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THE USE OF CONJOINT METHOD FOR ASSESSING THE RELEVANCE OF RAILWAY INVESTMENTS

Summary. The article deals with designing and testing the use of conjoint analysis method, as one of the tool that provides information gathered within carrying out the ex-ante evaluation of railway infrastructure investments. The authors point to a possible area of application of the method and its usefulness for policy-makers. The proposed method has been tested in empirical research, and the results confirmed the usefulness of the data that can be obtained through its use. Originality of undertaken subject arises from the fact that conjoint method has not been used as a component of ex ante evaluations of EU co-funded programmes, which focus on the railway sector investments. The use of the method may help to strengthen the synergy effects between planned to realize within broader programmes investments. The issue has important practical dimension resulting from intensified investments in the railway sector in the countries which benefit from EU cohesion policy's funds.

ZASTOSOWANIE METODY CONJOINT DO ANALIZY TRAFNOŚCI INWESTYCJI KOLEJOWYCH

Streszczenie. Artykuł koncentruje się na kwestiach związanych z projektowaniem i przetestowaniem metody conjoint w ramach ewaluacji ex ante projektów inwestycyjnych z zakresu infrastruktury kolejowej. Autorzy wskazują obszar zastosowania metody i jej przydatności dla decydentów. Proponowana metoda została przetestowana w badaniach empirycznych, a wyniki potwierdziły przydatność danych, które można uzyskać przez jej stosowanie. Oryginalność podjętego tematu wynika z faktu, że metoda conjoint nie została wykorzystana jako element oceny ex ante programów współfinansowanych ze środków unijnych w sektorze kolejowym. Wykorzystanie tej metody może się przyczynić do zwiększenia synergii planowanych w ramach programów operacyjnych inwestycji. Kwestia ta ma istotny wymiar praktyczny wynikający z intensywnych inwestycji w sektorze kolejowym w krajach, które korzystają ze środków unijnej polityki spójności.

1. INTRODUCTION

The development and upgrading of the transport infrastructure is an inherent part of strategic development plans in most countries [1]. In its 2007-2013 budget, the European Union allocated EUR 76 billion to this objective alone (and only as part of the ERDF). Railway plays a special role among the means of transport; it is safe and environmentally friendly, and generates low external costs in addressing transport needs. The literature on railway transport investments point the macroeconomic as well as less scaled important impacts these investments procure [2]. In the context of falling passenger figures and significant funds (mostly from the EU budget) spent on railway investments in countries with lower than average GDP levels, the question of the relevance and effectiveness of decisions concerning investments in rail infrastructure becomes more pertinent than ever.

In planning phase in railway investments programs, policy makers must face strategic problems, which concern the construction, and/or modification of existing infrastructure [3]. As the results of the evaluation studies conducted in Poland demonstrate, even minor changes in the scope of investments in the transport infrastructure can be of fundamental significance for improving the quality of such investments, reinforcing their results and increasing the relevance of the funds allocated to this particular sector [4, 5]. For this reason, the ex ante evaluation is so crucial at this stage since, in addition to the usual questions involving the appraisal of the financial profitability of the planned investments and their impact on socio-economic development, it can provide policy makers with data concerning the preferences of the final beneficiaries of the investments in question, that is, railway passengers.

'Relevance' is one of the evaluation criteria recommended for analysis at the stage of planning EU co-funded projects and programmes [6]. The relevance of railway investments handling passenger traffic, which can be defined as satisfying the needs of its final users, should become a priority for the policy makers responsible for the implementation of publicly funded programmes and projects. An in-depth analysis of the preferences of railway users at the stage of the ex ante evaluation (in relation to both individual programmes and projects) should help make informed decisions regarding the scope and sequence of planned railway investments, and therefore should lead to greater satisfaction and increased numbers of passengers using such modernised railways. In addition to considerable benefits associated with collecting information on the preferences of the final users of the infrastructure to be developed, planning a conjoint study as a component of the ex ante evaluation also allows estimating the synergy effects between the individual types of the planned interventions. It can also provide data on activities related to the daily management of railway services so as to ensure that they are best customised to the analysed passenger preferences.

In view of the above, the purpose set by the authors of this paper was to design a survey of the preferences of railway transport users using the conjoint analysis method, also known in the literature and research practice as a State Preference method, as part of the analyses complementing the relevance research at the stage of the ex ante evaluation. The method has many practical applications, mainly in marketing research. It is one of the so-called decomposition methods, which are typically associated with data obtained by mutual comparisons of various objects. Even though, the conjoint analysis techniques are being used for evaluation of particular transport infrastructure projects in many EU countries (for example [7, 8], also some unpublished feasibility studies in Poland), it has not as yet been used in evaluations of entire programmes co-financed from EU funds, which aim at railway sector interventions. This is all the more important giving the fact that the use of this particular method may help to strengthen the synergy effects between planned to realize within broader programmes investments. The paper has several parts. In the first part, the authors outline the context for using the conjoint method to look at the preferences of railway transport infrastructure users and propose a methodology for using such a method as a component of the ex ante evaluation of the planned investments. The main part of the paper discusses the practical applications of this method, using as examples the surveys conducted in Poland[1]. The final part indicates the advantages and limitations of this method in the ex ante evaluation of railway infrastructure programmes, as a tool for collecting data to be used by policy makers.

2. OVERVIEW OF THE CONJOINT METHOD ANALYSIS IN RAIL INFRASTRUCTURE INVESTMENTS

This method permits to measure the preferences of the final users of a given service/commodity and investigate the similarities and differences existing between alternative options of choice [9]. Conjoint analysis is one of the so-called decomposition methods, usually involving data obtained from the comparison of individual objects. The method consists in decomposing the total utility of a commodity into so-called part utilities (or part worths), resulting from specific attributes. This allows to collect information on the most desirable configuration of attributes that a given commodity/service should have, as seen from the perspective of its users [10-13]. The data collected with this method are analysed using statistical methods to ensure that the results obtained will be objective.

There are two main types of models to describe the interdependence between the total utility and part utilities: the additive model (main-effects model) and the interactive-type model (interaction-effect model). The decision on the choice of one of these two models determines the way in which the variables are interrelated, from the perspective of the respondent evaluating the profile characterised by these variables. The additive model implies a smaller number of profiles to be evaluated than the model taking into account the interactions between the variables, and guarantees that part worths' estimates will be easier to obtain [14].

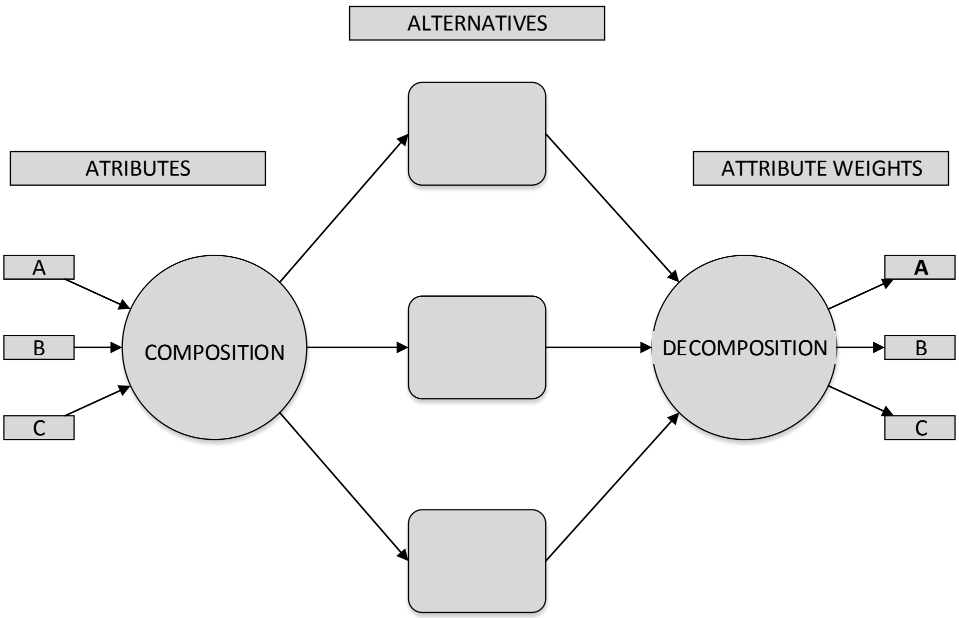

Fig. 1. Diagram of the choice-based conjoint as a decomposition method (Source: [13, pp. 9])
Rys. 1. Schemat choice-based conjoint (wyboru najbardziej preferowanej opcji) jako metody dekompozycyjnej (Źródło: [13, pp. 9])

The first step in planning a conjoint analysis is to identify the variables (attributes) to be included, and the values (levels) of factors, which will be evaluated by the respondents. This is associated with the mathematical formula for the utility function, expressing the researcher's hypothesis on the

[1] The survey was conducted within research project „Nowoczesne metody pomiaru oddziaływania inwestycji infrastrukturalnych i taborowych w transporcie" ("Modern methods of measuring the impact of investments in infrastructure and rolling stock in transport sector") financed by the Ministry of Regional Development, Department of Structural Policy Coordination, under Operational Programme Technical Assistance 2007-2013.

combinations of part worths selected by the respondents, which together are summed up into an overall evaluation of a given alternative. The total utility can be expressed using the following formula [16]:

$$U = \alpha_1 x_1 + \alpha_2 x_2 + ... + \alpha_n x_n \quad (1)$$

where: U = total utility, x_1 to x_n = values of attributes 1 to n, α_1 to α_n = utility weights for attributes 1 to n.

The number of attributes which are evaluated in different configurations should be limited so as not to make the choice of specific options too cumbersome for the respondents. Green and Srinivasan [17] suggested about six as the maximum number of attributes to handle full-profile concepts in traditional conjoint analysis.

In conjoint analysis, the choice options may be shown to the respondents in a variety of ways, e.g. using the full-profile approach, which comprises the set of all possible profiles being combinations of attributes and their levels, with the use of the pairwise comparison method or the experimental choice approach) – here sets of profiles are created (with each set including two or more profiles), and the respondents are requested to choose the most preferred profile for a given set [18].

Currently, research using the conjoint method is conducted with the use of special simulators, although they could also be designed, applying standard statistical software such as SPSS or Statistica. Advantages of such specialised software include, amongst others, automatic data analysis (with the analysis based on the algorithms integrated with the system), functionality allowing the use of design methods, as well as tools for clear presentation of results (e.g. charts showing the utilities of all the attributes and their levels, or relative relevance of specific attributes in the process of selecting specific alternatives).

A conjoint analysis using specialised software needs to be conducted with the use of CAPI[2] (or CASI[3], provided the pollster is present). Contrary to popular belief, this is a relatively inexpensive and efficient method for analyses involving train passengers for whom taking part in the survey can be a pleasant addition to the journey [see 19].

The theory and applications of the conjoint method (or based on the same methodological assumptions: the Stated Preference method, functional measurement, trade-off analysis)[4] in the transport sector have been described by Hensher and other authors [20-24], although for this paper Conjoint method has been used, because of its better availability, as it is widely used for market research in many sectors. Kroes and Sheldon [16] point to wide applications of this method in the railway sector surveys, particularly with respect to such areas as the evaluation of passengers' preferences for the development of various characteristics of public transport system, demand analysis and forecasting (conducting planning studies for government bodies). Some examples here include the studies conducted in Denmark [25], Sweden [26, 15] or United Kingdom [27]. According to Kottenhoff [19], various conjoint-based studies were commissioned by railway management companies (e.g. BR, DSB and NS). Until now, however, this method has not been used as a component of ex ante evaluations in the railway sector.

3. USING THE CONJOINT METHOD IN EX ANTE EVALUATIONS IN THE RAILWAY SECTOR

Investments in the rail infrastructure can be broadly divided into three categories: modernisation of the rolling stock, and of linear and punctual infrastructure (railway stations and terminals). As the Polish practice shows, not all such investments are being carried out concurrently; in many cases the purchase of rolling stock is not accompanied by modernising the railway track or stations situated along a given route. Earlier evaluation studies suggest that it is necessary to ensure complementarity

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[2] Computer Assisted Personal Interviewing.

[3] Computer-Assisted Self Interviewing.

[4] Kroes and Sheldon emphasise that despite the differences in the names, all these methods 'refer to a single general approach which uses experimental design procedures to generate transport options for appraisal by respondent' [10, pp. 11].

allowing for synergy effects between these types of investments to take place. This is particularly true for train and infrastructure investments reducing travel times. This is due to two specific issues: firstly, reaching speeds over 120 km/h typically requires a modernised railway track serviced by modern trains (investment in the rolling stock or in the railway track alone mean that reaching faster speeds is limited or hampered by the inferior technical conditions of one of these components). Secondly, lack of complementarity between these types of investments hampers the propensity of railway users to choose this particular means of transport, since passengers tend to assess a service on the basis of its lowest partial quality [4, 5]. In order to ensure an optimum relevance of the investment, i.e. fulfil the basic criterion examined in an ex ante evaluation, modernisation of the railway infrastructure should also be accompanied by decisions relating to services being offered via the line which is the object of the intervention, as these factors all add up to determine the quality of the final service [22, 26].

The authors of this paper decided to design the research using the conjoint method, which could be used for broader ex ante evaluation studies in the railway sector. Research makes it possible to define the preferences of railway users in the context of planned investments in the rolling stock, tracks and railway station infrastructure. The obtained data can also be used by evaluators, who assess the planned investment for modelling the different scopes of intervention. In this way, they can acquire information on the impact of specific activities on decisions of individuals associated with choosing this means of transport.[5] The sequence of research activities which should be observed while conducting an ex ante evaluation with the use of the conjoint method are:

1. Designing and conducting research aimed to define user profiles (analysing such issues as: frequency of train travels, purpose of travel), assessment of satisfaction with offered services, availability and intention/possibility to use alternative means of transport on three railway routes;
2. Designing and conducting research on railway user preferences using the conjoint method. Research conducted as part of ex ante evaluation may cover e.g. preferences between rail services differing in specific parameters (reflecting the options considered while designing investment in railway sector) (CONJOINT 1), preferences between using different means of transport (CONJOINT 2);
3. Modelling of the impact of specific activities aimed to improve the quality of railway services on their evaluation by potential users and analysing the synergy effect, understood as added value for users, generated by simultaneous implementation of investments in trains and in rail infrastructure.

The first step in the organisation of such research should be to collect information about the profiles of final railway users and the current level of services offered on selected routes. The selection of routes should be purposeful: the routes should be comparable (e.g. service connections with a similar length or functionality – daily commuting to work in an urban agglomeration, etc.) and should take into account the condition of the rolling stock and the railway line in four configurations presented below[6]. Such a selection is aimed to include both preferences declared by passengers who already use higher-quality services and those who normally do not, into the modelling process.

As a next step, conjoint models need to be prepared. The attributes taken into account while designing the conjoint models should be selected using the data collected during the first stage of the research; in such an approach, the models will comprise options that have strong links with the actual situation 'on the ground'. At the designing stage, the software should also be selected to enable conducting interviews with the use of the conjoint module. Owing to a considerable variety of the available conjoint simulators and the solutions that they propose, the scope of the planned research should be considered beforehand. The authors find that CBC software is one that is most respondent-friendly [see 21].[7]

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[5] How the collected material can used will be shown on a sample research conducted with the use of the conjoint in the further part of the paper.

[6] The surveys may naturally be conducted even on two comparable routes which are differentiated by the modernisation of the rolling stock and of the rail line. However, a survey including the four above situations will provide the fullest possible material for later analyses.

[7] Unlike the Adaptive Based Conjoint (ACA) model, based on ranking or scoring of the best scenarios from the respondent's perspective, the CBC method is based on a simple choice of one of the proposed scenarios.

In the proposed research model (cf. Fig. 2), the actual research is designed and carried out using two conjoint models. One includes attributes that together make up the quality of the transport services associated with the infrastructure that can be built under the planned investment. One additional goal will be to determine the price flexibility of railway clients using selected routes. Conjoint model 1 proposed by the authors uses the following attributes[8]: (i) travel price (several price levels), (ii) condition of the rolling stock (new train / old train), (iii) conditions of stations/terminals (old station/ new station), (iv) travel time (several travel time levels).

As mentioned above, conjoint models allow for adding projection techniques to the scenarios suggested to respondents. In the proposed research, the attributes ‘condition of the rolling stock’ and ‘condition of stations/terminals’ can be illustrated with photographs. The figure below shows an example of a screenshot to be shown to respondents – in case of subjective qualities, condition of the rolling stock and condition of stations/terminals, both picture and description (as above) have been provided for better understanding.[9]

Fig. 2. Sample screenshot of a conjoint interview about choosing between railway services (attributes as mentioned above)
Rys. 2. Przykładowy ekran wywiadu conjoint, dotyczącego wyboru pomiędzy usługami kolejowymi (atrybuty jak wskazane powyżej)

In designing conjoint models, special attention should be placed on precluding the possibility to pair up certain attributes. The aim is to restrict situations in which respondents can choose options which are overly desirable or overly undesirable; precluding certain choices helps eliminate a situation where one of the options is e.g. minimum price for the travel with optimum travel quality permitted by the programme (new train, new station) or travel with the lowest standard and highest price ticket.

In the proposed version of the research, the second designed conjoint model is aimed to determine whether various means of transport are mutually complementary. In this particular approach, we

[8] The base CBC system permits a maximum of ten attributes with at most 15 levels per attribute.
[9] As we used Polish version of conjoint simulator the words on screenshot are in Polish.

assumed that at least three attributes should be considered: (i) type of transport (train/bus/car), (ii) travelling time (several travel time levels), (iii) travel cost (several travel cost levels).

The results of a conjoint study may be presented in a variety of ways, although the analysis of utilities alone, i.e. results of the hierarchical Bayesian analysis, integrated with the CBS system using the data collected during the research. It allows obtaining the utilities for all the attributes/variants; regardless of the blocked possibilities to connect the attributes, at the end of the day every respondent taking part in a study with a conjoint module may be ascribed utility scores for all the attributes and levels.

Utilities from the conjoint study may be interpreted as measures of the preference every respondent has for a given scenario. The sum of utilities within one attribute is always zero for the entire surveyed population. This enables a simple interpretation of the result obtained: a negative result means that a given scenario is not popular with a given group of respondents, whilst a positive result suggests that the scenario presents a desirable situation. Conjoint simulators facilitate recalculating utility scores from part-worths for the individual attributes and their levels. Those simulators are constructed on the basis of utilities gathered during the study and our final simulator took the form of simple excel spreadsheet.

Finally, it should be observed that using the conjoint method in a study which is a component of the ex ante evaluation for planned railway sector interventions makes it possible to design a model of choices made by the passengers (of railways or a different means of transport) depending on the parameters of specific services; in this way, the impact of the infrastructure's modernisation as such can be modelled, so as the purchase of the rolling stock itself (i.e. implementation of 'every project separately') and the simultaneous implementation of both projects 'over the same area and for the same stakeholders'. This will help define the scale of the synergy effect and thereby provide policy makers with information on the significance of ensuring complementarity between these types of investments.

4. CONJOINT METHOD IN PRACTICE: RESULTS OF EMPIRICAL RESEARCH

The research model described above has been tested in practice: on three comparable routes, serviced with passenger trains and used for daily commuting to large agglomerations, e.g. from former regional capitals, viz.:

- Warsaw – Siedlce – line modernised to handle speeds up to 160 km/h with co-financing from the Cohesion Fund, mostly serviced using new rolling stock (Stadler Flirt), purchased from domestic (national) funds, later partly reimbursed (37 per cent) as part of additional SPOT purchases;
- Poznan – Konin – line modernised to handle speeds up to 160 km/h, with co-financing from the Cohesion Fund, serviced using old rolling stock (EN-57);[10]
- Cracow – Tarnów – unmodernised line (intended for modernisation up to the speed of 160 km/h in the 2007-2013 Financing Perspective, as part of the Infrastructure and Environment Operational Programme), serviced using traditional rolling stock (EN-57).

The number of conducted interviews is shown in Table 1.

The interviews were composed of three parts:

- general CAPI interview: aimed to define an overall profile of the respondents and provide a simple assessment of the quality of services that they use – the questions were identical for all respondents; allowed for the segmenting of travelers and determining real parameter values which are used in generating data for conjoint interviews;
- interview using conjoint module 1: related to choosing between railway services differing in such parameters as: price for the trip; travel time; modernised or unmodernised rolling stock; modernised or unmodernised stations;

[10] Initially, this type of route was not intended to be included in the research, but it was added in view of the fact that situations, in which trains which cannot use in full their technical parameters run on modernised lines, are quite common.

- interview using conjoint module 2: related to choosing between different means of transport: train, bus/van and car. For this model, also the time and cost of travel were examined.

Table 1

Size of the research sample[11]

	Scope of interview: Only preliminary part	Scope of interview: Full (incl. conjoint)	Total
Route 1: Cracow-Tarnów	189	214	403
Route 2: Poznan-Konin	193	176	369
Route 3: Warsaw-Siedlce	253	130	383
Total	635	520	1155

4.1. Results of general interview

Results of the first stage of research helped identify passenger profiles, define their practices concerning railway travel and learn how they evaluate selected attributes of the services that they use.[12] The general interview also enabled respondents to evaluate selected attributes of railway services provided to them and set the foundations for drawing preliminary conclusions which could be used in ex ante evaluations of future railway investments. Table 2 also shows the values of the NPS (Net Promoters Score) indicator, which shows how individual partial qualities of the service are perceived. This is calculated using the formula: (% Promoters - % Detractors) / N, where Promoters are those whose answers '5' (Very Good), Detractors – answers 1, 2 or 3, and N represents the size of the sample. The NPS index is interpreted as the prevalence (or not) of those who very highly view a given attribute over those who at best assess it as average or medium[13]. An analysis of NPS scores for specific parameters of the railway service in the surveyed lines indicates areas which are found as most unsatisfactory by the users. In that regard, railway stations and terminals are definitely in the lead; most passengers expressed a negative opinion about them, also in reference to the modernised routes Warsaw–Siedlce and Poznan-Konin. This corroborates the hypothesis that modernisation of train stations was not sufficiently broad (with only platforms being refurbished, while leaving the station's main buildings untouched), and that even the infrastructure which is being upgraded is so neglected and in bad repair that the positive perception effect of the exercise is not likely to last. This effect can be juxtaposed with a positive impact of the purchase of new rolling stock for the route Warsaw – Siedlce, which produced a significant effect in the form of distinctly more positive perceptions of the aesthetic values and cleanliness in trains servicing this connection. Other reasons for passenger dissatisfaction include the cleanliness of trains and toilets, as well as seat availability and ticket prices. As regards availability of seats, it was most negatively assessed in trains on the route Cracow – Tarnów, and most positively – on the route Warsaw – Siedlce. Similarly, train cleanliness

[11] A general CAPI interview (without conjoint modules) was conducted in two stages; the first included a sample of 635 passengers. This stage was treated by the researchers as a pilot application of the research tool. At the second stage, minor deficiencies in the questionnaire were removed and a total of 520 interviews were carried out. Not all the respondents would agree to extending the 'typical' interview by the conjoint module. Some of the respondents would also resign during the interview. In module and 495 interviews with the second conjoint module. This discrepancy could be explained by the fact that the second conjoint module was relatively shorter.

[12] Substantial material was collected in this part of the research, providing a wealth of information for the Polish Railways (Polskie Koleje Państwowe – PKP), which can be used not only for ex ante evaluations of railway investments. This paper discusses only selected issues.

[13] NPS measure was originally developed to show level of loyalty of customers. However in our case we found that NPS differentiate better than means or analysis of top 2 boxes.

was much more critically evaluated by passengers on the route Cracow – Tarnów than those on the route Warsaw – Siedlce. On the other hand, passengers travelling between Poznan and Konin more complained of ticket prices. Generally speaking, the smallest percentage of passengers dissatisfied with various aspects of the railway offer was found among those travelling between Warsaw and Siedlce, largely an effect of the newly purchased trains. The only aspect of the railway offer which received prevalently positive answers was train attendant's service, while in the remaining aspects, dissatisfaction or indifference were predominantly expressed.

Table 2

NPS scores showing how individual partial qualities of the service are perceived

	Total (N=1155)	Cracow (N=403)	Poznan (N=369)	Warsaw (N=383)
Ticket price	-50%	-49%	-54%	-47%
Number of connections	-42%	-44%	-52%	-32%
Travel time	-46%	-50%	-47%	-42%
Comfort	-40%	-71%	-38%	-10%
Schedule	-34%	-35%	-40%	-26%
Availability of seats	-52%	-65%	-49%	-43%
Information and service at the counter	-28%	-26%	-32%	-27%
Conductors' service	3%	7%	-6%	6%
Compartment's design	-39%	-71%	-37%	-8%
Clean compartments (and toilets)	-51%	-75%	-54%	-24%
Stations and train stops	-85%	-87%	-82%	-87%

4.2. Results of conjoint-based interviews

As regards the research concerning the choice of railway services with dissimilar parameters, price proved to be the main factor determining the respondents' decisions (cf. Table 3), followed by travel times. How the station looked proved to be the least valued attribute, much less valued than the condition of trains, ranked third). This can be explained by the conclusions from the introductory part, which suggested that the modernised infrastructure is still in a bad state of repair and small extent of the alterations made, which in fact were limited to the platforms and small and medium-sized train stations, as a consequence of which the passengers might 'not quite believe' in clean, comfortable railway stations and terminals.

No major differences were found between the surveyed routes as regards to the significance of the attributes, with the exception of a clearly higher utility of the 'train' attribute (type of rolling stock – new or old) on the route Poznan-Konin; this will be discussed in more detail below.

It should be pointed out, however, that the utilities of attributes are scored on the basis of the differences between the utilities at the individual levels of these attributes, i.e. the higher the spread of the utilities within a given attribute, the higher its final utility. As a result, attributes with a higher number of levels, such as the price and travel time, will normally produce higher utility[14].

Table 4 shows the utilities of individual attribute levels. Quite unsurprisingly, lower prices for the travel produce higher utility scores, just as shorter travel times. Also train station refurbishment and

[14] It is well known as a NOL Effect (Number of Levels Effect); Johnson 1992, "The Number of Levels Effect in Conjoint: Where Does It Come From and Can It Be Eliminated?", Sawtooth Software.

replacing old trains with new ones meant higher utilities for the respondents, regardless of where the survey was made.

Table 3

Attributes most strongly affecting the choice of the variant of a railway service

	Ticket price	Stations and train stops	Travel time	Type of train
Total (N=1155)	45,6%	9,3%	29%	16,1%
Cracow (N=403)	45,7%	10,4%	28,8%	15,2%
Poznan (N=369)	45,2%	8,2%	29,1%	17,4%
Warsaw (N=383)	45,8%	9,6%	29,1%	15,5%

Table 4

Utility of individual attribute levels in the model of choosing a railway service variant

	Total (N=1155)	Cracow (N=403)	Poznan (N=369)	Warsaw (N=383)
Price: 5 PLN	4,0	3,4	4,5	4,1
Price: 8 PLN	2,7	2,5	3,0	2,7
Price: 12 PLN	0,7	0,7	0,8	0,7
Price: 15 PLN	-1,5	-1,2	-1,6	-1,6
Price: 20 PLN	-4,4	-4,0	-4,9	-4,4
Train stop: neat	0,8	0,8	0,8	0,8
Train stop: unsightly	-0,2	0,6	-0,6	-0,7
Rolling stock: new	1,4	1,2	1,7	1,4
Rolling stock: old	-1,1	-0,9	-1,4	-1,1
Travel time: 1 hour	2,7	2,3	3,0	2,8
Travel time: 1 hour 10 min	1,4	1,3	1,6	1,4
Travel time: 1 hour 25 min	-0,5	-0,4	-0,6	-0,6
Travel time:1 hour 40 min	-2,8	-2,5	-3,1	-2,7

A similar situation can be observed with the second conjoint model, illustrating the process of choice between different means of transport: the cost of the travel is the most important factor affecting passenger decisions, following by the time of travel. Likewise, in the study using conjoint model 2, only Poznan is at variance as far as the evaluation of the significance of attributes is concerned: it clearly shows the higher utility of the attribute 'means of transport', i.e. utility which is directly associated with one means of transport: car, bus or train, regardless of the remaining parameters.

As regards to the individual attribute levels, similarly to conjoint model 1, it is clearly visible that lower prices and shorter travel times are translated into higher utilities. As regards to the attribute 'means of transport', the train connection got the highest utility scores in all the surveyed locations. In addition to a possible superiority of railways over alternative means of transport, this outcome could also be affected by the research method as such: the interviews were carried out in trains, among people half of whom – as we know from the completed questionnaires - were not able to take the journey using another means of transport. Also, this is not a representative sample in the sense that all the respondents in fact opted for the train journey. However, it should be pointed out that the two remaining means of transport (bus/van and car) got negative utilities in all the locations (cities), which means that the train, despite all its deficiencies, does become a 'liked' and preferred means of transport, at least among its users.

Table 5

Utility of individual attribute levels in the model of choosing a means of transport

	Total (N=1155)	Cracow (N=403)	Poznan (N=369)	Warsaw (N=383)
Train	1,0	0,8	1,4	0,9
Bus	-0,7	-0,6	-0,8	-0,8
Car	-0,3	-0,2	-0,6	-0,1
Price: 5 PLN	4,6	4,1	4,4	5,4
Price: 8 PLN	3,5	3,1	3,4	4,0
Price: 12 PLN	1,9	1,9	1,7	2,2
Price: 15 PLN	0,5	0,5	0,4	0,5
Price: 20 PLN	-1,6	-1,6	-1,5	-1,8
Price: 25 PLN	-3,3	-2,8	-2,8	-4,3
Price: 30 PLN	-4,7	-4,4	-4,7	-5,1
Travel time: 35 min	3,4	3,1	3,4	3,7
Travel time: 50 min	1,8	1,7	1,6	2,1
Travel time: 1 hour	0,9	1,0	0,9	0,8
Travel time: 1 hour 10 min	-0,2	-0,1	-0,3	-0,2
Travel time: 1 hour 25 min	-1,6	-1,5	-1,6	-1,7
Travel time: 1 hour 40 min	-3,8	-3,7	-3,6	-4,1

5. CONJOINT SIMULATOR BASED ANALYSIS IN EX ANTE EVALUATION OF RAILWAY SECTOR INVESTMENTS

The research exercise conducted on the basis of the proposed methodology helped to collect substantial material which can be used for ex ante evaluation purposes at least in two situations, viz.: (1) to assess the impact of the planned activities (investments in the lines, trains, infrastructure of train station buildings and terminals, etc.) on their evaluation by potential final users, and (2) to estimate the synergy effect between the planned investments.

Conjoint simulators allow for a free selection of the values of individual parameters (attributes) from the list of options, which was shown to the respondents. From the conjoint simulators prepared as part of the research exercise in question, we can select 269 scenarios for conjoint model 1 (which, multiplied by three locations + total utility scores gives a total of 1076 scenarios), and for conjoint model 2 – 223 scenarios (which, multiplied by four – gives a total of 892 scenarios). For each selected scenario, the simulator calculates the utility, and thereby provides information on the extent to which it is acceptable to final railway users. This is what makes this method definitely superior to traditionally designed questionnaires as it allows modelling of different intervention options, thus providing feedback on how specific decisions will be potentially received by passengers.

In addition to offering considerable simulation possibilities, useful at the stage of designing detailed intervention parameters, these models – in tune with the assumptions outlined in the introductory part of the paper - also help estimate the synergy effects between investments in the railway infrastructure and those in the rolling stock. The methodology for doing so is presented using an example based on the data collected as part of the research in question.

For each of the three routes, we can calculate the utility scores for every change (line modernisation and replacement of rolling stock). In order to avoid negative numbers, we will use the spreads of each change.

Table 6

Utility scores of unmodernised and modernised infrastructure and rolling stock (trains) on individual routes

Route	Utilities (scores of attributes: unmodernised / modernised)		Spread	
	Infrastructure	Trains	Line	Trains
Cracow-Tarnów	-0.7875	-0.794871795	1.43	2.1
Poznan–Konin	-0.79012346	-0.789473684	1.45	3.06
Warsaw–Siedlce	-0.78571429	-0.794117647	1.5	2.44

Table 7

Spreads of unmodernised and modernised infrastructure and rolling stock (trains) on individual routes

Route	Spreads (with signs of appreciation / need)		
	Line	Trains	Sum (S)
Cracow-Tarnów	-1.43	-2.1	-3.53
Poznan-Konin	1.45	-3.06	-1.61
Warsaw-Siedlce	1.5	2.44	3.94

On the routes where a given attribute was not changed, we define utility as the 'need for change' and on those where it was, as 'appreciation of change'. 'Need' will be shown as negative utility, and 'appreciation' – as positive utility (cf. Table 7). In order to examine the synergy effect, we need descriptions of four situations: (1) nothing has been done (need for changing the line and the rolling stock), (2) the line has been modernised (appreciation of the line's modernisation, need for changing the rolling stock), (3) the rolling stock has been replaced (appreciation of the trains' replacement, need for modernising the line), (4) everything has been done (appreciation of the trains' replacement and the line's modernisation).

Three of these items can be calculated directly from the table above because:

1. The situation 'nothing has been done' (need for modernising the line and replacing the rolling stock) – corresponds to the route Cracow – Tarnów;
2. The situation 'the line has been modernised' (appreciation of the line's modernisation, need for upgrading the rolling stock) – corresponds to the route Poznan – Konin;
3. The situation 'everything has been done' (appreciation of the trains' replacement and the line's modernisation) – corresponds to the route Warsaw – Siedlce.

The fourth item, i.e. a hypothesised situation with a modernised rolling stock but unmodernised infrastructure[15], can be calculated as: appreciation of the trains' replacement (Warsaw) minus need for upgrading the rolling stock (the average for the routes serviced with old trains, i.e. Cracow and Poznan ones):

$$S_4 = 2.44 - \bar{x}(-2.10; -3.06) = -0.14$$

As a result, we obtain the scores provided in Table 8, which are additionally rescaled to obtain non-negative utility.

In effect, the utility obtained as a result of simultaneous replacement of the rolling stock a modernisation of the line (7.47) is higher by 2.16 from the sum of individual utilities for such interventions (1.92 + 3.39). It is because, with 'step-by-step' activities (interventions), the users' need for continued changes tends to grow: on the Cracow route, both the trains and the infrastructure are in bad repair, as a result of which the utilities are divided (in the form of expectations) between these two attributes. On the Warsaw route, where both the line and the rolling stock have been modernised, these two attributes are similarly assessed by the users. In case of Poznan, the satisfaction with the upgraded line is not similarly matched by expectations concerning the replacement of trains. In this case, we can say that changing only one element will result in increased expectations concerning other changes. This can be explained by the fact that clients who have been 'won' thanks to short travel times (modernisation of the infrastructure) look more forward to travelling in new trains than the existing users.

Table 8

Sums of spreads of utilities on individual routes

Route	Utility (S) (Need - appreciation)	Rescaled utility[16]
Nothing has been done (S_1): *Cracow*	-3.53	0
Line modernised, rolling stock not replaced (S_2): *Poznan*	-1.61	1.92
Line modernised, rolling stock not replaced (S_3): *Warsaw*	3.94	7.47
Line not modernised, rolling stock replaced (S_4): $(S_3) - \bar{x}((S_1); (S_2))$	-0.14	3.39

6. CONCLUSIONS

Research based on conjoint method can be useful when designing interventions - both in terms of policies, programs and specific projects. It allows to model the impact of specific activities (eg, replacement of old rolling stock, reduction of travel time) on the competitiveness of services and thus choose the most effective and most desired by the passengers solutions. It provides the response on the relevance criterion of the planned investment within the ex-ante evaluation. A conjoint study, carried out at the stage of feasibility study will help decision-makers to choose and prove optimal 'projects' design': both at the level when deciding on what should be done (fe. by proving that the optimal intervention that increases the competitiveness of service provided on given line is the purchase of new rolling stock) and how should it be done (fe. by proving data on technical parameters of new rolling stock that should replaced the old one in a way to ensure optimal value-for money).

It should be noted that the (very simple) initial interview can provide valuable information concerning the preference of passengers. Gathered within such interview data enriches material, which

[15] Such situations are in practice frequently encountered in Poland – on routes serviced by railbuses. However, it would be unfounded to compare them directly with the routes used by commuters travelling to agglomerations, due to dissimilar traffic considerations and different passenger profiles.

[16] In the rescaling, the situation 'nothing has been done' (starting point) was ascribed the score '0'. That meant that 3.53 was added to every utility score.

should be analyzed in the process of planning of railway investments. Meanwhile, a number of projects in public rail transport sector is not preceded by any marketing research, and thus there is a high risk that they do not meet the real needs of passengers which are the ultimate users.

Moreover, except for proven in this paper usefulness of the conjoint method implemented within ex ante evaluation of planned investments, it can be successfully adopted as a tool that leads to the optimization of the operation and decisions undertaking within on-going management of public rail.

It should also be borne in mind that, in these considerations, we did not look at strictly technical synergy, resulting from the fact that joint activities associated with the purchase of new rolling stock and modernisation of the infrastructure in some cases can shorten the travel times more than a sum of individual activities. Naturally, with specific data, both these aspects can easily be integrated in one model, using the simulator described earlier in the paper.

In the users' opinion, the occurrence of the synergy effect between two kinds of investments (modernisation of rolling stock, modernisation of rail lines), demonstrated above, can be regarded as yet another indication concerning EU co-funded programmes, both nationally and regionally: that such programmes should promote broad rail line modernisations, including both the infrastructure and the rolling stock (and making the necessary additions to those partial activities which were completed in the past).

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