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# **Behavioural model of multiple criteria group decision aiding in creating a multi-component product promoting the post-industrial cultural heritage of Czeladź Commune**

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# Presentation outline

- Motivation
- Goals
- Diversity of local post-industrial heritage
- Decision-aiding protocol
- Conclusions
- Future work

# Motivation (1/3)

- The **cultural tourism products (CTPs)** play crucial role in **PR, territorial marketing, and promotion** [Briedenhann and Wickens, 2004; Chiriko, 2020; Lord, 1999].
- **Expanding** the tourism **offer** is the effect of **creating** new **CTPs** [Bec et al., 2021].
- **Original** and **distinctive** offer of **CTPs, attracts** tourists from **outside the region** (not only the inhabitants themselves) [Smith et al., 2021].
- There is a need to **develop** attractive new **CTPs** based on **diverse cultural heritage**.
- **Building CTP** is a **complicated process**, because CTP is a **complex product**.

# Motivation (2/3)

- Many **studies** [Chang, Wey, and Tseng, 2009; Chou, Hsu, and Chen, 2008; Huang and Nguyen, 2022] present some **formal techniques** used to analyse cultural tourism planning and management problems, however they **were not adapted to the context**, they **did not** comprehensively **take into account elements** such as:
  - variety of **heritage**,
  - **categories** and **types** of **CTPs**,
  - multiplicity of involved **resources, entities**,
  - **behavioural aspects** of decision making:
    - cognitive **limitations**,
    - **different** information processing **styles**,
    - **different** ways of **preference declarations**,
  - different **objectives of stakeholders**.



# Motivation (3/3)

Thing (map,  
guidebook)

Service  
(tour,  
catering)

Set of  
services (trip,  
holidays)

Event (picnic,  
festival,  
concert)

Object  
(historic  
buildings)

Route  
(cultural  
trail)

Area (historical  
land, post-  
industrial area)

- **Seven categories** of **CTPs** can be components of complex CTP.
- **Creating** a multi-component **CTP** can be considered a **knapsack problem**.
- **Components** can be **organised** as follows:



**SIMPLE PRODUCT + ORGANISATION AND MANAGEMENT  
+ LOCATION**

second level of integration  
(object, route, area)

**SIMPLE PRODUCT + ORGANISATION AND MANAGEMENT**  
first level of integration

(set of services – tourist party, event)

**SIMPLE (BASIC) PRODUCT**  
(thing, service)



# Goals

- Using **methodological approach** which is aimed at **developing decision support tools** in **creating** complex **CTP** promoting the **post-industrial heritage** of two former hard coal mines: "Saturn" and "Czeladź".
- Taking into account **behavioural aspects** in **expressing** criteria and alternatives **preferences**.
- Finding the **best solution** to **knapsack problem** which is decomposed into **four subproblems**:
  - **each** is a **separate** multi-criteria **problem**,
  - **subproblems** concern building the ranking of **alternatives** in each group of **four components** (simple, virtual-multimedia, event, route).

# Diversity of local post-industrial heritage (1/2)

- **Numerous literature:**

- [Binek-Zajda, Lazar and Szaleniec, 2016]
- [Chmielewska et al., 2016]
- [Domaszewski, 2000]
- [Kurek, 2012]
- [Lazar and Binek-Zajda, 2015]

provide **information** on the **heritage** of **two** former **hard coal mines** ("Saturn" and "Czeladź").



# Diversity of local post-industrial heritage (2/2)

- **Examples of different types of heritage:**
  - historic **post-industrial buildings**,
  - historic **machinery** and equipment,
  - workers' patronage **estates**,
  - **houses** for white-collar workers, skilled workers, officials,
  - **villas** of coal mines directors,
  - mine **administration buildings**,
  - **social** buildings, **school** buildings, buildings for **cultural purposes**,
  - **recreational** areas, **parks**, **gardens**, sports **facilities**,
  - Neo-Romanesque parish **church**.





# Decision-aiding protocol

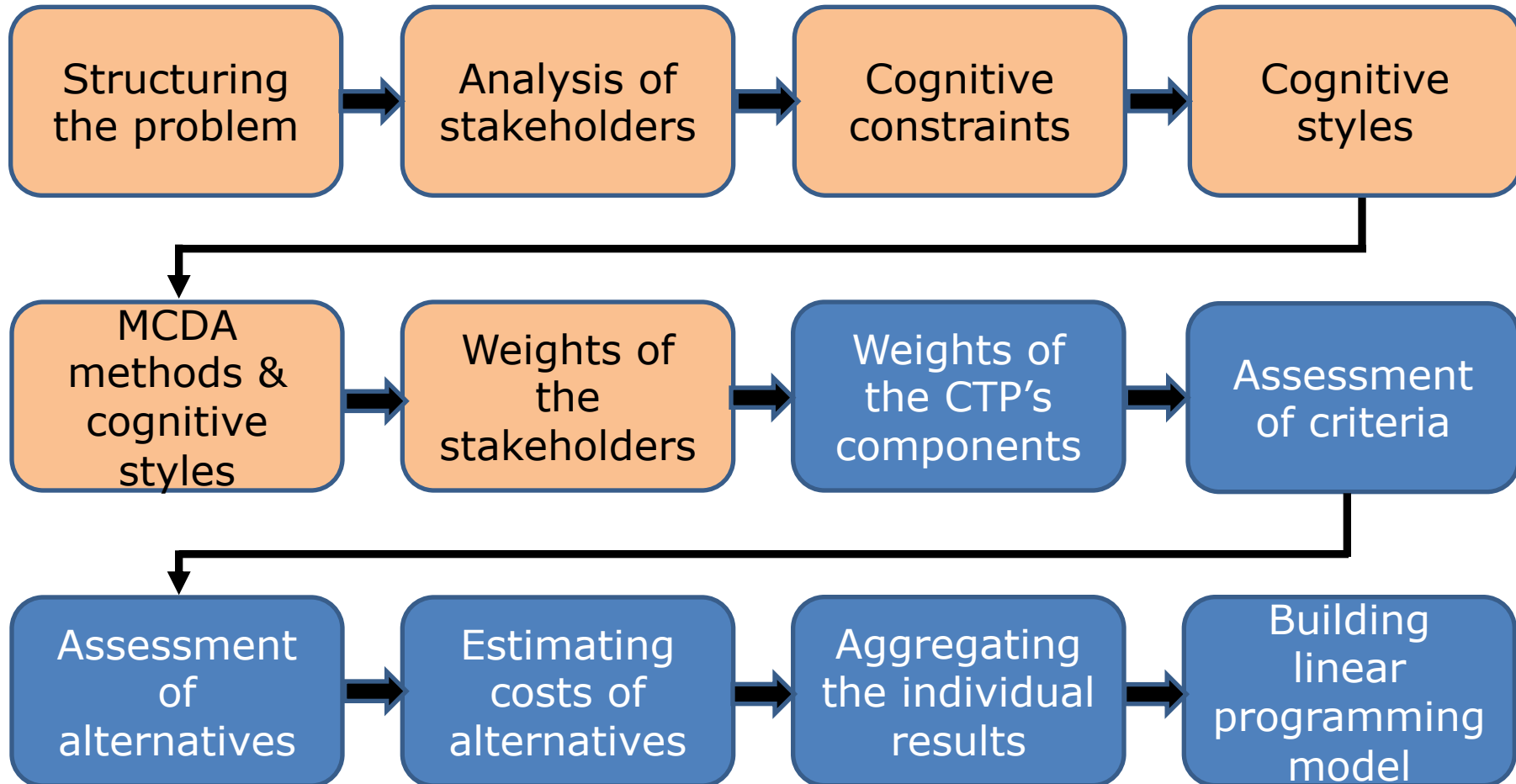
- The previously **presented aspects** and **premises** of building **complex CTP** require that a properly prepared **decision support protocol** should be used in the **creation of complex CTP**.
- **One** of the **intentions** of such a protocol is to **obtain individual results** from stakeholders (who are characterized by one of the three cognitive styles), and then to **aggregate those individual results** that were obtained after applying different MCDA methods.

# Decision-aiding protocol

- The **research** was divided into **two** main **parts**:
  - Part 1 – **theoretical analysis** and **survey**.
  - Part 2 – **workshop**.
- The first part has been carried out **currently**.
- The **second part** will rely on obtaining **information** from stakeholders **on**:
  - preferences of **component weights**,
  - preferences of **criteria**,
  - evaluation of **alternatives**,
  - evaluation of **estimated costs** of alternatives.
- **Workshop** part is **prepared** and **organised** now.
- The **whole research** is **structured** as follows:

# Decision-aiding protocol

## The main stages of the research model



# Decision-aiding protocol

## Structuring the problem

- **Defining the decision problem:** creating the best multi-component alternative of the CTP that holistically promotes local post-industrial heritage.
- **Defining the objectives** and evaluation **criteria.**
- **Creating alternatives** of **components** that will build a **complex CTP.**

# Decision-aiding protocol

## Structuring the problem

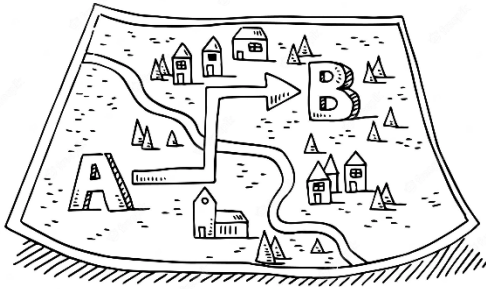
- The **analysis** of different **typologies** of **criteria** allowed for the **unification** and setting **seven criteria**:
  - $f_1$ : Innovation of the digital technologies use
  - $f_2$ : Socio-economic potential
  - $f_3$ : Uniqueness and originality
  - $f_4$ : Attractiveness and creating new experiences
  - $f_5$ : Complementarity of the tourist offer
  - $f_6$ : Educational value
  - $f_7$ : Promotional capabilities
- A set of **20 alternative components** of planned post-industrial CTP is researcher's proposal:



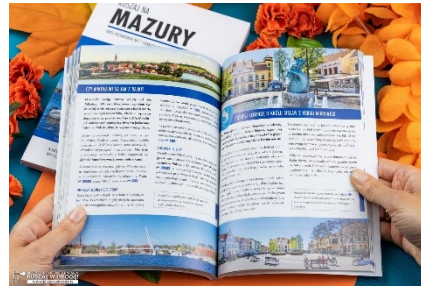
# Decision-aiding protocol

## Structuring the problem

**a<sup>1</sup>** "Map"



**a<sup>2</sup>** "BookGuide"



**a<sup>3</sup>** "Board Game – Industrialist"



**a<sup>4</sup>** "EduTour"



**a<sup>5</sup>** "Gadget"





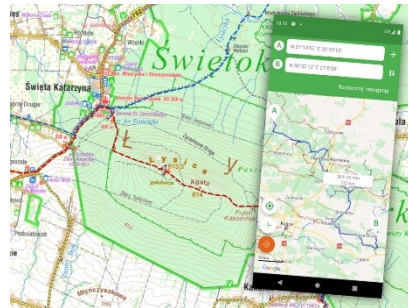
# Decision-aiding protocol

## Structuring the problem

a<sup>6</sup> "Net-Guide"



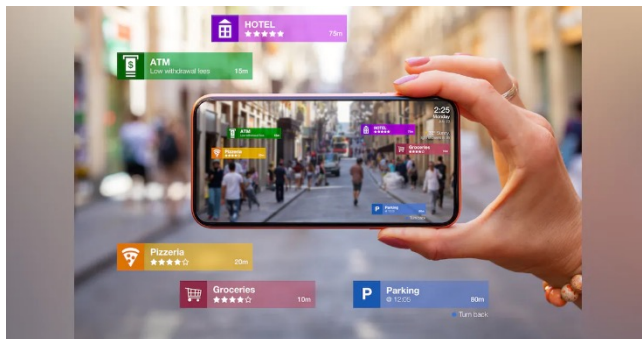
a<sup>7</sup> "Net-Route"



a<sup>8</sup> "Net-Walk"



a<sup>9</sup> "QR-AR"



a<sup>10</sup> "Net-Quest"



# Decision-aiding protocol

## Structuring the problem

**a<sup>11</sup>** "Picnic"



**a<sup>12</sup>** "Festival"



**a<sup>13</sup>** "Expo"



**a<sup>14</sup>** "Music"



**a<sup>15</sup>** "MediaShow"



# Decision-aiding protocol

## Structuring the problem

**a<sup>16</sup>** "Hybrid Route"



**a<sup>17</sup>** "Saturn Mine Quest"



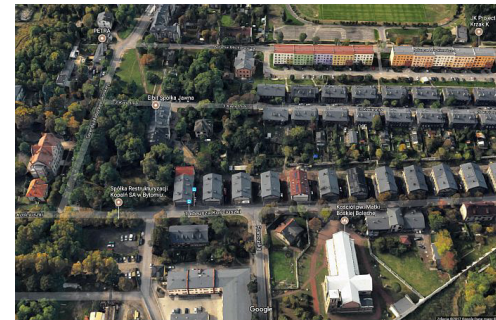
**a<sup>18</sup>** "Czeladź Mine Quest"



**a<sup>19</sup>** "Mining Industry Route"



**a<sup>20</sup>** "Real Heritage Route"



# Decision-aiding protocol

## Analysis of entities and creation of stakeholders set

- Stakeholders representing level of the **local government unit** (LGU) – Czeladź Commune.
- Stakeholders work in **entities** subordinate to the **LGU**.
- Stakeholders work in **municipal educational institutions** (related to history, culture, marketing or tourism).

# Decision-aiding protocol

## Identification of cognitive constraints of stakeholders

- **Stakeholders** have **different** cognitive **constraints**.
- **MCDA methods** may require **different skills** in expressing **preferences**.
- The **cognitive styles** of stakeholders can be **identified** using various **tests** (CSI, REI, CRT).
- **Stakeholders** with given **cognitive profiles** will prefer problem solving **procedures similar** to the **features** of their **cognitive style**.

# Decision-aiding protocol

## Identification of the cognitive styles of stakeholders

- **REI-20 test in Polish** was used to recognize cognitive styles.
- Test **questionnaire** was **available online**.
- **Results** allowed the stakeholders to be **assigned** the following **styles: analytical, intuitive and versatile**.

1. I try to avoid situations that require thinking in depth about something.

1 2 3 4 5  
I strongly disagree      I strongly agree

2. I am not that good at figuring out complicated problems.

1 2 3 4 5  
I strongly disagree      I strongly agree

3. I am not very good at solving problems that require careful thinking.

1 2 3 4 5  
I strongly disagree      I strongly agree

# Decision-aiding protocol

## Assigning MCDA method to stakeholders' cognitive style

- First issue – analysis of research [Roszkowska and Wachowicz, 2019a; Roszkowska, 2021] concerning the **connection** of cognitive **styles** with the **ways** of **expressing preferences**:
  - recommendation of **verbal** assessment for **versatile** style,
  - recommendation of **numerical** evaluations – **analytical** style,
  - recommendation of grading in a **graphical** way – **intuitive** style.

# Decision-aiding protocol

## Assigning MCDA method to stakeholders' cognitive style

- Second – analysis of research [Roszkowska, 2021; Roszkowska and Wachowicz, 2019b] concerning the **connection of cognitive styles with** the procedures of **MCDA methods**:
  - **analytical** style – **SMART**,
  - **intuitive** style – **TOPSIS**,
  - **versatile** style – **AHP**.



# Decision-aiding protocol

## Identification of the weights of the stakeholders

- Suggestions of **importance** (priority) of the **stakeholders** are as follows:
  - Stakeholders representing **Municipal Office in Czeladź** (direct decision-makers) **and** the managers in the **"Saturn" Museum – the highest priority.**
  - Stakeholders representing **marketing and promotion departments of Municipal Office in Czeladź and of "Saturn" Museum – high priority.**
  - Stakeholders representing **Municipal Sports and Recreation Centre – average priority.**
  - Stakeholders who work as **history, culture or tourism teachers – low priority.**
  - Stakeholders who are **directors in municipal schools – the lowest priority.**



# Decision-aiding protocol

## Identification of the weights of the stakeholders

- Proposals for giving **importance** (priority) to the **stakeholders** are:
  - **the highest** priority → **100%**
  - **high** priority → **80%**
  - **average** priority → **60%**
  - **low** priority → **40%**
  - **the lowest** priority → **20%**

# Decision-aiding protocol

## Identification of the weights of the main components of a complex CTP

- Giving **importance** (priority) to the **four** main **components**:
  - product-simple,
  - product in virtual-multimedia mode,
  - product-event,
  - product-route

will run in **accordance** with the **weighting procedure** in a **given MCDA method**.

# Decision-aiding protocol

## Assessment of significance of decision criteria

- First step – stakeholders will **select five criteria** out of **seven unified criteria** (e.g.):
  - $f_1$ : Innovation of the digital technologies use
  - $f_2$ : Socio-economic potential
  - $f_4$ : Attractiveness and creating new experiences
  - $f_6$ : Educational value
  - $f_7$ : Promotional capabilities



# Decision-aiding protocol

## Assessment of significance of decision criteria

- Second step – the stakeholders will assess the **priorities** of the **criteria** using three MCDA methods:
  - **SMART** – **ratings** from **0** to **100**,
  - **AHP** – **verbal ratings** from the **Saaty scale**,
  - **TOPSIS** – **evaluating** with the use of **graphic elements**.

# Decision-aiding protocol

## Assessment of the CTP components alternatives

- **Assessment** of components will be carried out **in accordance** with the **procedure** and **some recommendations** of each of the **three MCDA methods**:
  - AHP – verbal assessment.
  - SMART – numerical assessment.
  - TOPSIS – graphical assessment.

# Decision-aiding protocol

## Estimating the cost of a given alternative

- **Costs** will be **estimated** by **stakeholders**.

Alternatives	Estimated cost (in PLN)	Alternatives	Estimated cost (in PLN)
"Map" (1000 pcs)	5000	"Picnic"	3000
"BookGuide" (500 pcs)	10000	"Festival"	7000
"BoardGame" (200 pcs)	7000	"Expo"	3500
"EduTour"	2000	"Music"	8000
"Gadget" (200 pcs)	5000	"MediaShow"	10000
"Net-Guide"	3000	"Hybrid Route"	8000
"Net-Route"	4000	"Saturn Mine Quest"	4000
"Net-Walk"	4000	"Czeladź Mine Quest"	3000
"QR-AR"	3000	"Mining Industry Route"	5000
"Net-Quest"	3000	"Real Heritage Route"	7000

30



# Decision-aiding protocol

## Aggregating results of MCDA methods

- **AHP results** are expressed in **ratio scale**.
- **SMART** and **TOPSIS results** are expressed in **interval scale**.
- **Normalization** of individual **AHP results** (expressed in ratio scale) to **interval scale**.
- The **issue** of **choosing** the **method** of **aggregation** of results, e.g. arithmetic mean, geometric mean, minimum cost consensus model, **remains** to be **solved**.





- The **results** of using each of the MCDA methods **will be double-weighted**:
  - FIRST - in terms of **weights** of the main **CTP components**:

<u>Alternatives</u>	AHP	SMART	TOPSIS	<u>What method of aggregation?</u>
a <sup>1</sup>	0,03	0,08	0,07	0,06
a <sup>2</sup>	0,10	0,13	0,09	0,10
a <sup>3</sup>	0,08	0,04	0,11	0,08
a <sup>4</sup>	0,05	0,07	0,04	0,05
a <sup>5</sup>	0,02	0,05	0,04	0,04
a <sup>6</sup>	0,01	0,01	0,00	0,01
a <sup>7</sup>	0,02	0,04	0,03	0,03
a <sup>8</sup>	0,03	0,05	0,05	0,04
a <sup>9</sup>	0,06	0,04	0,06	0,05
a <sup>10</sup>	0,04	0,05	0,04	0,04
a <sup>11</sup>	0,09	0,20	0,20	0,16
a <sup>12</sup>	0,34	0,43	0,42	0,40
a <sup>13</sup>	0,13	0,11	0,09	0,11
a <sup>14</sup>	0,05	0,19	0,14	0,13
a <sup>15</sup>	0,32	0,33	0,33	0,33
a <sup>16</sup>	0,15	0,22	0,23	0,20
a <sup>17</sup>	0,24	0,22	0,22	0,23
a <sup>18</sup>	0,03	0,08	0,02	0,04
a <sup>19</sup>	0,03	0,11	0,08	0,08
a <sup>20</sup>	0,10	0,22	0,10	0,14

- The **results** of using each of the MCDA methods **will be double-weighted**:
  - SECOND – in terms of **weights** set for **stakeholders**:

<u>Alternatives</u>	AHP	SMART	TOPSIS	What method of aggregation?
a <sup>1</sup>	0,02	0,05	0,07	0,05
a <sup>2</sup>	0,08	0,08	0,09	0,08
a <sup>3</sup>	0,06	0,03	0,11	0,07
a <sup>4</sup>	0,04	0,04	0,04	0,04
a <sup>5</sup>	0,02	0,03	0,04	0,03
a <sup>6</sup>	0,01	0,01	0,00	0,01
a <sup>7</sup>	0,02	0,02	0,03	0,03
a <sup>8</sup>	0,03	0,03	0,05	0,03
a <sup>9</sup>	0,05	0,02	0,06	0,04
a <sup>10</sup>	0,04	0,03	0,04	0,03
a <sup>11</sup>	0,07	0,12	0,20	0,13
a <sup>12</sup>	0,27	0,26	0,42	0,32
a <sup>13</sup>	0,10	0,07	0,09	0,09
a <sup>14</sup>	0,04	0,11	0,14	0,10
a <sup>15</sup>	0,26	0,20	0,33	0,26
a <sup>16</sup>	0,12	0,13	0,23	0,16
a <sup>17</sup>	0,19	0,13	0,22	0,18
a <sup>18</sup>	0,03	0,05	0,02	0,03
a <sup>19</sup>	0,03	0,07	0,08	0,06
a <sup>20</sup>	0,08	0,13	0,10	0,10

# Decision-aiding protocol

Building linear programming model to solve the knapsack problem for complex CTP

- **General assumptions** of the **knapsack problem** model [Puchinger et al., 2010]:
  - set of  **$n$  items**:  $I_j = \{I_1, I_2, \dots, I_n\}$  ( $j=1, \dots, n$ ),
  - assigned to each item  $I_j$  certain **quantity  $w_j$**  and certain **value  $c_j$**  ( $j=1, \dots, n$ ),
  - **maximum knapsack weight** (capacity)  **$W$** .

We need to find  $q_1, q_2, \dots, q_n$  such that:

$$\max[c_1q_1 + c_2q_2 \dots + c_nq_n]$$

$$w_1q_1 + w_2q_2 \dots + w_nq_n \leq W$$

# Decision-aiding protocol

**Building linear programming model to solve the knapsack problem for complex CTP**

- **LP model** for complex **CTP** promoting post-industrial heritage:
  - set of **20 alternatives**:  $A = \{a_1, a_2, \dots, a_{20}\}$
  - assigned to each alternative  $A$  certain **cost**  $w_j$  and certain **aggregated results** (evaluation of alternatives)  $c_j$  ( $j=1, \dots, 20$ ),
  - **maximum cost** of CTP knapsack  $W$ ,
  - alternatives  $A$  are denoted as variables  $x_n$ .

**We need to find  $x_1, x_2, \dots, x_{20}$  such that:**

# Decision-aiding protocol

## Building linear programming model to solve the knapsack problem for complex CTP

$$\max[0,05x_1+0,08x_2+0,07x_3+0,04x_4+0,03x_5+0,01x_6+0,03x_7+0,03x_8+0,04x_9+0,03x_{10}+0,13x_{11}+0,32x_{12}+0,09x_{13}+0,10x_{14}+0,26x_{15}+0,16x_{16}+0,18x_{17}+0,03x_{18}+0,06x_{19}+0,10x_{20}]$$

$$5000x_1+10000x_2+7000x_3+2000x_4+5000x_5+3000x_6+4000x_7+4000x_8+3000x_9+3000x_{10}+3000x_{11}+7000x_{12}+3500x_{13}+8000x_{14}+10000x_{15}+8000x_{16}+4000x_{17}+3000x_{18}+5000x_{19}+7000x_{20} \leq 50000$$

$$x_5 + x_6 \leq 1$$

$$x_{16} + x_{19} + x_{20} = 1$$

$$x_{17} + x_{18} \geq 1$$

...

$$x_n \in \{0,1\}$$

# Conclusions (1/2)

- The use of **author's** methodological **approach** allows to:
  - drawing attention to the **importance** of **behavioural factors** in decision making,
  - the best **matching** of decision support **tools** to the **cognitive styles**,
  - obtaining **individual results** - the use of various MCDA methods – which will reflect the **criteria preferences** and **alternatives assessments as best as possible**.
- Thanks to the use of **knapsack problem**, it is possible to calculate the set of **elements** that will **create** the best **CTP** in terms of:
  - **cost limitations**,
  - **importance** (priorities) of the given **alternative components**.



# Conclusions (2/2)

- **There are issues to be resolved such as:**
  - which **aggregation tools** for the results from three MCDA methods **should** be **applied**?
  - **consensual** concept (reciprocity = equal concessions) **should** be **used**?
  - whether the **synergistic effects** between the **components** that are to build a complex CTP **should not be taken** into account?

# Future work

- **In the 2nd part of the research** – workshop with stakeholders – the following activities will be carried out:
  - giving **importance** (priority) to the **four** main **components** (simple, virtual-multimedia, event, route),
  - selection a **maximum** of **five** subjectively most important **criteria** from the list of unified criteria and possibly own suggestions added to them,
  - assigning **importance** to the selected **five criteria evaluating** the alternative **components** of the planned CTP,
  - **assessment** of alternative **components** of the planned, complex CTP in terms of established criteria,
  - **estimating** the manufacturing **costs** of a given alternative **component**.





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# Thank you for attention

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