Year 1

Two major tasks were carried out in the project's first year: reviewing the state-of-the-art international literature and developing the theoretical model. The extensive literature overview has resulted from four MSc theses [1], [2], [3], [4].

Based on the research group's previous experience in the field and the state-of-the-art solutions, we held monthly team meetings to enhance the distribution of common knowledge. The research group tested the prior hypothesis that in the cost-benefit analysis, the most sensitive parameter is the value of travel time [5]. Different hypothetical scenarios were created for transport projects (e.g., road reconstruction, new road development, railway reconstruction, new railway line development, and urban public transport development). For evaluation purposes, a unified cost-benefit analysis framework was established to estimate the impact of various travel times. A series of Monte Carlo simulations were run based on the sample projects.

The research group created a stated preference experiment and revealed that preference data is unavailable in Hungary.

Year 2

In the project's second year, three main tasks were planned: compiling the questionnaire, completing the test survey, and procuring and launching the final survey. Due to the unseen economic restrictions in the hosting institute, only the questionnaire was finalised and completed, but the survey was launched and failed. A correct survey design is necessary, which requires considerable effort from the research team. Therefore, a self-learning and adaptive form has been designed and coded into a Python environment. The novelty of the questioner is under review [6]. The first step was the statistical design of the survey. We needed to define the type of experiment, the choice set and the analysed attributes. The second step was the factorial design of the SP experiment. During this step, we designed the possible scenarios, created the choice set and determined the presented scenarios by eliminating the trivial choice or adding some contextual constraints. These decisions are made based not only on theoretical reasoning but also on feasibility. We had to consider the length of the survey, the available funds and the sample size. In the end, we needed to set the attributes and attribute levels. In the current stage, the first version of the SP survey is ready to test.

Year 3

In the project's third year, the main tasks were to collect the case study data and analyse the collected data.

We run a pilot (2023Q1) survey with a small number of participants (around 200) to calibrate the parameters mentioned above and find any survey design flaws. After analysing the pilot survey data, we can make the necessary changes to the final survey. The final survey started to run (2023Q3).

Analysis of the collected data is important for both research questions RQ2 (*Which parametrical distribution describes heterogeneity in VoTTS the best? Can we replace point estimates first with parametrical distributions, and then potentially with non-parametric ones?*) [7] and RQ3 (*In a public transport context, can we disentangle heterogeneity in VoTTS from the impact of varying degrees of crowding during data collection*) [8]. The already developed theoretical models were calibrated and validated based on these data. The first step was a thorough data cleaning process and a run of statistical tests and assessments to determine the validity of the data. Additional responses were collected on a need-to-do basis as we found it possible to investigate the newly introduced ticket system.

Related to research question RQ4 (*With updated user preferences, accounting for heterogeneity, what deviations should we expect in project appraisal, using the Hungarian CBA methodology?*), another data collection started this year [9]. Based on the research group's previous work in cost-benefit analyses, case studies were selected, and their related CBAs were collected. Based on the available literature, the best way to deal with such an ex-post evaluation will be determined, and a common framework will be formulated.

Year 4

On the data set collected in this research project, we estimated the parameters of travellers utility functions using different logit models (multinomial logit model and mixed logit models with various configurations). We included four main variables in the passenger's utility functions: the monetary price of the trip, the travel time, the number of transfers along the route, and the level of crowding experienced during the trip. We also controlled for the respondents' gender, age, and household income. All parameters have the expected signs, and the estimated values of travel time from the different models are in the same range as found in the literature. Based on different models, we estimated the value of travel time to be 4.32 - 13.36 €/h.

The final year of this research is devoted to the practical applicability of the project results as the main tasks are to carry out ex-post evaluation based on case studies, provide suggestions for policymakers and contribute to the current CBA methods [9].

A series of ex-post evaluations related to RQ4 were conducted (With updated user preferences, accounting for heterogeneity, what deviations should we expect in project appraisal using the Hungarian CBA methodology?). These assessments will provide a solid basis for the research and technical community about the robustness of the CBA results [10].

The last research question, RQ5 (Using empirical estimates of preference heterogeneity, what overarching conclusions can be derived from *the social and political attractiveness of policies?*), is related to an overarching conclusion. We developed an extension of the current CBA practice, which can be applicable in Hungary and worldwide. Based on the state-of-the-art, we created a model which predicts some social effects (i.e.: crowding).

To investigate the effect of crowding, we estimated pairs of utility functions: one did not include crowding in the utility function, while the other did. This allowed us to test how the value of travel time differs when crowding is not included in the utility function. The results confirm our hypothesis that if we do not control for the heterogeneity of conditions, such as crowding, it can be confounded with the heterogeneity of preferences. In other words, if we do not include crowding in our models, we will overestimate the value of travel, which can have far-reaching consequences, e.g. in the evaluation of transportation projects [11], [12].

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