Automotive Industry Association show that 71,678 passenger cars and 107,120 commercial vehicles were manufactured in March 2017 alone[1]. If the production rate is to stay constant, there would be more than two million cars and vehicles produced in a year, suggesting that there is high demand for automotive vehicles.

Undoubtedly, passenger cars are becoming increasingly necessary as the quality of life of the population improves. It could be said that owning a car is 'a must' for many households, up to the point where people are contented to be in debt to own one.

Purchasing a car is one of the most important tasks for many people; for some it might only happen once in a life time. There are many car aspects by which people take in to consideration when making a decision to buy a specific car. Some peoples' priority may be horsepower while many are constraints by their budgets or some may wish to choose more environmental-friendly options.

According to the Office of Industrial Economics of Thailand, there are currently more than 790 registered cars to choose from in the Thai market and many more available to be imported from abroad. Therefore, choosing a car which best satisfies the buyer's needs and wants can be a difficult task to perform.

This paper presents a new solution to assist people by suggesting the most optimal choices according to the user's specific criteria and how important each of them is. The tool applies a multi-criteria decision making method called 'Technique for Order Preference by Similarity to Ideal Solution' (TOPSIS) to a data set of all registered cars in Thailand.

2. TOPSIS and Previous Applications

Making decision against many criteria has been one of the most important tasks many people have to face and therefore, methods in which decision problems can be solved were proposed. Such problems are called 'Multi-Criteria Decision Analysis (MCDA)' or 'Multiple Attribute Decision Making (MADM)'.

In 1981, a group of researchers (Hwang and Yoon) first proposed the 'Technique for Order Preference by Similarity to Ideal Solution' or TOPSIS in solving problems relating to multi-criteria decision analysis. They proposed that it is possible to define the Positive Ideal Solution (PIS) which is the ideal best option and the Negative Ideal Solution (NIS) which is the ideal worst option based on the entire set of all options. Once the ideal points have been defined, alternatives can be ranked according to their Euclidian distances from the PIS and the NIS. The best solution is the alternative that has the shortest Euclidian distance from the PIS and the longest Euclidian distance from the NIS. On the other hand, the worst solution is the option that has the longest Euclidian distance to the PIS and the shortest Euclidian distance to the NIS.

There are other possible types of MCDA[2] but the TOPSIS method has been one of the most popular techniques[3] and found its use in many applications such as safety evaluation of coal mines[4], solving complex spatial decision problems together with geographical information systems [3], energy management in demand response programs and residential and industrial sector of the smart grid[2], sawability ranking of carbonate rock[5], thermal power plants [6], optimal generation evaluation[7] and selecting fixed seismic shelter for evacuation in cities[8].

Literature review has shown that there is little work done on the application of the TOPSIS method to the selection of cars. In 2014, a research group[9] demonstrated the use of TOPSIS method on a set of 4 cars in India. However, the criteria in the analysis were limited to style, life span, fuel economy and cost. Moreover, there is little work presented on how to weight each criterion. There is no previous work done on a large set of car data especially in the Thai market. The present paper extends the capacity of TOPSIS to use more parameters from the entire data on registered new cars in Thailand for the first time.

3. Methodology

Firstly, data of all registered new cars available for sale in Thailand were gathered from a reliable government website www.car.go.th to create a dataset containing important information printed on eco-stickers. An example of eco-sticker is shown in Fig. 1. The eco-sticker shows the following parameters: make, model, transmission type, fuel economy, emission standards, safety features, number of seats, weight and engine volume.

Fig. 1 shows an Eco Sticker of a car showing useful information (courtesy of www.car.go.th).

However, many of engine parameters are not shown on the eco-stickers such as rated horsepower and price. They were sourced from the car's brochure individually. In total, the dataset contains 792 cars, however the number may continue to change as more cars may be added to the website.

The following 10 criteria were taken into consideration. They can be classified as beneficial or detrimental or user-preference and numeric or linguistic as shown in Table 1. However, the user can change the classification to suit their requirements.

Table 1 Criteria and classifications

Price (baht)	Detrimental	Numeric
Seats	Detrimental	Numeric
Weight (kg)	Detrimental	Numeric
Engine volume (cm^3)	Detrimental	Numeric
Engine power (hp)	Beneficial	Numeric
CO_2 emission (g/km)	Detrimental	Numeric
Transmission	User-preference	Linguistic
Combined fuel economy (km/L)	Beneficial	Numeric
Fuel type	User-preference	Linguistic
Emission standard	Beneficial	Linguistic

The TOPSIS procedure is based on finding the optimal solution with maximum benefit and minimal cost. The procedure entails the following steps.

The first stage is to construct a decision matrix (DM) of size m × n, in this case 792×10. As shown in Table 2, the columns of the DM are made of the 10 selection criteria and the rows are the 792 car alternatives.

Table 2 shows the decision matrix (DM)

	Criterion 1	Criterion 2	…	Criterion n
Car 1	x_{11}	x_{12}	…	x_{1n}
Car 2	x_{21}	x_{22}	…	x_{1n}
…	…	…	…	…
Car m	x_{m1}	x_{m2}	…	x_{mn}

The user is able to specify which criteria are important to them and then customise what they mean by 'best' and 'worst' for each criterion. The elements x_{ij} can then be allocated scores according to the original value, where $1 \le x_{ij} \le 9$. For example, in the case of a detrimental numeric criterion such as CO_2 emission and price, the minimum value is given a score of 9 while the maximum value is given a score of 1. For numeric beneficial criteria such as fuel economy and horsepower, the opposite applies. The remaining cars are allocated scores by interpolation.

For user-preference linguistic criterion such as fuel types (diesel or gasoline), the specified type receives a score of 9 otherwise 1. For beneficial linguistic criterion such as emission standards (มอก, EURO 4, EURO 5, EURO 6), the latest standard (EURO 6) receives a score of 9 and the previous standards namely EURO 5, EURO 4, and มอก are deducted by 1, 2, 3, respectively.

The second step is to create a normalised decision matrix (NDM) according to Eq. (1).

$$\boldsymbol{NDM = R_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}} \quad (1)$$

The third step is to create a weighted decision matrix (WDM) by multiplying each element of each column of the NDM by the weighting (w_j) specified by the user as in Eq. (2).

$$\boldsymbol{WDM = V_{ij} = w_j \times R_{ij}} \quad (2)$$

The forth step is to define the ideal best and ideal worst cars from the criteria information for the entire cars in the database. The ideal best car is known as the positive ideal solution (PIS) and the ideal worst car is known as the negative ideal solution (NIS). The PIS is made up of the 'best' values of each criterion of the WDM. For example, the lowest value of CO_2 emission, the lowest price, the highest horsepower and the latest emission standard. On the other hand, the negative ideal solution contains the 'worst' values from each criterion.

The fifth step is to calculate the Euclidian distance from the PIS (V_j^+) and the NIS (V_j^-) to each alternative according to the Eqs. (3) and (4).

$$\boldsymbol{S^+ = \sqrt{\sum_{i=1,j=1}^{n,m} (V_j^+ - V_{ij})^2}} \quad (3)$$

$$\boldsymbol{S^- = \sqrt{\sum_{i=1,j=1}^{n,m} (V_j^- - V_{ij})^2}} \quad (4)$$

The sixth step is to calculate the relative closeness to the PIS (C_i) from Eq. (5) where $0 \le C_i \le 1$.

$$\boldsymbol{C_i = \frac{S_i^-}{(S_i^- + S_i^+)}} \quad (5)$$

The final step is to rank the value of C_i. The alternative with the highest value receives the highest ranking and hence the best performance.

The TOPSIS steps above were implemented by writing an algorithm in SciLab, an open-source mathematical application. The code was executed and yielded a vector of relative closeness which could then be visualised using an external visualisation application such as Microsoft Excel.

4. Results and Discussion

This section demonstrates an example of real car selection process. Firstly, the user may specify the weightings to be applied to each criterion by specifying how important on a scale of 0 to 100. If a criterion is unimportant and hence left from the consideration, a weighting of 0 is given. The entire weightings are then normalised.

A basic example of weightings is shown in Table 3. In this case, the only criterion the user has specified is that the best car should be as cheap as possible.

Table 3 shows a basic weighting allocated to price only.

Criteria	Weighting (scale of 0-100)	Normalised weighting
Price (baht)	100	1
Seats	0	0
Weight (kg)	0	0
Engine volume (cm^3)	0	0
Engine power (hp)	0	0
CO_2 emission (g/km)	0	0
Transmission	0	0
Combined fuel economy (km/L)	0	0
Fuel type	0	0
Emission standard	0	0

A weighted decision matrix was then created and the relative closenesses to the positive ideal solution were calculated. Table 4 shows the result of the ranking. Since the only criterion for selection is price, the best option is the cheapest price and the worst option is the most expensive car.

Table 4 shows the results of the TOPSIS for the conditions specified in Table 3.

Manufacturer	Model	Relative closeness to PIS	Rank	Price (B)
SUZUKI	CELERIO GA 1.0L MT	1	1	359,000
SUZUKI	CARRY PICK-UP 1.6L	0.999379	2	369,000
MITSUBISHI	Mirage GL	0.998621	3	383,000
NISSAN	MARCH 1.2L S MT	0.998103	4	392,000
TATA	Super Ace Mint	0.997701	5	399,000
NISSAN	ALMERA 1.2L S MT	0.995517	6	437,000
MITSUBISHI	Mirage GLX (MT)	0.995402	7	439,000
…	…	...	…	…
PORSCHE	911 Targa 4S	0.069429	791	16,550,000
PORSCHE	911 Turbo	0	792	17,758,000

The TOPSIS method suggests that the best car is the Suzuki Celerio GA 1.0L MT, which is indeed the cheapest car in the Thai market. A new example of more complicated weightings is shown in Table 5.

Table 5 shows a basic weighting allocated to price only.

Criteria	Weighting (scale of 0-100)	Normalised weighting
Price (baht)	100	0.6061
Seats	0	0
Weight (kg)	10	0.0606
Engine volume (cm^3)	0	0
Engine power (hp)	20	0.1212
CO_2 emission (g/km)	10	0.0606
Transmission	0	0
Combined fuel economy (km/L)	20	0.1212
Fuel type	0	0
Emission standard	5	0.0303

The relative closenesses were computed and the corresponding results are shown in Table 6.

Table 6 shows the ranking result from the weighting specified in Table 5.

Manufacturer	Model	Relative closeness to PIS	Ranking
MINI	Cooper S Hatch 3 door Special Edition	0.770986174	1
AUDI	A 3 2.0 TDI SB	0.76042818	2
BMW	330e M Sport	0.712221414	3
VOLVO	XC90 T8 Twin Engine Momentum	0.706737785	4
Mercedes-Benz	AMG A 45 4 MATIC	0.698532201	5
Mercedes-Benz	C 350e Avantgarde	0.697368995	6
MINI	Cooper S Hatch 3 door Special Edition	0.696116615	7
		…	…
PORSCHE	911 TARGA 4S	0.314141744	791
PORSCHE	911 TARGA 4	0.306876958	792

According to the results shown in Table 6, the relative closeness to the positive ideal solution changed due to the change in weighting. The TOPSIS now suggests that the new best option is now the MINI Cooper S Hatch 3 door Special Edition.

It can be seen that the TOPSIS method can be useful in optimising car choices when making a decision to buy a new car.

The dataset used in the study may not be the most comprehensive database of all cars traded in Thailand. Some options may not have been registered with the authority or published on the government's website.

The challenge of the TOPSIS method is the accuracy of the weighting allocated to each criterion and converting linguistic values into numerical values before they can be used by the TOPSIS method.

5. Conclusion

The TOPSIS method has been applied to the entire car data published by the Thai authority. It has been shown that the technique is able to help new car buyers during their decision making process.

The tool was tested by a simple example where one criterion is used. The result has proved that the method was able to suggest the cheapest car in the market as the best solution. Under a more complicated weighting with multiple criteria, the ranking changed accordingly.

However, the weighting is subject to personal preference. There is a challenge as to how to accurately give weightings to the criteria.

6. Acknowledgement

The authors would like to express their sincere appreciation and gratitude to Rajamangala University of Technology Isan, Khon Kaen Campus for the financial support of the work. Without the support, this work would not have been possible.

7. References

[1] The Thai Automotive Industry Association, "Statistics | The Thai Automotive Industry Association (TAIA)." [Online]. Available: http://www.taia.or.th/Statistics/Thailand+Automotive+Statistics+March+2017/. [Accessed: 29-Apr-2017].

[2] O. A. Sianaki, "Intelligent Decision Support System for Energy Management in Demand Response Programs and Residential and Industrial Sectors of the Smart Grid," no. October, 2015.

[3] D. Ozturk and F. Batuk, "(Topsis) for Spatial Decision Problems," vol. 1, no. 4, 1999.

[4] X. Li, K. Wang, L. Liuz, J. Xin, H. Yang, and C. Gao, "Application of the entropy weight and TOPSIS method in safety evaluation of coal mines," *Procedia Eng.*, vol. 26, pp. 2085–2091, 2011.

[5] R. Mikaeil, R. Yousefi, and M. Ataei, "Sawability ranking of carbonate rock using fuzzy analytical hierarchy process and TOPSIS approaches," *Sci. Iran.*, vol. 18, no. 5, pp. 1106–1115, 2011.

[6] T. Wang and B. C. Xin, "Thermal power plant sitting based on TOPSIS method," *Procedia Eng.*, vol. 15, pp. 5384–5388, 2011.

[7] J. Kittur, Poornanand. U. C, Pavankumar M.P, P. Reddy, and P. R. Patil, "Optimal generation evaluation by TOPSIS method," in *2016 Biennial International Conference on Power and Energy Systems: Towards Sustainable Energy (PESTSE)*, 2016, pp. 1–5.

[8] J. Chu and Y. Su, "The Application of TOPSIS Method in Selecting Fixed Seismic Shelter for Evacuation in Cities," *Syst. Eng. Procedia*, vol. 3, no. 2011, pp. 391–397, 2012.

[9] S. Srikrishna, S. R. A, and S. Vani, "A New Car Selection in the Market using TOPSIS Technique," vol. 2, no. 4, pp. 177–181, 2014.