

RANKING THE BEST DAYS OF THE WEEK THROUGHOUT THE PANDEMIC BASED ON DAILY SALES OF A COMPANY USING ANALYTICAL HIERARCHY PROCESS

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Abstract

The pandemic, where people from all different sectors and industries battle to survive in the new norm, served as the inspiration for this work. In order for every business to attain its targeted objectives, a great marketing plan would need to be used. However, a barrier to developing methods that might maximise profit and decrease costs in decision-making is often a lack of expertise within organisations. In order to solve this issue, the Analytical Hierarchy Process (AHP) is used in this study to rank the best day of the week according to the performance of the company daily sales. Once the best performing days have been identified, an effective marketing strategy such as discount offer will be conducted to optimize the profit. The following four criteria have been taken into account and ranked in importance: sales, orders, page views, and the number of potential customers. According to the findings, Sunday had the best performance of the week, followed by Wednesday, Friday, Monday, Tuesday, Thursday, and Saturday which are listed in order of importance respectively. The results from AHP were then compared with the experts' perspective for a more thorough accuracy verification. The findings demonstrate the consistency of the results obtained from the data and expert's opinion.

Keywords: Analytic hierarchy process, Performance, and Ranking.

1. Introduction

Ever since the COVID-19 virus, an infectious disease existed; The World Health Organization (WHO) has declared COVID-19 a global pandemic. Malaysia is currently under Movement Control Order (MCO) which came into force as a preventive measure to contain the spread of COVID-19 infection. Since then, online shopping has been increasingly popular among people of all ages all around the world. The government has made a lot of MCO waves that have forced everyone to stay home and have limited chance of doing outdoor activities and socialize around. Therefore, the internet has become a necessity in humans' daily lives as it is the only way to connect people, make new acquaintances, do work, and make countless hobbies and interests having no barrier to fulfil their desires. People can now shop for everything they need without having to travel to a physical store.

In the current digital environment, e-commerce has grown significantly. Currently, business characters are emerging with a focus on analytics techniques, such as revenue from advertising. Business to business marketing organizations spend more than a quarter of their annual budget on growth, transportation, and promotion of the content they run their business on. Some analytics solutions, nevertheless, are difficult to comprehend. It makes sense that online tracking would consider whether aspects of a company's sales and marketing efforts are resulting in conversions.

Therefore, this research use data from one company in Shopee, which is a well-known multinational technology company that emphasizes e-commerce. It has become an online marketplace that serves as both consumer-to-consumer and business-to-consumer. Undoubtedly, Shopee is a prominent online platform as they surpassed other online platforms such as Lelong, and becoming the third most visited e-commerce portals, and overtook the glorious Lazada to rank as the best application on both Google Play and iOS App stores. There are four type of data were collected from the company involved which are sales, orders, page views, and the number of potential customers during the pandemic timeframe. The main aim of this research is to rank the best performance day in a week based on the four main criteria chosen. Thus, this research provides scientific evidence to improve marketing strategies in order to optimize the company's profit.

2.Previous Study

The complex nature of Analytic Hierarchy Process (AHP) necessitates the use of essential step-by-step techniques. A single error could have disastrous consequences, so it is important to be familiar with AHP prior to avoid any mishaps. AHP method has been used in many applications widely. For instance, AHP method provides the ability to calculate the adequacy of a future debtor. It is the process of determining the eligibility of the debtor at a more appropriate time [1]. The results obtained are the basis for correct and accurate judgement of whether a debtor is eligible for credit, by increasing consumer satisfaction and providing the top-notch service which then improves the performance of the company. This can also be applied in this research objectives to provide an effective marketing strategy.

The issue of third-party logistics (3PL) provider selection is modelled in AHP, one of the most often utilised approaches of decision-making, that considers all tangible and intangible criteria. AHP results determine the best choice for 3PL providers. There are 6 steps that proposed by Gürcan et al. [2] when applying AHP,

which is constructing Pair-wise Comparison Matrices (PCM), normalization, compute weights, checking the consistency of PCM, construct integrated table and scaling the PCM. The decision-making process is growing more complex as alternatives, goals, and environmental conditions have increased simultaneously with technological advancement.

AHP is used to investigate E-tailer's website quality [3]. The quality is evaluated by weighing the customer's opinion against many criteria that define the quality of online services. The AHP technique described in this study enables website managers to prioritize service dimensions. The findings indicate service level flaws that need to be addressed, however, the framework does not give guidance for developing suitable corrective actions.

Lin et al. [4] declared that AHP is obtained by the priority vector from the nearest consistent matrix and creates a pairwise inconsistent comparison of the expert's viewpoint. This helps to mix coherence with expert evaluation. A technique that prevents orthogonal computations executes an iterative feedback loop. It may be used with some professional to reach an acceptable level of uniformity and efficiency. Other approaches may produce additional vectors of priority in this way.

The discussion of the strengths and weaknesses of the priority scheme is still controversial, mainly because existing priority schemes show other performance based on performance criteria. AlKou and Lin [5] claimed that Cosine Consistency Index (CCI) is simple to calculate and interpret for AHP. The Cosine Maximization Method (CM) has certain enticing features that make it a viable option to the other prioritising techniques. To determine the dependable priority vector, an optimization model for CM is provided. CM eliminates the need for statistical assumptions and gives a consistent signal for PCM.

Criteria and methods are organized under one also making comparison between them. The schematization described here is a good start, and its revisions are likely to be ultimately improved by expanding the criteria used and further discussing the importance and relevance of these factors in the assessment of multi-criteria decision-making techniques (MCDM).

A case study of the AHP, uses a scientific approach for decision-making, identified key components of ICT assistance in Chili's elementary education [6]. Identifying aspects of primary education and priority activities that contribute to learning allows schools to devote their efforts to training and improving their ability to use ICT. According to Oddershede et al. [6], AHP has helped professionals understand the advantages and limitations of ICT support. Reliable data results need great choice of tools. Therefore, Perzina, and Ramík, [7] wrote it out perfectly on their papers, and it relates very well with this research.

Industrial developments frequently use portal frame systems as their roofing. Numerous technical, financial, and logistical considerations, including expected cost, construction time, availability of materials, equipment, and skilled personnel, will affect the selection of the best portal frame system for a given project. Establishing a decision support system (DSS) to choose the best gantry frame system is the aim of this work [8].

Prioritization of factors is performed to determine their relative importance using the Analysis Hierarchical Process (AHP). Thirteen factors influencing the reporting of violations are considered in the study, which are grouped into four

main factors. Criminal nature and situational variables are the most important factors that can influence the intention of educators in India's private higher education sector to report abuse [9]. In [10], the main goal of this article is to propose a new supply chain (SC) design methodology. SC drivers, classified as logistic and cross-functional, are interconnected, and have different and often conflicting performance metrics. The AHP model attempts to develop weights for the efficiency and responsiveness of the entire SC design, not just individual SC drivers. The goal programming (GP) model determines the optimal set of SC driver solutions that will develop an overall satisfactory SC design [11].

Banking institutions are an important part of any country's economy, providing a variety of services to individuals and businesses. The framework presented is based on an expert-based sentiment analysis and multiple-criteria decision-making (MCDM) approach. Its quality is evaluated based on nine aspects / attributes [12].

3. Research Methodology

Figure 1 shows the flowchart of research design to successfully achieve this study.

Phase 1: Data pre-processing

This phase is where data collection and data preparation are applied. The data is collected from the preferred company in Shopee. The data will have to comply with the standards that has been set. In this sense, the data will be focused on the sales insights of the company that is operating on an e-commerce platform, this is to avoid any bias towards other products.

i) Data collection

The data is accumulated from a verified preferred Shopee shop on Shopee's Business Insights which is a one-stop portal to gain insights into the shop's performance. The data is extracted and saved to a .csv file for better compatibility.

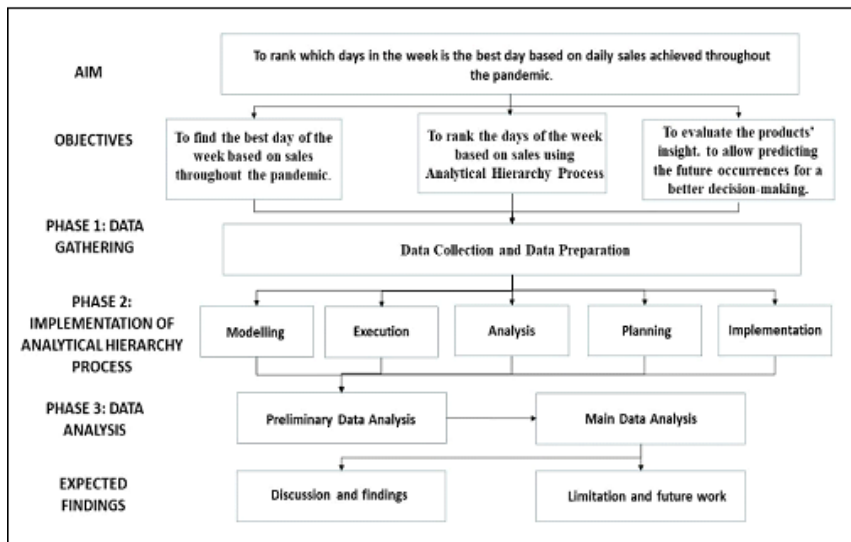


Fig. 1. Flowchart of research design.

There will be a number of dates that need to be accounted for based on the MCO waves because this research includes the pandemic, which was relatively recent. Table 1 shows the chosen dates of the MCO phases.

Table 1. Chosen dates of the movement control order phases.

MCO Phases	Chosen dates
MCO by states (11 January 2021 - 31 May 2021)	Phase 1: 7 February 2021 - 20 February 2021 Phase 2: 9 May 2021 - 22 May 2021
Total lockdown (1 June 2021 - 28 June 2021)	6 June 2021 - 19 June 2021
National Recovery Plan (15 June 2020 - 31 December 2021)	3 October 2021 - 16 October 2021

ii) Data preparation

The raw data extracted directly from Shopee is a bit cluttered and needs to be filtered and sorted for maximal utilization when executing AHP. The insights for eight chosen weeks were taken. The provided data contains a lot of unnecessary information that does not relate to this study. Therefore, it is omitted which reduces the number of required attributes to four: Sales, Orders, Page Views and Number of potential buyers. The data is then sorted by the days of the week which are Saturday, Sunday, Monday, Tuesday, Wednesday, Thursday, and Friday. The data is then tabulated in a well-ordered manner.

iii) Data Normalization

The prepared data is not fully ready for the implementation of AHP where the attributes come from different scales parameters which makes cross-examining complicated. However, by normalizing the data, the execution would be much easier. The data needs to be standardized for an equal evaluation. Equation (1) is used to normalise the data.

$$\text{normalized score} = \frac{1}{2} \left(1 - \frac{\text{sum}}{\text{total sum}} \right) \quad (1)$$

The data is standardized in several ranges. To ensure that all attributes have the same range value, each factor must be converted. It needs to be linearly transformed.

$$\text{new score} = \frac{nlb-olb}{oub-olb} (\text{original score} - olb) + nlb \quad (2)$$

Phase 2: Implementation of analytical hierarchy process

In this phase, there are a few steps that must be taken in a specific order for better results.

i) Alternative and criteria determination

Before the actual implementation of the decision-making process; identification of alternatives and criteria is important. The alternatives are days of the week from Monday to Sunday and the criteria are sales, orders, page views, and number of

potential buyers. A cross tabulation of the normalised data is necessary for a more detailed analysis and for the comparison of improvement prospects. It is considerably more likely that an ideal solution can be created using this tabulation.

ii) Pairwise comparison

The elements are listed on the left and top of the matrix, and each element is compared with every other element, including itself, making the matrix an excellent foundation for organising the comparison. It's a comprehensible framework. AHP was supposed to be created to solve problems and linear equations. The underlying scale can be recovered by arranging the numbers in a matrix. The items are compared pair wise in relation to the goal. Each comparison is based on the values between the parts that were compared using the Likert scale. The ranges above vary depending on which category each comparison falls under.

iii) Comparison matrix

In the next step, the comparisons are arranged in a matrix. The normalised Eigen Values and Eigen Vectors are computed from this matrix. The pairwise comparison matrix, $A \in \mathbb{R}^{n \times n}$, needs to satisfy the following properties,

$$a_{i,j} > 0; a_{i,i} = 1; a_{i,j} = \frac{1}{a_{j,i}} \tag{3}$$

iv) Priority vectors

Priority vector, also known as the normalised principal Eigen vector. The corresponding positive non-zero reciprocal matrix example is tabulated as shown in Eq. (4). The matrix is to be normalized eigen vector corresponding to its principal eigenvalues. In the normalization, the first step would be summing the numbers in each column as shown in Eq. (5). Each entry in the column is then divided by the column sum to yield its normalized score (see Eq. (6)). Normalized score is tabulated as in matrix (Eq. (7)). The sum of each column is supposedly to be 1.

$$\begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \end{bmatrix} \tag{4}$$

$$C_{ij} = \sum_{i=1}^n C_{ij} \tag{5}$$

$$X_{ij} = \frac{C_{ij}}{\sum_{i=1}^n C_{ij}} \tag{6}$$

$$\begin{bmatrix} X_{11} & X_{12} & X_{13} \\ X_{21} & X_{22} & X_{23} \\ X_{31} & X_{32} & X_{33} \end{bmatrix} \tag{7}$$

The contribution of each criterion to the organizational goal is determined by calculations made using the priority vector (or Eigenvector). The Eigenvector shows the relative weights between each criterion; it is obtained in an approximate manner by calculating the mathematical average of all criteria referring to Eq. (8).

$$W_{ij} = \frac{\sum_{j=1}^n X_{ij}}{n} = \begin{bmatrix} W_{11} \\ W_{12} \\ W_{13} \end{bmatrix} \tag{8}$$

v) Consistency index and ratio

The consistency ratio and its value is checked to make sure that the original preference ratings were consistent. The original preference ratings are based on the normalized values of the cumulative average. Consistency Index (CI) reflects the consistency of one's judgement. The maximum Eigenvalue, on which the inconsistency index is based, is obtained by multiplying each element of the Eigenvector by the corresponding column total of the initial comparison matrix. Maximum Eigenvalue is calculated as shown in Eq. (9).

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^n \left\{ \frac{\sum_{j=1}^n a_{ij} \times w_j}{w_i} \right\} \quad (9)$$

The consistency measure where the corresponding weights of the rows are multiplied. This is then divided by the weighted total of the row entries. It computes the values' average. Next, Eq. (10) is used to construct The Consistency Index (CI).

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (10)$$

Phase 3: Data analysis

Phase 3 will be divided into two parts which is preliminary data analysis and main data analysis.

i) Preliminary data analysis

The preliminary data analysis will include prescriptive data analysis. Descriptive data analysis combines the insights of all previous analyses to determine current issues and actions to be taken in making decisions. Data visualization is to present the data graphically so that it can be easily understood.

ii) Main data analysis

In main data analysis, AHP and data interpretation will be applied. The results are then used to make decision and ranking. By that, the relationships can be observed, unknown facts and trends can be discovered with meaningful information.

4. Results and Discussion

The main aim of this study is to rank the best day of the week, which is known as alternative, based on the four chosen criteria. After establishing the priority criteria, it is now possible to determine how each of the alternatives of this study fits the chosen criteria. Meanwhile, criteria prioritization has been made, the alternatives of this are pair-wisely compared, considering every established craterisation. There are two main results presented (criteria and alternative) in order to come out with the ranking.

4.1. Criteria matrix

The result for the criteria matrix is shown in Table 2. First ranking obtained from AHP procedure is Sales with the highest weightage value of 0.406. followed by Orders, Page Views, and number of potential buyers with weightage of 0.288, 0.208, and 0.098 respectively. The results are illustrated in Table 2.

Table 2. Criteria comparison result.

Criteria	Rank	Weightage
Sales	1	0.406
Orders	2	0.288
Page Views	3	0.208
No. of potential buyers	4	0.098

To assess the consistency of judgments, calculating consistency is quite important. Therefore, the criteria matrix resulted a Lambda Maximum with a value of 4.41. Which then computed the CI with a value of 0.047 and the CR with a value of 0.0521. The CR value is ≤ 0.10 which indicates that judgement matrix has a relatively satisfactory consistency. So, the degree of consistency exhibited in the comparison matrix is acceptable. The results are tabulated in Table 3 for a better understanding.

Table 3. Consistency result.

	Consistency
Lambda max (λ_{max})	4.141
Consistency Index (CI)	0.047
Consistency Ratio (CR)	0.052

4.2. Alternative matrix

With the greatest weightage value of 0.308, Sunday comes in first on the list. The Thursday would come in second with a weight of 0.194. Wednesday would rank third and fourth with a weight of 0.154. With a weight of 0.118, Tuesday comes in fourth place. The Monday would come in fifth place with a weight of 0.102. The Friday would be ranked sixth with a weight of 0.070. Number of potential purchasers comes in last and is weighted at 0.054. Table 4 provides an illustration of the outcomes.

Table 4. Alternative comparison result.

Alternative	Rank	Weightage
Sunday	1	0.308
Thursday	2	0.194
Wednesday	3	0.154
Tuesday	4	0.118
Monday	5	0.102
Friday	6	0.070
Saturday	7	0.054

The criteria matrix resulted a Lambda Maximum with a value of 7.665. Which then computed the CI with a value of 0.111 and the CR with a value of 0.084. The CR value is ≤ 0.10 which indicates that judgement matrix has a relatively satisfactory consistency. So, the degree of consistency exhibited in the comparison matrix is acceptable. The results are tabulated in Table 5 for a better understanding.

Table 5. Consistency result.

	Consistency
Lambda_max (λ_{max})	7.665
Consistency Index (CI)	0.111
Consistency Ratio (CR)	0.084

4.3. System comparison

Consistency is important in decision making. Therefore, in order to make the consistent judgments, the expertise of experts is needed in order to improve the understanding. The data is inputted to an AHP based system that calculates the data automatically for both Criteria and Alternatives matrices. Table 6 shows the tabulated results with description.

Table 6. Alternative and criteria.

Criteria Alternative	Sat	Sun	Mon	Tue	Wed	Thu	Fri
Sales	0.4104	0.3910	0.4260	0.5042	0.4688	0.3165	0.4649
Orders	0.3600	0.6050	0.3300	0.3550	0.2900	0.5700	0.4650
Page Views	0.3721	0.3636	0.4404	0.4154	0.5630	0.4343	0.3779
No. of potential buyers	0.3950	0.5050	0.4042	0.2944	0.3000	0.2531	0.3050

As shown in Table 7 the ranks between using manual calculation and automatic calculation are similar, there are only a slight difference in weightage. For the criteria which are Sales, Orders and Page Views and Number of Potential Buyers gives of a 0.7, 0.3, 1.5 and 2.1 error in percentage respectively. For errors $\leq 10\%$ is considered accepted.

Table 7. Manual calculation vs. automatic calculation for criteria.

Criteria	Manual calculation		Auto Calculation		Percentage error (%)
	Rank	Weightage	Rank	Weightage	
Sales	1	0.406	1	0.409	0.7
Orders	2	0.288	2	0.289	0.3
Page Views	3	0.208	3	0.205	1.5
No. of potential buyers	4	0.098	4	0.096	2.1

As shown in Table 8, the ranks between using manual calculation and automatic calculation are the same, with only slight difference in weightage. For the criteria which are Sales, Orders and Page Views and Number of Potential Buyers gives a of a 0.7, 0.3, 1.5 and 2.1 error in percentage consecutively. Errors $\leq 10\%$ is considered accepted.

Expert's perspective

An expert's judgment is needed to verify the findings from the AHP systems. Therefore, in this study, an interview with the company's owner is conducted in order to get his opinions about the daily sales with the criteria discussed earlier. The input from the owner was analysed to make sure the results obtained are accurate decisions and consistent. The results are compared and presented in Table 9.

As shown in Table 9, the ranks are the same, there are only a slight difference in weightage value. Percentage error for criteria Sales, Orders and Page Views are very small: 3.8%, 4.3%, and 6.7% respectively. However, only Number of Potential Buyers criteria gives of a 28.9 percent of error. Generally, an error less than 10% considered acceptable. So, Number of Potential Buyer’s is supposed to be rejected. In spite of that, maybe there are a few faults that must be taken into accounted, such as the number of decimals that are considered.

Table 8. Manual calculation vs. automatic calculation for alternative.

Alternative	Manual calculation		Auto Calculation		Percentage error (%)
	Rank	Weightage	Rank	Weightage	
Sunday	1	0.054	1	0.053	1.9
Wednesday	2	0.308	2	0.316	2.5
Friday	3	0.118	3	0.117	0.8
Monday	4	0.102	4	0.095	7.3
Tuesday	5	0.194	5	0.199	2.5
Thursday	6	0.070	6	0.068	2.9
Saturday	7	0.154	7	0.155	0.6

Table 9. Data vs. Experts comparison.

Criteria	Data		Expert’s perspective		Percentage error (%)
	Rank	Weightage	Rank	Weightage	
Sales	1	0.406	1	0.391	3.8
Orders	2	0.288	2	0.276	4.3
Page Views	3	0.208	3	0.195	6.7
No. of potential buyers	4	0.098	4	0.138	28.9

The consistency of judgments, as has been shown in the previous section, is a crucial factor to take into account when evaluating the final decision's quality. It is highly challenging to attain perfect consistency, and it is assumed that some degree of consistency failure will occur in practically any collection of pairwise comparisons.

5. Conclusions

This study utilizes four factors over the course of the pandemic to identify the greatest day of the week based on daily sales. In order to improve their earnings, marketing strategy will be implemented on the best day that was selected. This study is based on data collected from one of the companies in the online platform (Shopee) and then compared with the expert's insight using the Analytical Hierarchy Process. The overall performance was deemed satisfactory based on these case studies. The analysis's findings make it very evident that sales are the most important factor, and Sunday is the best day of the week overall.

Therefore, in order to optimize the company's profit, the decision-maker can launch an offer or offer a promotion discount for their goods on the indicated day. On the other side, forecasting is crucial for future planning in the business sector. As a result, this knowledge can assist the decision-maker in forecasting market and consumer behavior changes as well as deciding where and when to invest money.

6. Limitations of the Study

During the epidemic, this analysis was based solely on one firm from the Shopee platform. The analysis' findings can be applied to the same kind of business with the same objective, which is to rank the best day of the week in order to strengthen that business's marketing plan. Therefore, compared to other days of the week, the promotion or discount offered on the chosen day would be great to achieve maximum profit. For future research, it is recommended to use data from few other different company so that it can be compare thoroughly.

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