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27E01000 - Decision Making and Choice Behavior

Group Y

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Abstract

In this report, we aim to solve a decision problem currently considered by employing the Multi-Attribute Value Theory (MAVT) and value-focused thinking approach. Our report consists of *five* sections. In this first section, there will be an outline of the case's main points. Section II, problem formulation, talks about methods used, and thus constructed objectives and corresponding attributes to solve the case. The more technical and mathematical aspects will be mentioned in section III, problem solving, and IV, decision analysis. The last section will provide a final overview of the decision-making process as well as considerations on limitations and opportunities for improvement. References will be mentioned at the end.

1 Introduction

The decision maker, our group member named Q, is considering purchasing a plane ticket from Helsinki, Finland to Hanoi, Vietnam while being bound by certain conditions.

Those constraints are as follows:

- Departure date: Q cannot leave before 1st June, as his school year concludes 31st of May.
- Arrival date: Q must be home during 11th June by the latest to attend an evening academic event.
- Type of trip (one-way or round trip): Having to renew his residence permit (RP), Q does not want to book a round trip in case his new RP arrives *after* his booked return date to Helsinki.

The forthcoming section will hone how we formulate the problem.

2 Problem formulation

Following Raph L. Keeney's principle (Keeney, 1994) that values, not alternatives, should be the main focus in decision making, in this section, via insights on the decision maker's persona, we utilize the value-focused thinking method to determine fundamental objectives and corresponding attributes of the ticket case before exploring for possible alternatives.

2.1 Objectives

To begin, we have the decision maker (Q) listing out *seven* goals he aims to achieve with his desirable plane ticket:

- Departing early (in terms of date)
- Having short transit time
- Having short flying time
- Paying less for the ticket
- Carrying ample luggage
- Arriving at a convenient time for last-mile transportation

Based on Q's initial answers, via suggested WITI approach (Keeney, 1994), we construct with the means-ends objectives diagram, as in the photo below.

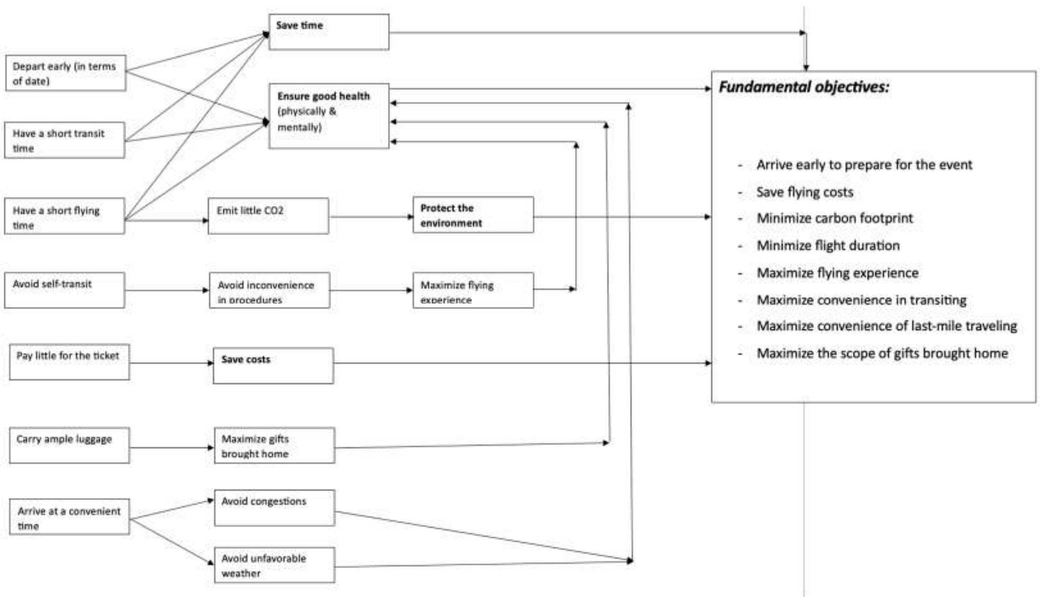

Figure 1. Means-ends objectives diagram.

The idea is that while some objectives are, in themselves, fundamental, some are just convenient means implying deeper purposes. By repeatedly asking "*why*" to evoke further reasons behind Q's choices, we arrive at the core objectives, thus avoiding biases, myopic issue, and the overlook of valuable criteria.

2.2 Attributes

For each of the now fundamental objectives, we develop suitable corresponding attributes, which can also be summarized in Table 1.

Table 1. Corresponding attributes to each objective.

Number	Objectives	Attributes
1	Arrive early for better even preparation	Arrival date
2	Save flying costs	Ticket price
3	Minimize carbon footprint	Average carbon emission
4	Minimize flight duration	Flight duration
5	Maximize flying experience	Professional airlines' ratings
6	Minimize convenience in transiting	Transit conditions
7	Maximize the scope of gifts brought home	Total luggage allowance
8	Maximize convenient of last-mile traveling	Conditions of arrival time

Further details on attribute scaling of the sixth and eighth objectives will be provided in section 3.1.

2.3 Alternatives

After developing the objectives and attributes for this case, we proceed to look for alternatives, successfully shortlisting four options. Those screenshot from (Cathay Pacific, 2023) and (Kiwi.com, 2023) can be seen in Figure 2, Figure 3, Figure 4, and Figure 5 in the Appendix.

Additional information on carbon footprint and third-party airlines' ratings are also collected via (Google Flights, 2023) and (Skytrax, 2023). Lastly, we summarize the alternatives' performances on Table 2.

Table 2 Alternatives' performances summary.

Alter-native	Arrival date	Ticket price (€)	Average carbon emission (kg CO2/ hour)	Flight duration (h = hours, m = minutes)	Professional airlines' ratings	Transit conditions	Total luggage allowance (kg)	Arrival time
1	Jun 9th	522.20	45.59	24h50m	Turkish, 4 stars	2 stops (1 auto-transit + 1 self-transit)	27	00:30
2	Jun 3rd	499.19	41.08	30h05m	Cathay, 5 stars	2 stops (auto-transit)	30	18:00
3	Jun 3rd	526.20	45.59	22h10m	Turkish, 4 stars	2 stops (1 auto-transit + 1 self-transit)	27	23:10
4	Jun 9th	500.49	37.51	37h45m	Cathay, 5 stars	2 stops (auto-transit)	30	9:45

3 Problem solving

3.1 Clarification on attribute scaling

Here, we delve into the reasons behind the decision maker's (Q's) scaling of 3 special attributes: price ticket, transit conditions, and arrival time.

Regarding price ticket, Q anchors his range on the recent purchases of acquaintances, his past experience, and the prevailing price in the market. Eventually, he comes up with a range from 490€, the cheapest available ticket, to 550€, the maximum price he is willing to pay at this moment.

Both transit conditions and arrival time represent nuanced objectives - convenience. Hence, they can be treated as indirect and constructed attributes, requiring detailed scoring rubrics, as in Table 3 and Table 4, to avoid scaling biases (further explanations in section 5).

Table 3 Rubric for arrival time.

Time slots	Score out of 5	Reasons
6:00 - 7:00 14:00 - 16:00	5	The temperature at time of arrival is pleasant enough considering the sweltering summer climate in Vietnam. The roads are not congested, and various means of transportation are readily available. The arrival time is neither too early nor too late, allowing daytime activities while minimizing fatigue.
9:00 - 14:00	4	Having the same criteria as options scoring 5/5, except for a **higher** midday **temperature**.
4:00 - 6:00 20:00 - 24:00	3	Having the same criteria as options scoring 5/5, except for either the **late** arrival time not allowing for midday activities OR the too **early** arrival time causing tiredness.
7:00 - 9:00 16:00 - 20:00	2	The roads are heavily **congested.**
0:00 - 4:00	1	The late-night arrival time limits the **availability of vehicles** and raises concerns regarding **travel safety**.

Table 4 Rubric for transit conditions.

Number of transits	Mode of transit	Score on scale of 5
1	Auto-transit	5
1	Self-transit	4
2	2 auto transits	3
2	1 auto-transit, 1 self-transit	2
2	2 self-transit	1

3.2 Elicitation of attributes' partial values

In hopes of eliciting the partial values of attributes, we use the bisection method algorithm for the sake of simplicity, although it's important to note that in a more complex multi-party decision-making problem, bisection method can induce desirability bias. A summary of its use is in the picture below.

- Define the best (x_i^*) and worst (x_i^0) consequence for attribute i, and fix their values at $vi(x_i^0) = 0$ and $vi(x_i^*) = 1$
- Ask the DM (Q) to assess level $x_{0.5} \in [x_i^0, xi^*]$ such that he is indifferent between change $x_{0.5} \leftarrow x_i^0$ and change $x_i^* \leftarrow x_{0.5}$.
- Then, ask him to assess levels $x_{0.25}$ and $x_{0.75}$ such that he is indifferent between:
  + change $x_{0.25} \leftarrow x_i^0$ and $x_{0.5} \leftarrow x_{0.25}$
  + change $x_{0.75} \leftarrow x_{0.5}$ and $x_i^* \leftarrow x_{0.75}$
- Use linear interpolation between elicited point

3.3 Elicitation of objectives' weights

After that, we use the SWING method to elicit weights of the objectives. The rescaled version of objectives' weights is presented in Table 5.

Table 5 Objectives' weights.

Attribute swung from worst to best	Consequence to compare	Rank	Wj	wj
(Benchmark)	85.63 h, €550, 50 kg, 11th June, 22 kg, 1 stars, 2 Self-transits, 0 - 4AM arrival time			
Flight duration (hours)	85.63 h, €550, 50 kg, 11th June, 22 kg, 1 stars, 2 Self-transits, 0 - 4AM arrival time	3	80	0.20253
Price ticket	15.67 h, €490, 50 kg, 11th June, 22 kg, 1 stars, 2 Self-transits, 0 - 4AM arrival time	1	100	0.25316
Average carbon emission during flight time (kg CO2)	85.63 h, €550, 33 kg, 11th June, 22 kg, 1 stars, 2 Self-transits, 0 - 4AM arrival time	8	5	0.01266
Arrival day	85.63 h, €550, 50 kg, 2nd June, 22 kg, 1 stars, 2 Self-transits, 0 - 4AM arrival time	2	90	0.22785
Luggage allowance (hand + checked luggage, kg)	85.63 h, €550, 50 kg, 11th June, 37 kg, 1 stars, 2 Self-transits, 0 - 4AM arrival time	4	50	0.12658
Online airline sevice's rating	85.63 h, €550, 50 kg, 11th June, 22 kg, 5 stars, 2 Self-transits, 0 - 4AM arrival time	5	40	0.10127
Ease of transit	85.63 h, €550, 50 kg, 11th June, 22 kg, 1 stars, 1 Auto-transit, 0 - 4AM arrival time	6	20	0.05063
Arrival time	85.63 h, €550, 50 kg, 11th June, 22 kg, 1 stars, 2 Self-transits, 6-8AM arrival time	7	10	0.02532
		Total	395	1

3.4 Decision analysis

After the attribute-specific value functions have been elicited, the performance matrix in the end of section 2, Problem formulation, can be transformed into Table 1, which displays the attribute-specific value scores for each alternative.

Table 6 Score matrix.

Alter-native	Arrival date	Ticket price	Average carbon emission	Flight duration	Professional airlines' ratings	Transit conditions	Total luggage allowance	Arrival time	MAV
1	0.250	0.430	0.338	0.774	0.571	0.250	0.250	0.000	0.451
2	0.875	0.770	0.620	0.690	1.000	0.500	0.375	0.250	0.733
3	0.875	0.363	0.338	0.840	0.571	0.250	0.250	0.500	0.575
4	0.250	0.743	0.812	0.582	1.000	0.500	0.375	0.750	0.578
Weight	0.203	0.253	0.013	0.228	0.127	0.101	0.051	0.025	

Alternative 2 emerges as the best option with the highest overall value (0.733), followed by alternatives 4, 3, and 1, respectively. Consequently, the decision maker (Q) ends up selecting the Cathay flight on June 2nd.

The 3 most strongly weighted attributes are ticket price (0.253), flight duration (0.228), and arrival date (0.203). Option 2 receives high partial values in all those critical aspects, ranking first in arrival day as well as ticket price and second in flight duration.

4 Final overview and considerations

This section will shift the focus away from technical aspects to a more holistic view of the entire problem-solving example.

4.1 Theoretic assumptions and possible violations

In this section, we provide an overview of the plane-ticket case by discussing theoretic assumptions underlying MAVT problems and their possible infringements. Behavioral issues that can impair decision-making are also highlighted, as well as other limitations regarding our approach and recommendations for improvements in problem-solving.

In order for a problem to be considered MAVT, several requirements have to be met. However, in real-life problems, it is not uncommon that these axioms do not hold.

- Certainty Assumption: The certainty assumption in MAVT implies that outcomes are certain. However, in our case, flight duration and arrival time can vary due to externalities, e.g weather conditions.
- Preference Independence: The principle of preference independence says that the decision-maker's preference for a particular option should not be influenced by the presence or absence of other options. However, in this case, this principle can be violated, for example, if Q would assign more weight to the ticket price attribute were all flights available be extended/delayed.
- Difference Independence: The difference independence assumption states that the value of a change in a particular attribute's value is independent of that of other attributes. However, in our context of buying a plane ticket, the evaluation of a price reduction can depend on other factors, e.g the airline's name. For instance, a $100 reduction may be valued more if it's offered by a highly ranked airline than by one with a lower reputation.

Another assumption, although not peculiar to MAVT, is about the rationality of the decision-maker, saying that a decision-maker has well-defined goals and cognitive capabilities to always recognize the objectively optimal alternative.

4.2 Behavioral issues

However, similar to prior assumptions, the last expectation of human rationality can be wrecked during the problem-solving process as decision makers do not solely rely on logical thinking.

In this section, due to word limit, we pick out to analyze the three most relevant categories of such behavioral fallacies in our context of buying the ticket plane, and offer ways to overcome those *biases*.

4.2.1 Biases related to generating objectives and alternatives

Under this broad category are myopic issue - when the constructed objective is too narrow, limiting the scope of possible choices - and omission bias - when harms caused by omission are undervalued compared to those caused by commission.

While the myopic issue can be safely avoided in this instance thanks to the use of WITI approach as mentioned in section II, the omission bias can emerge as Q limits his final choice to the four cheapest flights. As for a higher-priced option, Q might be more heavily affected by the premium price he has to pay for the flight than the added non-monetary benefits he may lose should he not choose it. However, considering his budget restriction, it is understandable that in this case, the decision-maker prefers to stick to his final four shortlisted options.

4.2.2 Biases related to attribute scales

For ambiguous objectives, such as maximizing convenience in transiting and last-mile traveling in our situation, decision makers often develop rating scales for the associated attributes. Scaling biases can occur when decision makers use the whole scale to evaluate available alternatives regardless of their realistic quality. This has been tackled in our problem case through the use of detailed verbal description in the grading rubric for our 2 complex attributes, as illustrated in section 3.

4.2.3 Biases related to attribute weights

In this most prominent category of biases related to multi-criteria decision analysis (MCDA) models, range insensitivity refers to the assignment of a huge weight to an attribute regardless of its value range. This concern can be mitigated using the SWING method, explicitly requiring the decision maker to think about the impact on the alternatives' overall performance when changing an attribute's particular value from the worst to the best level. This approach, however, can still be manipulated if a decision-making process involves multiple stakeholders. Nevertheless, in our example, SWING effectively helps prevent range insensitivity bias.

4.3 Limitations and recommendations

The first limitation is the *short range of alternatives*. Although it's true that those ultimate options were picked considering Q's high weight on the money attribute, this limited set might not capture all possible flights that meet his other criteria. Bringing in a more dynamic scope of alternatives, therefore, can alter the relative weights placed on different aspects of flying.

The second minus in this case is the reliance on the decision maker's *subjective evaluation*, and thus incorporating more neutral assessments of objectives, especially expert opinions, can offer a more realistic and comprehensive understanding on the matter, enriching Q's viewpoint.

The last point we aim to make is not about our model's limit, but a consideration for future decision makers to take into account. Our method is designed for a simple, single decision-maker scenario. If the problem involves multiple parties, a more robust approach might be needed.

5 Conclusions

In this report, we introduced the problem our group member has currently been considering: buying a one-way ticket plane from Helsinki to Hanoi during 1st and 11th of June, 2023.

By applying the multi-attribute value theory (MAVT) and the value-focused thinking approach, we guide the decision maker towards the best available options from his viewpoint. However, as the fulfillment of all theoretical assumptions is impossible during the decision-making process, we had to inevitably relax several stringent axioms fundamental to MAVT to smoothen problem solving. Despite such necessary adjustments, our innovative and extensive employment of theoretical methods effectively assists the decision maker in avoiding detrimental biases and reaching the most satisfying outcome.

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Appendix

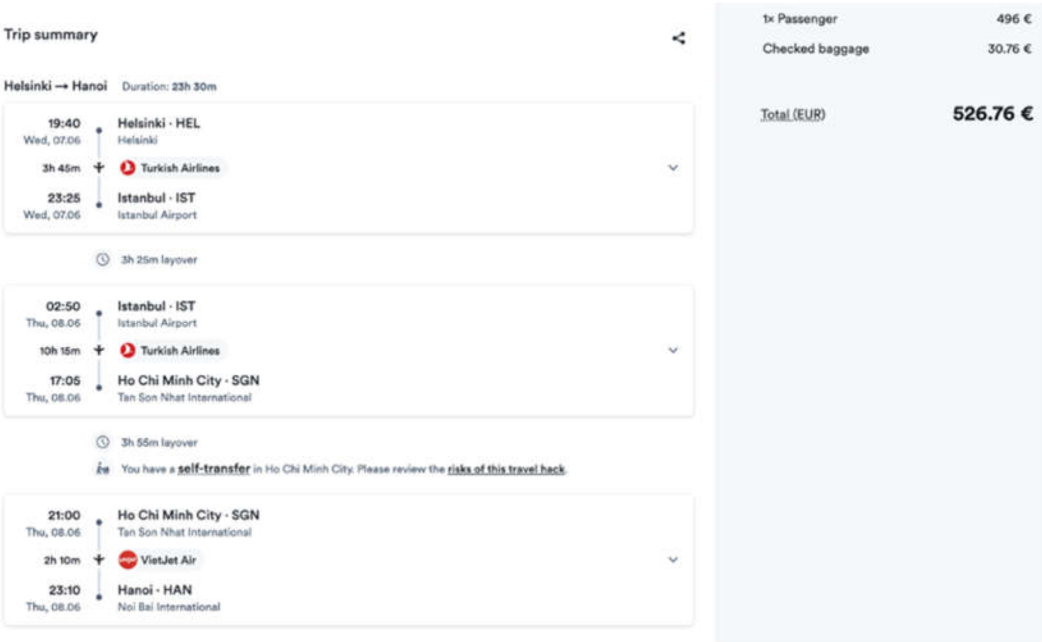

Figure 2. Decision alternative 1. (Kiwi.com, 2023)

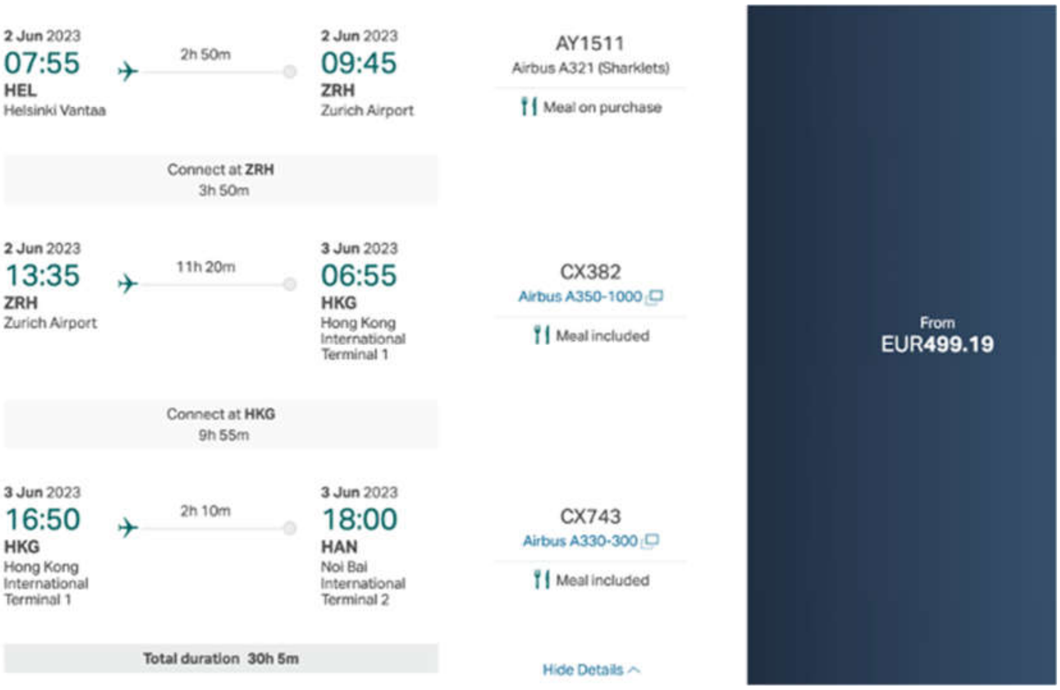

Figure 3. Decision alternative 2. (Cathay Pacific, 2023)

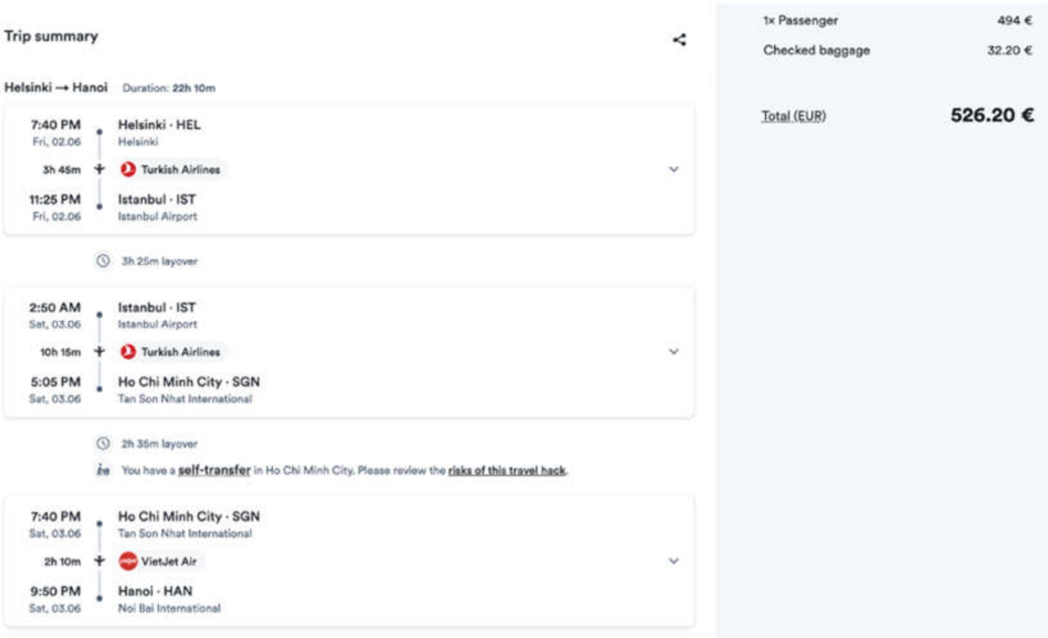

Figure 4. Decision alternative 3. (Kiwi.com, 2023)

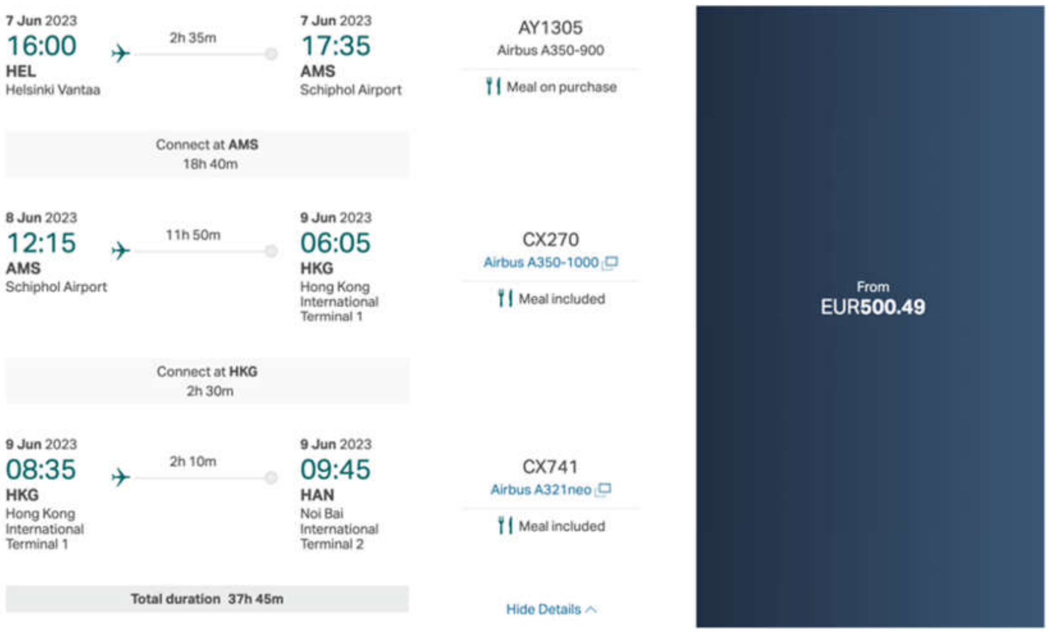

Figure 5. Decision alternative 4. (Cathay Pacific, 2023)