Passenger transportation BMEKOKUM208

3. Task

Quality evaluation of travel chain

Evaluate the quality of the same travel chain that was selected in task 2 using multi-criteria decision analysis. Briefly describe the characteristic of route, transportation and related services. It is sufficient to determine the quality of travel chain in the direction of University → WestEnd City Center shopping mall.

The criterion set for the evaluation (quality criteria) is given. Calculate the weight numbers of each criterion using AHP method. Summarize in one table the evaluation and weight numbers (table 1). Briefly describe the evaluation numbers assigned to subjective features.

Consider the aggregated quality index and give proposals to improve the competitiveness of transportation modes.

Table 1. Evaluation and weight numbers

Evaluation table			
Name of criterion	c_i	Justification of c_i, if subjective	g_i
perceived walking time	3,27	-	5
…			

TRADITIONAL PUBLIC TRANSPORT

QUALITY FEATURES

c_1, perceived walking time: the magnitude of walking during travel, and the circumstances of walking. c_1 is:

- 1, if the perceived walking time is >20 mins;
- 5, if the perceived walking time is <5 mins;
- use linear interpolation between 5 and 20 mins.

The perceived walking time is calculated on the base of (1).

$$t_{walk,p} = \sum_i t_{walk,i} \cdot Q_{walk,i} \tag{1}$$

Where:

$t_{walk,p}$: perceived walking time [min];

$t_{walk,i}$: the real time requirement on foot of section ‘i’ [min] (measurable or can be calculated with formula s/v; where v=0,9 m/s);

$Q_{walk,i}$: quality of the environment during walking for section 'i' [-]. The value is calculated on the base of (2). The value of $Q_{walk,i}$ is between 0,8 and 1,2.

$$Q_{walk,i} = 1 + \sum_{j} q_{walk,i,j} \tag{2}$$

$q_{walk,i,1}$: consider the environment, where $q_{walk,i,1}$ is:

- -0,15, less than 25% of the entire section is upward (estimation is enough) (e.g.: the terrain is flat, or elevator/escalator is available);
- 0, 25-60% of the entire section is upward;
- 0,15, 60% or more of the entire section is upward.

$q_{walk,i,2}$: consider the protection from bad weather, consider the lack of protection if the condition of weather was wrong.

- lack of protection from strong wind: +0,03;
- lack of protection from rain: +0,05;
- lack of protection from the sun: above 23°C: +0,03;

$q_{walk,i,2}$ is between 0 and 0,08.

$q_{walk,i,3}$: consider the services that are available with a small bypass (2-3 min) on foot, where:

- -0,1, if there is service nearby;
- 0, if there is no service nearby.

$q_{walk,i,4}$: it can be measured with the knowledge of road conditions, where:

- 0, if the road is maintained (clean, secure, homeless are not living near the road, and not constitute moving barrier, etc.)
- +0,05, if the road is not maintained.

c_2, perceived waiting time: the extent and the circumstances of waiting. Value of c_2:

- 1, if the perceived waiting time is >20 perc;
- 5, if the perceived waiting time is <5 min;
- use linear interpolation between 5 and 20 mins.

The perceived waiting time is calculated on the base of (3).

$$t_{wait,p} = \sum_{k} t_{wait,k} \cdot Q_{wait,k} \tag{3}$$

Where:

$t_{wait,p}$: perceived waiting time [min];

$t_{wait,k}$: real waiting time for section ‘k’ [min];

$Q_{wait,k}$: quality of the environment during waiting for section ‘k’ [-]. It is calculated according to (4). $Q_{wait,k}$ value is between 0,8 and 1,2.

$$Q_{wait,k} = 1 + \sum_{l} q_{wait,k,l} \tag{4}$$

$q_{wait,k,1}$: consider the protection of the waiting place from bad weather, consider the lack of protection if the condition of weather was wrong:

- lack of strong wind protection: +0,03;
- lack of rain protection: +0,05;
- lack of sun protection 23°C above: +0,03;

$q_{wait,k,2}$: consider the nearby services (can be reach within 2-3 mins on foot), where:

- -0,15, if there is service nearby;
- 0, if there is no service nearby.

$q_{wait,k,3}$: consider the conditions of the waiting place, where the values:

- 0, if the waiting place is maintained (clean, secure, etc.)
- +0,1, if the waiting place is not maintained.

c_3, punctuality (reliability): punctuality of the transport service. c_3 is:

- 5, if $\overline{d_r}$ (relative average delay) ≤ 3 min;
- 1, if $\overline{d_r}$ ≥ 10 min;
- use linear interpolation between the two values.

$\overline{d_r}$ can be calculated on the base of (5).

$$\overline{d_r} = \frac{\sum_m d_{r,m}}{n+1} \tag{5}$$

Where:

$d_{r,m}$: the relative delay of journey ‘m’ [min];

n: number of changes [pc].

$d_{r,m}$ can be calculated on the base of (6).

$$d_{r,m} = d_m \cdot \prod_{x} f_x \cdot a \tag{6}$$

Where:

d_m: the real delay of journey ‘m’, it is measured at the arrival station [min];

f_x: the frequency index for the m-th and the following travels [-] (table 2);

a: the index for the m-th travel alternatives [-] (table 3.). Two lines are alternatives if the departure and arrival points are the same. E.g.: Between Moricz Zsigmond square and Szell Kalman square tram 61 is an alternative for tram 6;

Table 2

frequency of the service [min]	<5	5-7	7,1-9	9,1-11	11,1<
f_x	0,8	0,9	1	1,1	1,2

Table 3

alternatives	yes	no
a	0,95	1

c_4, number of changes. It is determined according to table 4.

Table 4

number of changes [pc]	0	1	2	3 or more
c_4	5	4	2,5	1

c_5, speed: travel speed. c_5 is:

- 1, if v_{tr} ≤3,25 km/h;
- 5, if $v_{tr} \geq v_a$;
- use linear interpolation between the two values.

The value of $\mathbf{v_{tr}}$ is determined on the base of (7).

$$v_{tr} = \frac{s_{shortest}}{t_{travel}} \tag{7}$$

Where:

$\mathbf{v_{tr}}$: travel speed;

$\mathbf{s_{shortest}}$: shortest way between the departure and arrival destination (not necessary equal with the travel distance);

$\mathbf{t_{travel}}$: travel time of travel chain;

$\mathbf{v_a}$: average speed of traffic, values:

- in peak time (between 6-8 AM and 4-6 PM): 25 km/h,

- in normal traffic period (between the two peaks): 35 km/h,
- in low peak traffic period (between 6 PM and 6 AM): 45 km/h.

Travel comfort: accessibility, crowdedness and the appearance of the vehicle.

c_6, vehicle accessibility, values:

- 1, if the vehicle is high-floored at the entire length (e.g.: Ikarus 260);
- 2, if the vehicle has decreased high-floor, but not low-floor (e.g.: Ikarus 415);
- 3, if the vehicle is not low-floored, but has an elevator or ramp (e.g.: some suburban trains);
- 4, if the vehicle has low-entry floor (pl. Volvo B7R/ Alfa Localo);
- 5, if the vehicle is low-floored at the entire length.

c_7, vehicle crowdedness, values:

- 1, the crowdedness is maximal;
- 2, all seats are occupied and the passengers are standing densely;
- 3, all seats are occupied, some standing passenger;
- 4, almost all seats are occupied but no standing passenger;
- 5, the half of the seats are available.

c_8, cleanliness and aesthetics: subjective feature, influenced by the following factors:

- vehicle cleanliness;
- exterior and interior appearance of the vehicle.

Cleanliness and aesthetics is a subjective criterion, its value varies between 1 and 5. Short explanation is required (2-3 sentences).

c_9, system usability: the system usability is influenced by the following factors:

- network, timetable and the transparency of the tariff system;
- discount fares and season ticket system,
- vendor machine handling.

Handling of the system is subjective criterion, its value varies between 1-5. Short explanation is required (2-3 sentences).

c_{10}, passenger facilities and passenger information system:

$$c_{10} = 1 + u_{fac} + u_{inf} \tag{8}$$

where:

u_{fac}: quality of the passenger service varies between 0 and 1,5. Two extreme values are: 0, if the staff is rude and poorly trained (driver, ticket controller, etc.); 1,5 if the staff is nice and well trained. The value is a subjective feature, short explanation is required (1-2 sentences).

u_{inf}: the quality of the passenger information system is varied in the range of 0 and 2,5. Two extreme values are: 0, if the information for passengers are little, static and hard to reach; 2,5 if the data are lot and easy to access. The value of u_{inf} is subjective, short explanation is required (1-2 sentences).

c_{11}, safety: passenger and traffic safety. Its values are between 1 and 5. Subjective feature, where the probability of the accident or crime, the severity of the harm and the safety should be taken into account. Short explanation is required.

c_{12}, environment protection: 5.

WEIGHT NUMBERS

g_1, g_2, … g_{12}: use AHP method to determine weights.

AGGREGATED QUALITY INDEX

$$Q = \sum_{x=1}^{12} c_x \cdot g_x \tag{9}$$

BICYCLE TRANSPORT

c_1, perceived walking time: the calculation method is the same as mentioned in the traditional public transport chapter.

c_2, characteristic of the cycling road: weighted aggregate value of each section. The weight of a section is its length. Decrease the value by 1 if the road surface is not flat or smooth is (e.g.: dirt road).

- in case of public bike the score of the sections:
    - 5, if slightly sloping;
    - 4, if horizontal;
    - 3, if slightly sloping, or strongly rising;
    - 2, if strongly rising.
- in case of your own bike:
    - 5, if horizontal;
    - 3, if slightly sloping or rising;
    - 2, if strongly sloping or rising.

c_3, travel safety: weighted aggregate value of each section. The weight of a section is its length. The values of the road-sections:

- 5, if entirely separated or well-distinguished cycling path from the pavement;
- 4, if pavement, a shared pedestrian and bike path, or less indicated bike path;
- 3, if cycling path / bicycle sharrows / shared bicycle and bus lane, and travel at off-peak time;
- 2, if cycling path / bicycle sharrows / shared bicycle and bus lane, and travel at peak-time;
- 1, if there is no indicated cycling path/ bicycle sharrows / cycling road.

c_4, bike storage at the arrival spot:

- 5, if there is a place for bike storage or public bike rental storage;
- 4, if there is a place for bike storage, but not guarded;
- 1, there is no place for bike storage.

c_5, speed: its value is equal to the c_5 feature in case of the traditional public transport

c_6, system usability and acceptance: the usability and the acceptance of the system is influenced by the following factors

- transparency of the cycling roads;
- discount fares and season ticket system,

- transportation moral.

Usability and acceptance are subjective features, its values vary between 1 and 5. Short explanation is required (2-3 sentences).

c_7, environmental protection: 5.

WEIGHTNING NUMBERS

g_1, g_2, … g_7: use AHP method to determine weights.

AGGREGATED QUALITY INDEX

$$Q = (c_1 \cdot g_1) + \sum_{x=2}^{5} \frac{c_x \cdot g_x}{W} + \sum_{x=6}^{7} c_x \cdot g_x \tag{9}$$

Where:

- W: the weather index [-], values:
  - 1, if the weather is good (10-23°C, no rain);
  - 1,2, if the weather is slightly unpleasant (0-10°C or 23-29°C, no rain);
  - 1,4, the weather is unpleasant (<0°C or >29°C, or there is rain).

TRAVEL BY CAR

QUALITY FEATURES

c_1, perceived walking time: the calculation method is the same as parameter c_1 mentioned in the traditional public transport chapter.

c_2, speed: the calculation method is the same as parameter c_5 mentioned in the traditional public transport chapter.

c_3, travel comfort: the travel comfort is influenced by the following factors:

- capacity,
- size of seats,
- vehicle interior.

The travel comfort is subjective feature, its value varies between 1 and 5. Short explanation is required (2-3 sentences).

c_4, system usability: the system usability is influenced by the following factors:

- network and the transparency of the tariff system;
- vendor machine handling.

Handling of the system is subjective; its value varies between 1 and 5. Short explanation is required (2-3 sentences).

c_5, Parking conditions: the parking conditions are influenced by the following factors:

- parking construction (parallel or perpendicular);
- the type of the approaching road (size, traffic);
- guarded or not;
- covered or not.

Parking conditions are subjective, its value varies between 1 and 5. Short explanation is required (2-3 sentences).

c_6, environment protection: values:

- 4, if the vehicle is fully electric (there is no internal combustion engine) and at least 3 people travel with it (in case of taxi the driver doesn't matter);
- 3, if the environmental classification of the vehicle is at least Euro 5, not fully electric and at least 3 people travel with it, or fully electric and at least 3 people travel with it (in case of taxi the driver doesn't matter);
- 2, if the environmental classification of the vehicle is at least Euro 5, not fully electric and maximum 2 people travel with it (in case of taxi the drives doesn't matter);
- 1, if environmental classification of vehicles is EURO 4 or less.

WEIGHT NUMBERS

g_1, g_2, … g_6: use AHP method to determine weights.

AGGREGATED QUALITY INDEX

$$Q = \sum_{x=1}^{6} c_x \cdot g_x \tag{11}$$

Route and mode choice modelling

Visualize all the aggregated features connected with travel opportunities in table form (based on the first part of the task 2. and 3). Let's the table columns are: C, D, T, Q.

Based on the route and mode choice models calculate the choice probability of your own travel chain, take into account all the aggregated criteria of the possible travel.

I. with general Logit model

a., The utility function is equal to the aggregated quality index (N_i=Q_i).

b., The utility function is:

$$N_i = \frac{Max(0{,}2 \cdot C_i + 0{,}8 \cdot T_i) - (0{,}2 \cdot C_i + 0{,}8 \cdot T_i)}{Max(0{,}2 \cdot C_i + 0{,}8 \cdot T_i) - Min(0{,}2 \cdot C_i + 0{,}8 \cdot T_i)}$$

1 hour spent with travelling is equivalent with 3000 HUF purchase.

II. with resistors

Calculate the resistance function <w_i=f(C_i, Q_i,)> and parameter ‘a’ in the way that the calculated value do approach the result in task I.a. (consider the travel chain in an aggregated way).

Try to modify the resistance function and parameter ‘a’ in two steps that the calculated value does approach the result calculated in I.a. Document and justify the actions and the obtained results.

Submission: in editable format (doc or docx format). The documentation should be sent via e-mail to the lecturer.

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