Deliverable D6.3 Performance and impact assessment

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1. Executive Summary

The IP4MaaS Project aims at demonstrating the benefits of Innovation Programme 4 (IP4) through pilot demonstrators of collective and shared mobility services in six different European countries' cities: Athens, Barcelona, Padua, Liberec, Osijek, and Warsaw. The technologies have been created within IP4 Shift2 Rail Joint Undertaking (S2R JU), developed mainly within the COHESIVE[1] project and tackle various aspects of traveller experience, meaning the interoperability of Transport Service Providers' (TSPs) services, travel shopping, booking & ticketing, trip tracking, travel companion technologies and business analytics.

IP4MaaS outcomes will impact on existing complementary projects COHESIVE, ExtenSive and CONNECTIVE[2], aiming at developing passenger service platform specifications for an enhanced multi-modal transport eco-system including Mobility as a Service (MaaS). The relevant expected impact of this complementary topic is related to the integration of urban sprawl underpinned by the opportunities that the digitalization of transport e.g., MaaS brings. This is particularly relevant for the implementation of truly user-centric services for co-modality in multimodal journeys integrating public transport, shared mobility, micro-mobility as well as private and on demand approaches.

IP4MaaS has adopted an iterative approach for the demonstrations. There are two iterations, C-REL (Core Release) and F-REL (Final Release). The first iteration initially involved Padua, Athens and Barcelona, due though to limitations from CFMs' side and technical limitations from certain TSPs side, it involved only Athens, while the second iteration has included all demonstration locations.

This document constitutes the Deliverable *D6.3 Performance and impact assessment* which aims to assess, through the methodology explained in the Deliverable *D6.1 Assessment Methodology* [4], the KPI indicators formed by the data collected during the whole WP4.

The document starts with the introductory section, followed by the project background and the overall evaluation objectives of the deliverable (section 5 and 6).

In section 7 the implementation steps of the evaluation process, already presented in deliverable 6.1, are summarized, and considerations about statistical representativeness of results elaborated are provided.

In section 8 the results of performance assessment methodology are reported.

In section 9 the results of impact assessment methodology are reported.

In section 10 the conclusions of the deliverable are presented, with the objective to introduce the next deliverable 6.4 "Final Assessment Report: conclusions about COHESIVE solutions efficiency and impact",

[1] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=COHESIVE
[2] https://projects.shift2rail.org/s2r_ip4_n.aspx?p=CONNECTIVE

2. Abbreviations and acronyms

Abbreviation / Acronym	Description
CFM	Calls for Members
DL	Dissemination and exploitation leader
DoA	Description of the Action
EL	Ethical leader
EU	European Union
FS	Financial Statement
GA	Grant Agreement
H2020	Horizon 2020
IP4	Innovation Programme 4
KPI	Key Performance Indicator
OC	Open Call
PC	Project coordinator
PM	Project manager
PMO	Project Management Office
PMT	Project Management Team
PO	Project Officer
QAC	Quality Assurance Committee
S2R JU	Shift2Rail Joint Undertaking
TC	Travel Companion (application)
TL	Technical leader
TSP	Transport Service Provider
USI	User satisfaction Index
WP	Work Package
WPL	Work package leader

3. List of figures

4. List of tables

5. Background

The present document constitutes the Deliverable *D6.3 Performance and impact assessment* in the framework of the W6, Task 6.3 of the IP4MaaS project (S2R-OC-IP4-01-2020, GA 101015492). Mobility as a Service (MaaS), extensively introduced in D6.1, aims to get over the car ownership model as well as the current market fragmentations, exploiting the integration between different means of transport and networks, especially rail, through combined mobility packages. The main objective is to reduce traffic congestion, emissions and parking problems in urban areas.

From the operational feasibility viewpoint, MaaS development might influence the involved operators in transport service provision. From the technical feasibility viewpoint, the most important elements of the MaaS concept are the design, operation and maintenance of an integrated service. From the economic feasibility viewpoint, transport operators and mobility service providers have complex fare structures which should be analysed to define and implement a potential single-payment system within the MaaS concept.

The validation process in the demo sites enabled a scientific sound analysis of the evaluation data, whose analysis is reported in the present document along with the site-specific results. The overall discussion of such results will be provided in *D6.4 - Final Assessment Report*: conclusions about COHESIVE solutions efficiency and impact.

6. Objective

IP4MaaS WP6 aims to assess the performance and impact generated by the project through COHESIVE demonstrations in relation with the overall project objectives and, after setting performance and impacts goals, to evaluate how they are met in the demonstrations.

The purpose of the document is to show the results of performance and impact assessment. Specifically, the results have been collected in order to assess the positive impact encountered thanks to the development of the demo site and the use of IP4 technologies. Therefore, the overall impacts and performances against the defined project objectives and related indicators has been quantitatively assessed.

7. Implementation steps of the evaluation process

The goal of Work Package 6 in the IP4MAAS project is to define and implement the overall evaluation methodology for assessing the impact generated by the project innovations at MaaS demo sites against the project's objectives. Performance and impact assessment have been accomplished to assess impacts in the mobility business sector as well as in the project sites.
In deliverable *D6.1 Assessment Methodology* [4] the implementation steps of the evaluation process have been presented and they are summarised hereafter:

1. The first essential and critical step is the collection of data and the difference between objective and subjective data.
2. The second step is the identification of the main target's groups involved in MaaS operations and development and their correlation with IP4MAAS project aims and the specific objectives.
3. The third step is the understanding of criteria for the selection of the KPIs and for their assessment.

Besides these actions, common for both Performance and Impact assessment, the respective methodologies were applied and led to results that are reported in the next sections.
Nevertheless, problems encountered during the experimentations, reported in final reports on Demo sites executions (deliverables of WP5), led to low user participations and consequent limited statistical representativeness of data collected.
The following table reports the survey quality indicators applicable for users that fed USIs data:

Table 1. Survey quality indicators for IP4MaaS

Demo site	Sample registered users	Net sample (respondents)	Survey response rate
Barcelona	31	11	35%
Athens (phase 1)	140	17	12%
Athens (phase 2)	79	33	41%
Warsaw	244	204	84%
Padua	77	13	17%
Liberec	124	112	90%
Osijek	43	41	95%

According to Eurostat guidelines on Passenger Mobility Statistics [20], for a confidence level of 95% and a margin of error of 5% the net sample (the respondents to the surveys for inquired variables) should be 384. The table below shows that this value is not reached in any Demo site and therefore there is not statistics representativeness of collected data at the above mentioned 95% confidence level.

However, other aspects should be considered to assess the validity of the present evaluation:

- A sampling should be random and stratified to ensure appropriate representativeness of the statistics, but this was not the objective of the IP4MaaS experimentations, that had the primary goal to identify testers available to use a prototypal application: this attitude is higher for younger people with specific characteristics, the so-called early adopters; a larger sampling would have required more complex recruitment strategies and was not the purpose of the project.
- The maturity of the app, not comparable to similar travel planners or integrated ticketing services already on the market makes not possible to ensure a random sampling, being some subjects reluctant to travel with services provided by prototypal tools.
- The ambition of the project was to deploy MaaS services thanks to the service integration between IP4 solutions and TSPs and to test its effectiveness. This result was achieved by demonstration activities and USI surveys provided meaningful indication about this effectiveness.

For these reasons, despite the limited number of respondents, the received feedback deserves to be analysed with solid methodologies and resulting assessments are meaningful for:

- Providing to developers and involved stakeholders relevant insights for future refinements
- Provide to the whole research community a robust assessment methodology for future studies for the evolving MaaS concept.

These considerations guided the overall WP6 work and the following sections report the results of both performance and impact assessment, along with the updates about methodological aspects occurred during the elaboration of data.

8. Performance assessment

The assessment methodology of the IP4MaaS project focuses on the methodological framework "List of operational KPIs, analysis of the users' satisfaction and methodology as a whole". Specifically this assessment introduces the final list of KPIs to be used for the evaluation and assessment of demonstrations in WP5 (Task 5.2 Barcelona demonstration, Task 5.3 Padua demonstration, Task 5.4 Athens demonstration, Task 5.5 Osijek demonstration, Task 5.6 Liberec demonstration, and Task 5.7 Warsaw demonstration). After explaining the latest updates in the methodology to define the final list of KPIs in all the demonstration scenarios, this assessment outlines the methodology for conducting User Satisfaction Index (USI) questionnaires, which are used to evaluate the satisfaction of users with the IP4 solutions, and explains in detail how the effectiveness will be calculated for each user profile. The data from USIs and operational KPIs in phase II are an input for the IP4 toolbox which has been prepared in Task 6.1 "Assessment methodology" [1]and Task 6.2 "Performance assessment"[2].
This assessment provides a comprehensive framework for setting the final results and outcomes of the methodological framework to evaluate the IP4MaaS tool in each of the IP4MaaS 6 demonstration sites[3].

As introduced in previous deliverables D6.1[1] and D6.2[2], the performance assessment was based on a **toolbox** aimed to evaluate the performance of the Travel Companion application and more in general the ecosystem developed within IP4 in six Demo sites: Athens, Padua, Warsaw, Liberec, Osijek, and Barcelona.

The toolbox is based on several mathematical data analysis operations executed sequentially:

1. AHP (MODULE 1);
2. Regression Analysis (MODULE 2);
3. Bayesian Network and Bellman shortest path (MODULE 3);
4. ANOVA test (MODULE 4);
5. USI of travellers, TSPs & Effectiveness (MODULE 5).

Three main inputs fed the application:

1. Collected data from USI (User Satisfaction Index) travellers from online surveys[4], [5];
2. Collected data USI (User Satisfaction Index) TSPs (Transport Service Providers) from online surveys;
3. Collected data from Operational KPIs (Key Performance Indicators) from CFMs (Travel Companion /IP4 ecosystem developers)[6].

The assessment as well as general profiles, is focused on 4 specific (sensitive) profiles (the definition of the profile variable "r" is reported below in this paragraph) [6]:

1. General profiles (r=1)
2. Unemployed people, low-income people, retired people, and students (r=2)
3. Disabled or impaired people, people with physical or mental illnesses, people in wheelchairs, people with reduced mobility, people with visual impairment, and hearing impairment (r=3)
4. Elderly (r=4)
5. Women (r=5)

The *performance assessment toolbox* is working with data collected from *Operational KPIs* and *USIs surveys* in the WP5 during the execution of the demo.
Regarding Operational KPIs: Given that at this point, performance assessments are done discretely (one per each demo) instead of in a continuous pattern, the development of an API (application programming interface) for an automatic feed of this data from the TC APP regarding operational KPIs is not needed; alternatively, the data related to operational KPIs is gathered through the cloud wallet shared by CFMs after each demo site execution[7].

Regarding data collected through USI surveys: The performance assessment toolbox is automatically fed with data gathered through USI surveys programmed in Google Forms. The whole exercise has been designed in a process-oriented manner. This process involves preparing the toolbox and the data structure of the gathered data on one demo site, to begin with. Once the process has been established in a fail-safe manner for one demo site, the same process and techniques were applied to the other demo sites. As a result, the toolbox assessment manages the data analysis in six different pilots in the IP4MaaS project and the established process has the readiness to be used for more sites in the future[7].

The **definition**, **steps**, **mathematical formulas,** and the **reason for applying** each aforementioned module of this assessment are introduced can be found in D6.1 (Impact assessment) [4]and D6.2 (Performance assessment)[3].

The definition of each variable that is used in this data analysis is: "**r**" the type of profile of respondents in this study (r=1 general profile vectors, r=2 low-income people, r=3 people with disability, r=4 elderly and r=5 women), "**J**" the name of innovative technology or functionality, "**K**" the name of TSP (Transport Service Provider) which is providing that specific functionality and "**q**" associated question linked to that specific functionality.
In the following tables (Tables 1 and 2) the definition and meaning of each variable indicated above are illustrated:

Table 2. Final list of TSPs "K" used in performance assessment.

Associated code "K"	Name of the demo site	Name of TSP (K) integrated with each demo site
1	**Athens**	OASA
2		MIRAKLIO
3		Taxiway
4		Brainbox
5	**Padua**	Treinitalia
6		BusItalia
7	**Liberec**	KORID
8	**Warsaw**	ZTM
9		MZA
10		TW
11	**Osijek**	GPP PT

12		GPP sharing mobility
13	**Barcelona**	TMB
14		BUSUP
15		AMTU

Table 3. Final list of "J" Innovative technologies or functionalities considering "K" as TSP which offers each functionality[6]

No.	Name of the demo site	Name of TSP (K) integrated with each demo site	Name of functionalities (J) assessed in each TSP (K) for travellers	Name of functionalities (J) assessed in each TSP (K) for TSPs
1	**Osijek**	GPP PT (K=11)	Journey planning (J=1), Navigation (J=9)	CRM portal (J=32)
		GPP sharing mobility (K=12)	Journey planning (J=1), Navigation (J=9)	
2	**Warsaw**	ZTM (K=10), MZA (K=8), TW (K=9)	Guest user (J=12) , Preferences and profiles (J=13) , digital onboarding (J=20), Journey planning (J=1), Trip sharing (J=11), Travel arrangement (J=21) , Navigation (J=9) , Traveller's feedback (J=10) , Collaborative space (J=15)	Asset manager (J=23)
3	**Liberec**	KORID (K=7)	Travel companion Web-Portal (J=16), Guest user (J=12) , Journey Planning (J=1), Smart Locations (J=18) , Booking (J=2) , Issuing (J=3) , Validation, and Inspection (J=5) , Trip tracking orchestration (J=6) , Alternatives calculation (J=7) , Traveller's feedback (J=10), Navigation (J=9), Trip sharing (J=11) and Travel Arrangement (J=21)	Asset manager (J=23)
4	**Barcelona**	TMB (K=13)	Guest user (J=12), Preferences and profiles (J=13), digital onboarding (J=20), Journey planning (J=1), Trip sharing (J=11), Navigation (J=9), Traveller's feedback (J=10), Collaborative space (J=15)	Asset manager (J=23), Contractual management Market Place (CMMP) (J=25)
		BusUp (K=14)	Travel companion Web-Portal (J=16), Travel Companion for Kids (J=22), Guest users (J=12) , Preferences and profiles (J=13), digital onboarding (J=20) , Journey planning (J=1), Trip sharing (J=11), Booking (J=2) , Mobility	

			packages (J=4) , Navigation (J=9), Traveller's feedback (J=10), Collaborative space (J=15)	
		AMTU (K=15)	Guest user (J=12), Preferences and profiles (J=13), digital onboarding (J=20), Journey planning (J=1), Trip sharing (J=11), Mobility packages (J=4), Traveller's feedback (J=10), Collaborative space (J=15), Booking (J=2)	
5	**Athens**	OASA (K=1)	Travel companion Web-Portal (J=16), Guest user (J=12), Preferences and Profiles (J=13), Journey planning (J=1), Intermodal Fare Optimization (J=17), Issuing (J=3), Mobility packages (J=4), Validation and Inspection (J=5), Navigation (J=9), LBE (J=8) , Map Content (J=19) , Traveller's feedback (J=10)	Asset manager (J=23), Travellers Orchestration and supervision (J=29), Specific messages (J=33), Distributed Ledger – Transaction Anchoring (J=30), Distributed Ledger – TSP Inclusion (J=31)
		MIRAKLIO (K=2)	Travel companion Web-Portal (J=16), Guest user (J=12) , Preferences, and Profiles (J=13), Journey planning (J=1), Navigation (J=9), LBE (J=8), Map Content (J=19), Traveller's feedback (J=10)	Asset manager (J=23), LBE editor (J=24), Travellers Orchestration and supervision (J=29), Specific messages (J=33), Distributed Ledger – Transaction Anchoring (J=30), Distributed Ledger – TSP Inclusion (J=31)
		Brainbox (K=4)	Travel companion Web-Portal (J=16), Booking (J=2), Guest user (J=12), Preferences and Profiles (J=13), Journey planning (J=1), Intermodal Fare Optimization (J=17), Issuing (J=3), Mobility packages (J=4), Validation and Inspection (J=5), Navigation (J=9), LBE (J=8), Map Content (J=19), Traveller's feedback (J=10)	Asset manager (J=23), Contractual management Market Place (CMMP) (J=25), LBE editor (J=24), Travellers Orchestration and supervision (J=29), Specific messages (J=33), Distributed Ledger – Transaction Anchoring (J=30), Distributed Ledger – TSP Inclusion (J=31)
		Taxiway (K=3)	Travel companion Web-Portal (J=16), Guest user (J=12) , Preferences and Profiles (J=13), Journey planning (J=1), Intermodal Fare Optimization (J=17), Booking (J=2), Issuing (J=3), Mobility packages (J=4), Validation and Inspection (J=5) , Navigation (J=9), LBE (J=8), Map Content (J=19), Traveller's	

			feedback (J=10)	
6	**Padua**	Trenitalia (K=5)	Guest user (J=12), Preferences and Profiles (J=13), Journey planning (J=1), Trip sharing (J=11), Booking (J=2), Issuing (J=3), Navigation (J=9), Traveller's feedback (J=10), Collaborative space (J=15)	Asset manager (J=23), Collaborative space portal (J=28), Travellers Orchestration and supervision (J=29), Specific messages (J=33)
		Busitalia (K=6)	Guest user (J=12) , Preferences and Profiles (J=13), Trip sharing (J=11), Navigation (J=9), Traveller's feedback (J=10), Collaborative space (J=15)	

On the other hand, the list of operational KPIs which are used in this data analysis with their associated code is listed in the following table (**Error! Reference source not found.**)[6]:

Table 4. Final list of "Operational KPIs" associated with "J" used in the performance assessment

	Name of the innovative technology or functionality	Unit	Associated code "J" and "KPI"
1	LBE (Location-Based Experience)	Number of entertainment services offered during the demo	J8KPI0
2	JP (Journey Planning)	The average number of modes involved in the journey	J1KPI1
3	JP (Journey Planning)	Average number of shopped offers	J1KPI2
4	JP (Journey Planning)	Number of TSP integrated	J1KPI3
5	Booking	Average number of booked offers	J2KPI4
6	Issuing	Average Number of issued offers	J3KPI5
7	Mobility Packages	Number of mobility packages offered	J4KPI6
8	Guest user	Number of connections without passwords per day	J12KPI7
9	Asset Manager	Number of services integrated with the pilot	J23KPI8
10	Contractual management marketplace	Number of mobility packages handled	J25KPI9
11	Contractual management marketplace	Number of involved stakeholders	J25KPI10
12	Traveler's feedback	Number/day	J10KPI11
13	Travel Arrangement	number per pilot	J21KPI12

In the following sections results of the data analysis are shown:

In **Module 1** (**AHP** and pairwise comparison matrix) the **top three** first-level benefits[3] produced by IP4 functionalities are illustrated (the most important ones from the point of view of the expert panel[4]).

In **Module 2** (**regression**) the **most correlated functionalities** from the point of view of their acceptance level were figured out.

In **Module 3** (**BN analysis and Bellman shortest path**) the **top ten** benefits are shown (the most influencing ones on the acceptability of all IP4 functionalities offered by each TSP)

In **Module 4** (**ANOVA**) functionalities showing discrimination regarding sensitive profiles are shown (those showing significant differences in the satisfaction score for some socio-demographic profiles), and

In **Module 5** (**Effectiveness**), the metric "**Effectiveness**" as defined in deliverable[21] D3.3 is shown per each functionality ("j"), TSP ("k"), and profile ("r").

An overview of the number of respondents per profile in each demo site is presented in Table 4:

Table 5. Statistics of respondents to the USI surveys in each IP4MaaS demo site considering each socio-demographic groups

Demo sites	Total number of respondents (r=1)	Number of low-income profiles (r=2)	Number of disabled profiles (r=3)	Number of Elderly (r=4)	Number of Women (r=5)
Athens	38	6	-	-	21
Padua	13	8	-	-	6
Warsaw	208	41	6	8	69
Liberec	121	42	5	10	63
Osijek	40	13	-	-	14
Barcelona	11	-	1	1	4

[3] **First level benefits** or **Factors level 1** are those general benefits to travellers and TSPs where functionalities could be clustered inside. For example: Safety, Cost, …..

[4] The **expert panel** was consisting of TSPs experts in each demo site, two experts from associations in IP4MaasS project (UITP and UNIFE) and two members of Travel Companion developers (HACON and INDRA).

8.1. Availability of materials, inputs, models, and scripts of performance assessment toolbox

All the materials, inputs, models, and scripts which are used in the performance assessment toolbox are available in the attached folders[5] to this deliverable.

The attached folder contains the following:

1. Module 1_AHP and Pairwise comparison matrix calculation_IP4MaaS II (formulations and calculations of pairwise comparison matrix per each IP4MaaS demo site).
2. Module 2_Regression analysis (inputs, scripts, and formulations of regression analysis per each IP4MaaS demo site).
3. Module 3_ BN analysis_Graphs and weights (the inputs, weights, graphs, and scripts of Bayesian Network analysis per each IP4MaaS demo site).
4. Module 4_Calculation of ANOVA test (the input, formulation, macros, and scripts of ANOVA test per each IP4MaaS demo site).
5. Module 5_Results and outputs of USI Travellers, USI TSPs, Effectiveness (Travellers & TSPs) and the average of Effectiveness of all functionalities individually across all 6 demo sites (inputs, calculation, formulation, scripts of USI travellers, TSPs and Effectiveness per each IP4MaaS demo site).

8.2. The results of the Athens demo site phase II

8.2.1. Results regarding Module 1: AHP (Analytic Hierarchy Process) and pairwise comparison matrix

The definition of this module includes two parts: 1 - **A Hierarchical model** (see following figures 1 and 2), 2 - **A pairwise comparison matrix** (filled by the expert panel[6]). The AHP analysis has the following two main goals (These goals were in the mind of experts during the building process of the hierarchical model and the process of filling the pairwise comparison matrix)[8]:

1. **For Travellers:** To encourage people to use more intermodal solutions in public transport, especially railways, by making it more attractive to users.
2. **For TSPs:** To encourage TSPs to use the solution Travel Companion (APP)

In the following figures the hierarchical model for both travellers and TSPs in the Athens demo site is illustrated:

[5] All the matrials, script and additional data are avaible for download in the library of IP4MaaS website (https://www.ip4maas.eu/library/), and IP4MaaS Zenodo community (https://zenodo.org/communities/ip4maas/).

[6] The **expert panel** was consisting of TSPs experts in each demo site, two experts from associations in IP4MaasS project (UITP and UNIFE) and two members of Travel Companion /IP4 ecosystem developers (HACON and INDRA).

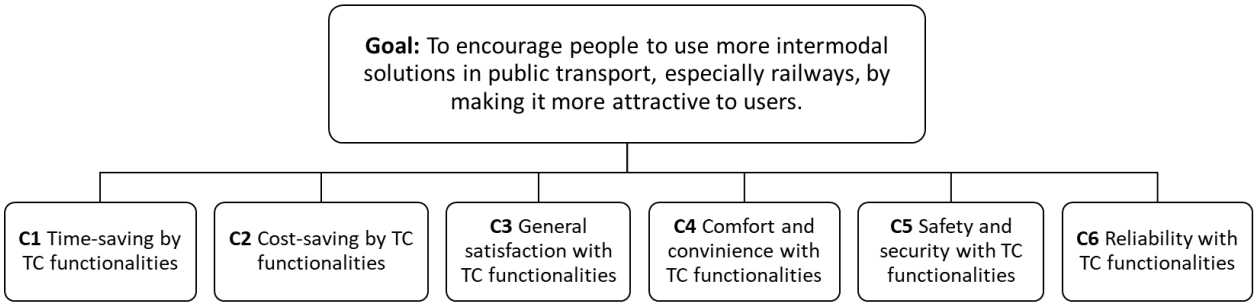


Figure 1. Hierarchical model for travellers (Athens)

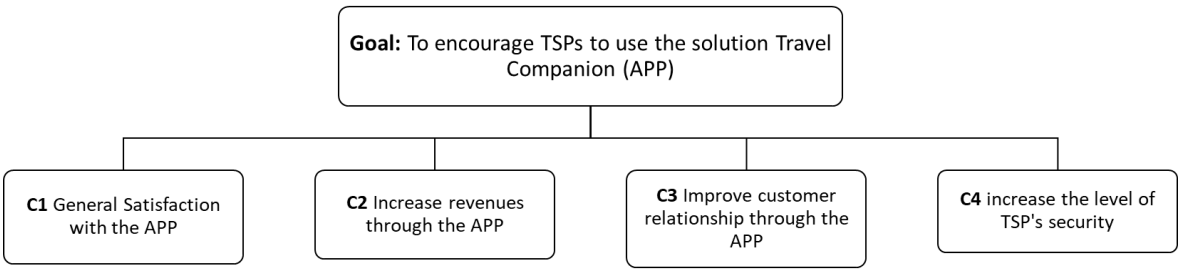


Figure 2. Hierarchical model for TSPs (Athens)

After removing inconsistent values from the data[7], the rank of each criterion (first level benefit[1]) considering its weight and a graphical representation is shown in Tables 5 and 6 and Figures 3 and 4 respectively:

[7] Those with CR>0.01. See Eq. 1 in Deliverable D6.2 TOOL FOR PERFORMANCE ASSESSMENT

Table 6. Global weights of travellers in AHP (Athens)

CL1 (Travellers)	Description	Weight	Rank
C1	Time-saving by TC functionalities	0.30	1
C2	Cost-saving by TC functionalities	0.24	2
C3	General satisfaction with TC functionalities	0.08	5
C4	Comfort with TC functionalities	0.06	6
C5	Safety and Security with TC functionalities	0.15	3
C6	Reliability with TC functionalities	0.13	4

Table 7. Global weights of TSPs in AHP (Athens)

CL1 (TSPs)	Description	Weight	Rank
C1	General Satisfaction with the APP	0.25	2
C2	Increase revenues through the APP	0.25	3
C3	Improve customer relationships through the APP	0.29	1
C4	Increase the level of TSP's security	0.19	4

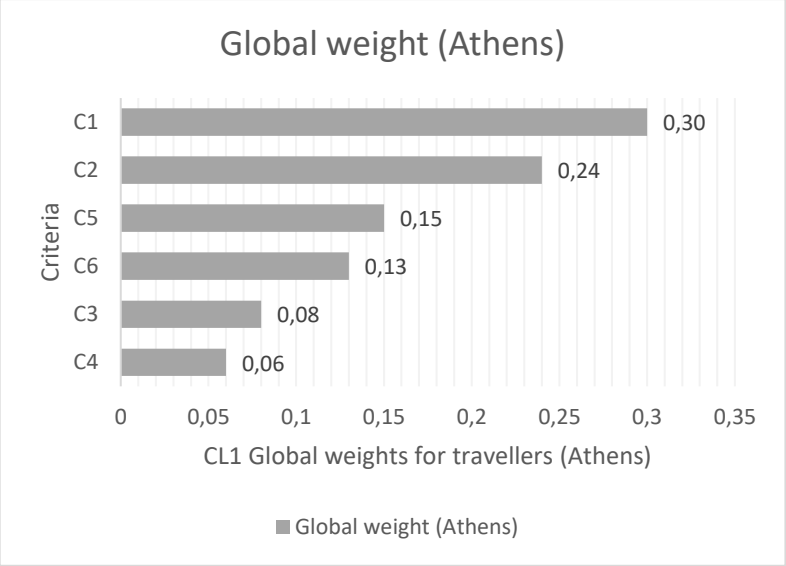


Figure 3. Graphical representation of global weight for travellers (Athens)

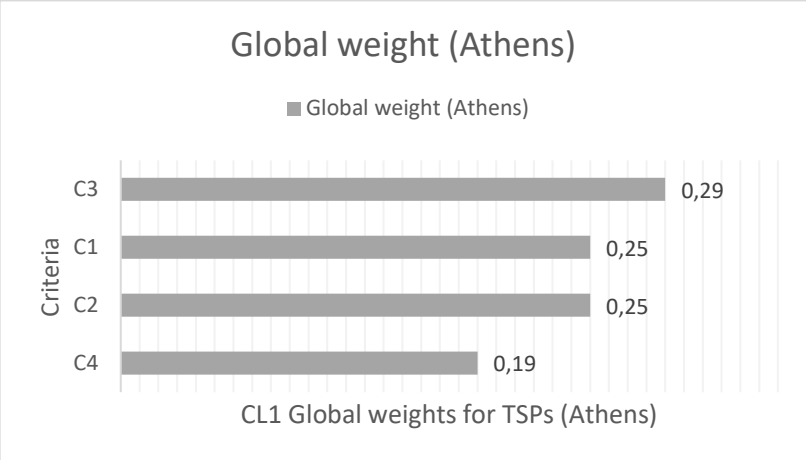


Figure 4. Graphical representation of global weight for TSPs (Athens)

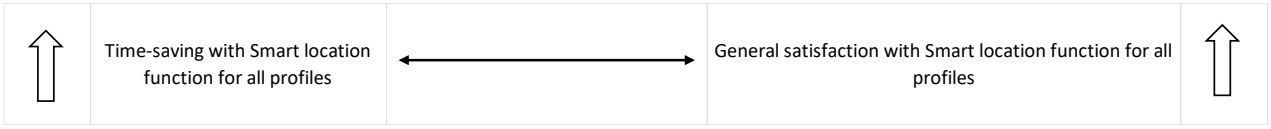
Considering the above data for **Athens:**

For TRAVELLERS: Time-saving and Cost-saving benefits, along with the safety and security benefits through the Travel Companion (TC) APP have got the highest importance and weights among other criteria or first-level factors. For **TSPs: Improving customer relationships, General satisfaction,** and **Increased revenues through the TC APP** were the most significant criteria[9].

8.2.1. Results regarding Module 2: Regression analysis

As detailed in D6.2[3], the regression analysis is done as a previous step to identify **Second level Benefits**[8] highly correlated in a way that the heuristic process followed by the Bayesian Network Analysis (Module 3) already starts from learned networks, achieving better results in less time. The p-value in the following two pair variables is less than 0.05 (p-value<0.05), which means there is a high correlation between them.

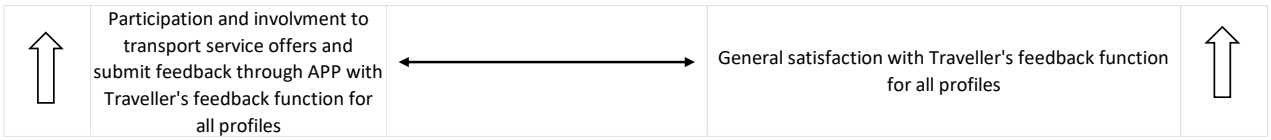
The results of this Regression analysis are based on data gathered through **USI Travellers surveys** and they are shown in the following for the case of the **Athens** demo site:



- As is shown in the figure, increasing the "Time-saving with Smart location function for all profiles" will increase indirectly the "General satisfaction with Smart location function for all profiles".

- As it is shown in the figure, increasing the "Willing to pay for Trip sharing function for all profiles" will increase indirectly the "Increase trip safety with Trip sharing function for all profiles".

- As it is shown in the figure, increasing the "Time-saving with Validation and inspection function for all profiles" will increase indirectly the "General satisfaction with Validation and inspection function for all profiles".



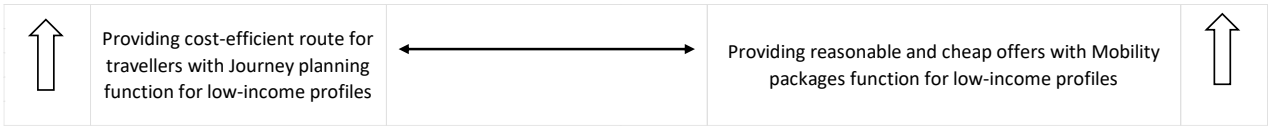
[8] **Second level benefits** are more detailed factors, clustered inside each of the first level benefits or factors level 1, with an influence on the usage of IP4 functionalities.

- As it is shown in the figure, increasing the "Participation and involvement to transport service offers and submit feedback through APP with Traveller's feedback function for all profiles" will increase indirectly the "General satisfaction with Traveller's feedback function for all profiles".

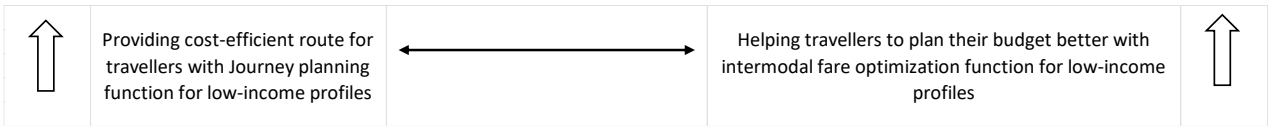
- As it is shown in the figure, increasing the "Fast access to the TC APP and basic functionalities with Guest user function for all profiles" will increase indirectly the "General satisfaction with Guest user function for all profiles".

- As is shown in the figure, increasing the "Cost-saving with Journey planning for all profiles" will increase indirectly the "General satisfaction with Journey planning function for all profiles".

- As it is shown in the figure, increasing the "General satisfaction with Map content function for all profiles" will increase indirectly the "Helping travellers to identify stops and stations with Map content function for all profiles".



- As it is shown in the figure, increasing the "Providing a cost-efficient route for travellers with Journey planning function for low-income profiles" will increase indirectly the "Providing reasonable and cheap offers with Mobility packages function for low-income profiles".



- As it is shown in the figure, increasing the "Providing a cost-efficient route for travellers with Journey planning function for low-income profiles" will increase indirectly the "Helping travellers to plan their budget better with intermodal fare optimization function for low-income profiles".

- As it is shown in the figure, increasing the "Helping travellers to plan their budget better with intermodal fare optimization function for low-income profiles" will increase indirectly the "Providing reasonable and cheap offers with Mobility packages function for low-income profiles".

The output from regression analysis will now be introduced as a forced connection into the BN analysis. This is done to establish consistency in the correlations in the output generated by the BN analysis since the operation is done on a limited number of iterations to produce combinations and relationships among variables in the BN analysis. Considering what has been discussed so far, based on the output of regression analysis the correlations established between variables do not contradict the correlation established by the BN analysis, since the operation is done on the same data values for each variable respectively. Hence, there is no possibility of the graph from the BN analysis to have cyclic connections between the variables upon the introduction of forced connections.

8.2.2. Results regarding Module 3: Bayesian network analysis and BELLMAN shortest path

The output of BN analysis from the **Athens** demo site indicates what are the **more influent second level benefits**[3] for the acceptance by **users** of IP4 functionalities offered by TSPs considered in the **Athens** demo site, taking into consideration the **Bayes score** and **cumulative weights** (Table 7)[10]:

Table 8. Top second-level benefits according to BN analysis in the Athens demo site

Normalized Weight	Code of factors	Definition of factors
0.0093	r1J17q1	General satisfaction with intermodal fare optimization function for all profiles
0.0087	r2J17q3	Cost-saving with intermodal fare optimization function for low-income profiles
0.0083	r3J1q6	Making traveller's trip more convenient and comfortable and providing more accessible route with journey planning function for disabled profiles
0.0083	r1J8KPI0	Number of entertainment services offered during the demo site with Location-Based Experience tool
0.0083	r1J11q2	Providing a safe trip with trip sharing function for all profiles
0.0082	r2J4q4	Providing cheap and affordable offers with mobility packages function for low-income profiles

Impact assessment/predictions of correlated variables:

The main reason for identifying and analysing correlations among various factors associated with respective demo sites is to carry out an impact assessment of these variables individually through predictive simulations. These simulations give us an insight into assessing the overall impact of an investment made on improving a certain factor at a demo site. The study through these simulations becomes the basis of decision-making at a high level for various stakeholders involved in the project. The methodology used in these predictive simulations is as follows:

1. Identification of the most impactful variables/factors.
The first step in the process is to find out the variables/factors with the highest weight from the BN and AHP analysis.

2. Among the top second-level variables, the top 3 variables with the highest weight are set aside and used as the factors to focus on to see the impact of each of them on the other remaining variables.

3. One by one, each of the three chosen variables are selected and simulations are conducted to see the impact of this factor on the other correlated variables when the factor through investment and improvement of service are improved. The range of simulation begins with "Most probable value before investment" (Their original score - 1, 2, 3, 4, based on the survey data) and goes all the way up to "Most probably score after investment" (The highest score of 5)

4. Based on the above simulations the assessment tries to find out if the investment to improve this factor has a positive or a negative impact on the other correlated factors.

The above methodology of simulations has been designed to work with changing and scaling datasets in the future. The design of simulations makes them easily replicable to new demo sites and new factors as they get introduced in the future.

8.2.3. Results regarding Module 4: the ANOVA test

ANOVA test (Analysis of Variance) for Travellers is applied in this analysis to determine if some **socio-demographic profiles** (per age, gender, incomes level, residential area, travelling with a dependent person, professional status, disability, and familiarity with technology) show significant differences regarding the satisfaction with **second level benefits**[3] based on the data gathered through the **USI travellers survey** [5]. Table 8 shows the socio-demographic profiles and the second-level benefits with significant differences regarding satisfaction:

Table 9. Significant socio-demographic variables and their associated factors among the top 10 variables in the ANOVA test (Athens)

8.2.4. Results regarding Module 5: USI travellers, TSPs, and EFFECTIVENESS

As detailed in D3.3, values of USI travellers and USI TSPs are required for the calculation of the Effectiveness.

8.2.4.1. Results of USI travellers

After applying the Eq. 2 of D3.3[9] [21] for the calculation of the variable "**USI Travellers**", which mainly considers the average satisfaction with relevant benefits shown by travellers (through the **USI Travellers survey)**[5] belonging to several profiles regarding functionalities offered by involved TSPs**,** it can be concluded that those sets (profiles, functionality, TSP) achieving the highest satisfaction are the next:

Significant socio-demographic factors (profiles)	Significant factors
Income (low-income profiles)	Providing affordable and cheap offers for travellers with Mobility packages function
Travelling weekly with a dependent person (all profiles)	General satisfaction with the Trip-sharing function
Income (all profiles)	Providing a safe trip with Trip sharing function
Income (all profiles)	General satisfaction with the Preferences and Profiles function
Income (all profiles)	Increase in the usability and fast handling of the application by traveller with the Preferences and Profiles function
Income (all profiles)	General satisfaction with the Intermodal fare optimization function
Income (all profiles)	Cost-saving with Intermodal fare optimization function
Income (low-income profiles)	Cost-saving with Intermodal fare optimization function

Table 10. Values of the top 10 sets (Profiles, Functionality, TSP) regarding the USI Traveller in the Athens demo site

No.	Name of variable	Value
1	USI Traveller_r1J9K2	1
2	USI Traveller_r1J17K3	0.9
3	USI Traveller_r2J17K3	0.9
4	USI Traveller_r2J4K3	0.9
5	USI Traveller_r1J4K3	0.85
6	USI Traveller_r1J16K3	0.85
7	USI Traveller_r1J17K1	0.85
8	USI Traveller_r1J19K3	0.84

[9] $USI_{Traveller_{rjk}} = \frac{\sum_{w=1}^{m_{rjk}} \sum_{v=1}^{n_{1jk}+n_{2jk}{}^{r}} Score\ question_{wv}}{m_{rjk} \cdot (n_{1jk} + n_{2jk}{}^{r}) \cdot 5}$

9	USI Traveller_r1J3K4	0.84
10	USI Traveller_r1J18K3	0.84

As it is shown in the aforementioned table **Error! Reference source not found.**, the highest value of USI travellers belongs to, the **Navigation** functionality provided by **MIRAKLIO** for **all profiles** (r1J9K2), the **Intermodal fare optimization** functionality provided by **Taxiway** for **all profiles** and **low-income profiles** (r1J17K3) and (r2J17K3) respectively, the **Mobility packages** functionality provided by **Taxiway** for **low-income profiles** and **all profiles** (r2J4K3) and (r1J4K3) respectively, the **Travel Companion** web-portal functionality provided by **Taxiway** for **all profiles** (r1J16K3), the **Intermodal fare optimization** provided by **OASA** for **all profiles** (r1J17K1), **the Map content** functionality provided by **Taxiway** for **all profiles** (r1J19K3), the **Issuing functionality** provided by **Brainbox** for **all profiles** (r1J3K4) and the **Smart location** functionality provided by **Taxiway** for **all profiles** (r1J18K3).

8.2.4.2. Results of USI TSPs

After applying the Eq.3 of D3.3[10] for the calculation of the variable "**USI TSP**", which mainly considers the average of the satisfaction with relevant benefits shown by TSPs (through the **USI TSP survey)** regarding functionalities of the Travel Companion**,** it can be concluded that those sets (functionality, TSP) achieving the highest satisfaction are the next:

Table 11. Values of the top 10 sets (functionality, TSP)regarding USI TSPs in the Athens demo site

No.	Name of variable	Value
1	USI TSP_J29K3	0.9
2	USI TSP_J33K3	0.86
3	USI TSP_J24K1	0.76
4	USI TSP_J30K1	0.73
5	USI TSP_J23K2	0.7
6	USI TSP_J25K3	0.68
7	USI TSP_J25K1	0.68
8	USI TSP_J31K1	0.66
9	USI TSP_J24K2	0.66
10	USI TSP_J33K2	0.66

As it is shown in the aforementioned table **Error! Reference source not found.**, the highest value of USI TSPs belongs to, the Travellers Orchestration and supervision functionality provided to Taxiway (J29K3), the Specific messages functionality provided to Taxiway (J33K3), the Location-Based Experience tool provided to OASA (J24K1), the Distributed Ledger – Transaction Anchoring provided to OASA (J30K1), the Asset Manager tool provided to MIRAKLIO (J23K2), the Contractual Management Market Place provided to Taxiway and OASA (J25K3) and (J25K1), the Distributed

[10] $USI_{TSP_{jK}} = \frac{\sum_1^{m_{jk}} \sum_{v=1}^{n_j} Score\ question_v}{m_{jk} \cdot n_j \cdot 5}$

Ledger – TSP Inclusion provided to OASA (J31K1), the Location-Based Experience tool provided to MIRAKLIO (J24K2) and the Specific messages provided to MIRAKLIO (J33K2).

8.2.4.3. Results of EFFECTIVENESS

Considering the values of **USI traveller**, **USI TSPs,** and **operational KPIs** in the **Athens** demo site, and applying Eq.1 in D3.3[11], those sets (Profile, Functionality, TSP) with the highest values of the "Effectiveness" are the next:

Table 12. Values of the top 10 sets (Profile, Functionality, TSP) in terms of Effectiveness in Athens (travellers functionalities)

No.	Name of Variable	Value
1	Effectiveness_r1J9K2	1
2	Effectiveness_r2J4K3	0.95
3	Effectiveness_r1J4K3	0.92
4	Effectiveness_r2J4K1	0.90
5	Effectiveness_r1J12K2	0.9
6	Effectiveness_r1J12K3	0.9
7	Effectiveness_r1J17K3	0.9
8	Effectiveness_r2J17K3	0.9
9	Effectiveness_r1J4K1	0.89
10	Effectiveness_r1J12K1	0.88

As it is shown in the aforementioned table (Table 11), the top 10 variables, in terms of Effetiveness, for the TC functionalities that are provided to travellers belong to, the Navigation functionality provided by MIRAKLIO for all profiles (r1J9K2), the Mobility packages functionality provided by Taxiway for low-income profiles and all profiles (r2J4K3) and (r1J4K3) respectively, the Mobility packages functionality provided by OASA for low-income profiles (r2J4K1), the Guest user provided by MIRAKLIO and Taxiway for all profiles (r1J12K2) and (r1J12K3), the Intermodal fare optimization functionality provided by Taxiway for all profiles and low-income profiles(r1J17K3) and (r2J17K3) respectively, the mobility packages provided by OASA for all profiles (r1J4K1), and the Guest user functionality provided by OASA for all profiles (r1J12K1).

On the other hand, taking into account the values of USI traveller, USI TSPs, and operational KPIs in the Athens demo site, the top 10 variables in terms of the concept of Effectiveness for the case of TSPs are shown in the following table (**Error! Reference source not found.**):

[11] $Effectiveness_{rjk} = \frac{\sum_{n=1}^{N} KPI_{n_{jk}} + USI_{Traveler_{rjk}} + USI_{TSP_{jk}}}{N + \delta_{Traveller} + \delta_{TSP}}$

Table 13. Values of the top 10 variables in terms of Effectiveness in the Athens (TSPs functionalities)

No.	Name of Variable	Value
1	Effectiveness_J23K3	1
2	Effectiveness_J29K3	0.9
3	Effectiveness_J25K1	0.89
4	Effectiveness_J25K3	0.89
5	Effectiveness_J33K3	0.86
6	Effectiveness_J23K2	0.85
7	Effectiveness_J23K1	0.82
8	Effectiveness_J24K1	0.766
9	Effectiveness_J30K1	0.73
10	Effectiveness_J31K1	0.66

As it is illustrated in the abovementioned table (Table 12), the **top 10 variables**, in terms of **Effectiveness**, for the **TC functionalities** that are provided to **TSPs** belong to, the **Asset manager tool** and **Travellers Orchestration and supervision** provided to **Taxiway** (J23K3) and (J29K3) respectively, the **Travellers Orchestration and supervision** provided to **OASA** and **Taxiway** (J25K1) and (J25K3), the **Specefic messages** provided to **Taxiway** (J33K3), the **Asset manager tool** provided to **MIRAKLIO** and **OASA** (J23K2) and (J23K1) respectively, the **LBE tool** provided to **OASA** (J24K1), the Distributed Ledger – Transaction Anchoring and Distributed Ledger – TSP Inclusion provided to OASA (J30K1) and (J31K1) respectively.

8.3. The results of the Padua demo site phase II

8.3.1. Results regarding Module 2: Regression analysis

As detailed in D6.2[3], the regression analysis is done as a previous step to identify **Second level Benefits**[12] highly correlated in a way that the heuristic process followed by the Bayesian Network Analysis (Module 3) already starts from learned networks, achieving better results in less time. The p-value in the following two pair variables is less than 0.05 (p-value<0.05), which means there is a high correlation between them.

The results of this Regression analysis are based on data gathered through **USI Travellers surveys** and they are shown in the following for the case of the **Padua** demo site:

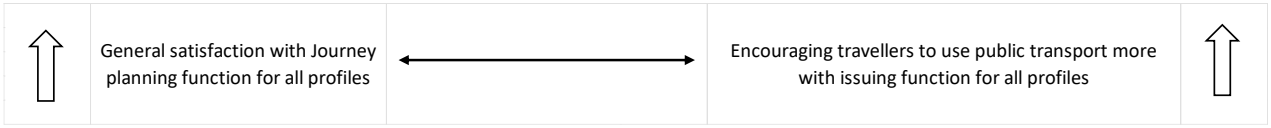
[12] **Second level benefits** are more detailed factors, clustered inside each of the first level benefits or factors level 1, with an influence on the usage of IP4 functionalities.

- As it is shown in the figure, increasing the “General satisfaction with Guest user function for all profiles” will increase indirectly the “Fast access to the TC APP and basic functionalities with Guest user function for all profiles”.

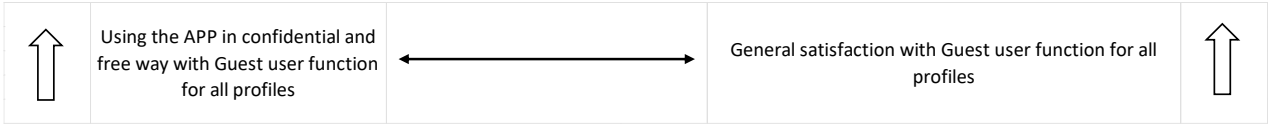
- As it is shown in the figure, increasing the “Helping travellers to make appropriate travel decisions with Journey planning function for all profiles” will increase indirectly the “Cost-saving with Issuing function for all profiles”.

- As it is shown in the figure, increasing the “Willing to pay for Trip sharing function for all profiles” will increase indirectly the “Participation and involvement to transport service offers and submit feedback through APP with Traveller's feedback function for all profiles”.

- As it is shown in the figure, increasing the “Time-saving with Journey planning function for all profiles” will increase indirectly the “Cost-saving with Journey planning function for all profiles”.



- As it is shown in the figure, increasing the “General satisfaction with Journey planning function for all profiles” will increase indirectly the “Encouraging travellers to use public transport more with issuing function for all profiles”.

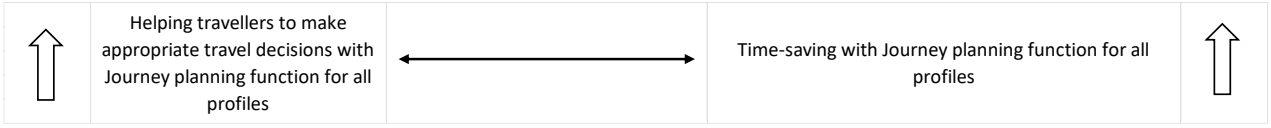


- As is shown in the figure, increasing the “Using the APP in a confidential and free way with Guest user function for all profiles” will increase indirectly the “General satisfaction with Guest user function for all profiles”.

- As it is shown in the figure, increasing the “General satisfaction with Navigation function for all profiles” will increase indirectly the “Time-saving with Navigation function for all profiles”.

- As is shown in the figure, increasing the “Time-saving with issuing function for all profiles” will increase indirectly the “Helping travellers to make appropriate travel decisions with Journey planning function for all profiles”.

- As it is shown in the figure, increasing the “Time-saving with issuing function for all profiles” will increase indirectly the “Increase trip security with Issuing function for all profiles”.



- As it is shown in the figure, increasing the “Helping travellers to make appropriate travel decisions with Journey planning function for all profiles” will increase indirectly the “Time-saving with Journey planning function for all profiles”.

The output from regression analysis will now be introduced as a forced connection into the BN analysis. This is done to establish consistency in the correlations in the output generated by the BN analysis since the operation is done on a limited number of iterations to produce combinations and relationships among variables in the BN analysis. Considering what has been discussed so far, based on the output of regression analysis the correlations established between variables do not contradict the correlation established by the BN analysis, since the operation is done on the same

data values for each variable respectively. Hence, there is no possibility of the graph from the BN analysis to have cyclic connections between the variables upon the introduction of forced connections.

8.3.2. Results regarding Module 3: Bayesian network analysis and BELLMAN shortest path

The output of BN analysis from the **Padua** demo site indicates what are the **more influent second-level benefits**[3] for the acceptance by **users** of IP4 functionalities offered by TSPs considered in the **Padua** demo site, taking into consideration the **Bayes score** and **cumulative weights** (Table 13):

Table 14. Top second-level benefits according to BN analysis in the Padua demo site

Normalized Weight	Code of factors	Definition of factors
0.046	r1J1KPI2	Average number of shopped offers with the journey planning function
0.038	r1J12q3	Giving instant and fast access to TC APP without registration with guest user function for all profiles
0.038	r1J1KPI1	The average number of modes involved in the journey with the journey planning function
0.033	r1J10q2	Encouraging travellers to participate in public transport services offers and submit comments and feedback through TC APP with traveller's feedback function for all profiles
0.032	r1J11q1	General satisfaction with trip sharing function for all profiles
0.030	r1J11q3	Willing to pay for trip sharing function for all profiles
0.029	r1J12q2	Giving freedom to the travellers to use the TC APP in a confidential way with guest user function for all profiles

Impact assessment/predictions of correlated variables:

The main reason for identifying and analysing correlations among various factors associated with respective demo sites is to carry out an impact assessment of these variables individually through predictive simulations. These simulations give us an insight into assessing the overall impact of an investment made on improving a certain factor at a demo site. The study through these simulations becomes the basis of decision-making at a high level for various stakeholders involved in the project. The methodology used in these predictive simulations is as follows:

1. Identification of the most impactful variables/factors.
The first step in the process is to find out the variables/factors with the highest weight from the BN and AHP analysis.

2. Among the top second-level variables, the top 3 variables with the highest weight are set aside and used as the factors to focus on to see the impact of each of them on the other remaining variables.

3. One by one, each of the three chosen variables are selected and simulations are conducted to see the impact of this factor on the other correlated variables when the factor through investment and improvement of service are improved. The range of simulation begins with “Most probable value before investment” (Their original score - 1, 2, 3, 4, based on the survey data) and goes all the way up to “Most probably score after investment” (The highest score of 5)

4. Based on the above simulations the assessment tries to find out if the investment to improve this factor has a positive or a negative impact on the other correlated factors.

The above methodology of simulations has been designed to work with changing and scaling datasets in the future. The design of simulations makes them easily replicable to new demo sites and new factors as they get introduced in the future.

For the purpose of demonstration, an example of one of the demo sites “Padua” has been taken to clearly state the utility of conducting simulations. Following the above 4 steps of methodology, conduction simulations for factors associated with the demo site “Padua”:
1. Identification of the most impactful variables/factors in the Padua demo site:
Following are the top second-level factors according to their BN weights in the Padua demo site: J12K5q3, J10K5q2, J11K5q1, J11K5q3, and J12K5q2. The meaning and definition of these factors are already introduced in Table 35.

2. The top 3 factors as per their BN weights in the Padua demo site are as follows: J12K5q3, J10K5q2, and J11K5q1. The meaning and definition of these factors are already introduced in Table 35.

3. The simulation results of each top 3 factors from step 2 are shown and illustrated in the following Excel spreadsheet:

J12K5q3		J10K5q2						
Most probable value BEFORE investment	Most probable value AFTER investment	Probability to get a score between 1-4 BEFORE investment	Probability to get a score between 1-4 AFTER investment	Gradient	Probability to get a score between 5-8 BEFORE investment	Probability to get a score between 5-8 AFTER investment	Gradient	KPI
4	5	0.153846	NaN	NaN	0.846154	NaN	NaN	Not a good investment
		J11K5q1						
		Probability to get a score between 1-4 BEFORE investment	Probability to get a score between 1-4 AFTER investment	Gradient	Probability to get a score between 5-8 BEFORE investment	Probability to get a score between 5-8 AFTER investment	Gradient	KPI
		0.153846	NaN	NaN	0.846154	NaN	NaN	Not a good investment
		J11K5q3						
		Probability to get a score between 1-4 BEFORE investment	Probability to get a score between 1-4 AFTER investment	Gradient	Probability to get a score between 5-8 BEFORE investment	Probability to get a score between 5-8 AFTER investment	Gradient	KPI
		0.0769231	NaN	NaN	0.923077	NaN	NaN	Not a good investment
		J12K5q2						
		Probability to get a score between 1-4 BEFORE investment	Probability to get a score between 1-4 AFTER investment	Gradient	Probability to get a score between 5-8 BEFORE investment	Probability to get a score between 5-8 AFTER investment	Gradient	KPI
		0.153846	NaN	NaN	0.846154	NaN	NaN	Not a good investment

J10K5q2		J12K5q3						
Most probable value BEFORE investment	Most probable value AFTER investment	Probability to get a score between 1-4 BEFORE investment	Probability to get a score between 1-4 AFTER investment	Gradient	Probability to get a score between 5-8 BEFORE investment	Probability to get a score between 5-8 AFTER investment	Gradient	KPI
4	5	0.230769	NaN	NaN	0.769231	NaN	NaN	Not a good investment
		J11K5q1						
		Probability to get a score between 1-4 BEFORE investment	Probability to get a score between 1-4 AFTER investment	Gradient	Probability to get a score between 5-8 BEFORE investment	Probability to get a score between 5-8 AFTER investment	Gradient	KPI
		0.153846	NaN	NaN	0.846154	NaN	NaN	Not a good investment
		J11K5q3						
		Probability to get a score between 1-4 BEFORE investment	Probability to get a score between 1-4 AFTER investment	Gradient	Probability to get a score between 5-8 BEFORE investment	Probability to get a score between 5-8 AFTER investment	Gradient	KPI
		0.0769231	NaN	NaN	0.923077	NaN	NaN	Not a good investment
		J12K5q2						
		Probability to get a score between 1-4 BEFORE investment	Probability to get a score between 1-4 AFTER investment	Gradient	Probability to get a score between 5-8 BEFORE investment	Probability to get a score between 5-8 AFTER investment	Gradient	KPI
		0.153846	NaN	NaN	0.846154	NaN	NaN	Not a good investment

J11K5q1		J12K5q3						
Most probable value BEFORE investment	Most probable value AFTER investment	Probability to get a score between 1-4 BEFORE investment	Probability to get a score between 1-4 AFTER investment	Gradient	Probability to get a score between 5-8 BEFORE investment	Probability to get a score between 5-8 AFTER investment	Gradient	KPI
3	5	0.230769	NaN	NaN	0.769231	NaN	NaN	Not a good investment
		J10K5q2						
		Probability to get a score between 1-4 BEFORE investment	Probability to get a score between 1-4 AFTER investment	Gradient	Probability to get a score between 5-8 BEFORE investment	Probability to get a score between 5-8 AFTER investment	Gradient	KPI
		0.153846	NaN	NaN	0.846154	NaN	NaN	Not a good investment
		J11K5q3						
		Probability to get a score between 1-4 BEFORE investment	Probability to get a score between 1-4 AFTER investment	Gradient	Probability to get a score between 5-8 BEFORE investment	Probability to get a score between 5-8 AFTER investment	Gradient	KPI
		0.0769231	NaN	NaN	0.923077	NaN	NaN	Not a good investment
		J12K5q2						
		Probability to get a score between 1-4 BEFORE investment	Probability to get a score between 1-4 AFTER investment	Gradient	Probability to get a score between 5-8 BEFORE investment	Probability to get a score between 5-8 AFTER investment	Gradient	KPI
		0.153846	NaN	NaN	0.846154	NaN	NaN	Not a good investment

4. The aforementioned results give a high-level view of the impact of an investment made on the chosen 3 factors for the Padua demo site.
As mentioned the predictive simulation models used for assessing the impact of investment on these factors become important for decision making for the stakeholders involved in the Padua demo site.

8.3.3. Results regarding Module 4: the ANOVA test

ANOVA test (Analysis of Variance) for Travellers is applied in this analysis to determine if some **socio-demographic profiles** (per age, gender, incomes level, residential area, travelling with a dependent person, professional status, disability, and familiarity with technology) show significant differences regarding the satisfaction with **second level benefits**[3] based on the data gathered through the **USI travellers survey**. Table 14 shows the socio-demographic profiles and the second-level benefits with significant differences regarding satisfaction:

Table 15. Significant socio-demographic variables and their associated factors among the top 10 variables in the ANOVA test (Padua)

Significant socio-demographic factors (profiles)	Significant factors
Income (all profiles)	General satisfaction with the Trip-sharing function

8.3.4. Results regarding Module 5: USI travellers, TSPs, and EFFECTIVENESS

As detailed in D3.3, values of USI travellers and USI TSPs are required for the calculation of the Effectiveness.

8.3.4.1. Results of USI travellers

After applying the Eq. 2 of D3.3[13] for the calculation of the variable "**USI Travellers**", which mainly considers the average of the satisfaction with relevant benefits shown by travellers (through the **USI Travellers survey)** belonging to several profiles regarding functionalities offered by involved TSPs**,** it can be concluded that those sets (profiles, functionality, TSP) achieving the highest satisfaction are the next:

Table 16. Values of the top 10 sets (Profiles, Functionality, TSP) regarding the USI Traveller in the Padua demo site

No.	Name of variable	Value
1	USI Traveller_r1J10K6	0.9
2	USI Traveller_r1J11K5	0.83
3	USI Traveller_r1J12K5	0.8
4	USI Traveller_r1J11K6	0.8

[13] $USI_{Traveller_{rjk}} = \frac{\sum_{w=1}^{m_{rjk}} \sum_{v=1}^{n_{1jk}+n_{2jk}{}^{r}} Score\ question_{wv}}{m_{rjk} \cdot (n_{1jk} + n_{2jk}{}^{r}) \cdot 5}$

5	USI Traveller_r1J9K6	0.76
6	USI Traveller_r1J15K5	0.76
7	USI Traveller_r1J2K5	0.75
8	USI Traveller_r1J10K5	0.75
9	USI Traveller_r1J13K6	0.75
10	USI Traveller_r1J13K5	0.75

As it is shown in the aforementioned table (Table 15), the highest value of USI travellers belongs to, the **Traveller's feedback** functionality provided by **Busitalia** for **all profiles** (r1J10K6), the **Trip sharing and Guest user** functionality provided by **Trenitalia** for **all profiles** (r1J11K5) and (r1J12K5) respectively, the **Trip sharing** functionality provided by **Busitalia** for **all profiles** (r1J11K6), the **Navigation** functionality provided by **Busitalia** for **all profiles** (r1J9K6), the **Collaborative space portal for travellers functionality** provided by **Trenitalia** for **all profiles** (r1J15K5), the **Booking** functionality provided by **Trenitalia** for **all profiles** (r1J2K5), the **Traveller's feedback** functionality provided by **Trenitalia** for **all profiles** (r1J10K5) and the **Preferences and profiles** functionality provided by **Busitalia and Trenitalia** for **all profiles** (r1J13K6) and (r1J13K5) respectively.

8.3.4.2. Results of USI TSPs

After applying the Eq.3 of D3.3[14] for the calculation of the variable "**USI TSP**", which mainly considers the average of the satisfaction with relevant benefits shown by TSPs (through the **USI TSP survey)** regarding functionalities of the Travel Companion**,** it can be concluded that those sets (functionality, TSP) achieving the highest satisfaction are the next:

Table 17. Values of the top 5 sets (functionality, TSP)regarding USI TSPs in the Padua demo site

No.	Name of variable	Value
1	USI TSP_J28K5	0.8
2	USI TSP_J23K5	0.75
3	USI TSP_J33K5	0.73
4	USI TSP_J23K6	0.7
5	USI TSP_J33K6	0.6

As it is shown in the aforementioned table Table 16, the highest value of USI TSPs belongs to, the **Collaborative space portal** provided to **Trenitalia** (J28K5), the **Asset manager tool** provided to **Trenitalia** (J23K5), the **Specific messages** provided to **Trenitalia** (J33K5), the **Asset manager tool** provided to **Busitalia** (J23K6), and the **Specific messages** provided to **Busitalia** (J33K6).

8.3.4.3. Results of EFFECTIVENESS

Considering the values of **USI traveller**, **USI TSPs,** and **operational KPIs** in the **Athens** demo site,

[14] $USI_{TSP_{jK}} = \frac{\sum_1^{m_{jk}} \sum_{v=1}^{n_j} Score\ question_v}{m_{jk} \cdot n_j \cdot 5}$

and applying Eq.1 in D3.3[15], those sets (Profile, Functionality, TSP) with the highest values of the "Effectiveness" are the next:

Table 18. Values of the top 10 sets (Profile, Functionality, TSP) in terms of Effectiveness in Padua (travellers functionalities)

No.	Name of Variable	Value
1	Effevtiveness_r1J10K6	0.9
2	Effevtiveness_r1J11K5	0.83
3	Effevtiveness_r1J11K6	0.8
4	Effevtiveness_r1J12K5	0.8
5	Effevtiveness_r1J9K6	0.76
6	Effevtiveness_r1J15K5	0.76
7	Effevtiveness_r1J10K5	0.75
8	Effevtiveness_r1J13K5	0.75
9	Effevtiveness_r1J13K6	0.75
10	Effevtiveness_r1J9K5	0.74

As it is shown in the aforementioned table (**Error! Reference source not found.**), the **top 10 variables**, in terms of **Effectiveness**, for the **TC functionalities** that are provided to **travellers** belong to, the **Traveller's feedback** functionality provided by **Busitalia** for **all profiles** (r1J10K6), the **Trip sharing** functionality provided by **Trenitalia** and **Busitalia** for **all profiles** (r1J11K5) and (r1J11K6) respectively, the **Guest user** functionality provided by **Trenitalia** for **all profiles** (r1J12K5), the **Navigation** provided by **Busitalia** for **all profiles** (r1J9K6), the **Collaborative space portal** functionality provided by **Trenitalia** for **all profiles** (r1J15K5), the **Traveller's feedback** functionality provided by **Trenitalia** for **all profiles** (r1J10K5), the **Preferences and profiles** functionality provided by **Trenitalia** and **Busitalia** for **all profiles**(r1J13K5) and (r1J13K6) respectively, and **Navigation** functionality provided by **Trenitalia** to **all profiles** (r1J9K5).

On the other hand, taking into account the values of USI traveller, USI TSPs, and operational KPIs in the Padua demo site, the top 5 variables in terms of the concept of Effectiveness for the case of TSPs are shown in the following table (**Error! Reference source not found.**):

Table 19. Values of the top 5 variables in terms of Effectiveness in the Padua (TSPs functionalities)

No.	Name of Variable	Value
1	Effectiveness_J23K5	0.87
2	Effectiveness_J23K6	0.85
3	Effectiveness_J28K5	0.8
4	Effectiveness_J33K5	0.73

[15] $Effectiveness_{rjk} = \frac{\sum_{n=1}^{N} KPI_{n_{jk}} + USI_{Traveler_{rjk}} + USI_{TSP_{jk}}}{N + \delta_{Traveller} + \delta_{TSP}}$

5	Effectiveness_J33K6	0.6

As it is illustrated in the abovementioned table (Table 18), the **top 5 variables**, in terms of **Effectiveness**, for the **TC functionalities** that are provided to **TSPs** belong to, the **Asset manager tool** provided to **Trenitalia and Busitalia** (J23K5) and (J23K6) respectively, the **collaborative space portal** provided to **Trenitalia** (J28K5), the **Specific messages** tool provided to **Trenitalia** and **Busitalia** (J33K5) and (J33K6) respectively.

8.4. The results of the Warsaw demo site phase II

8.4.1. Results regarding Module 1: AHP (Analytic Hierarchy Process) and pairwise comparison matrix.

In the following figures the hierarchical model for both travellers and TSPs in the Warsaw demo site is illustrated:

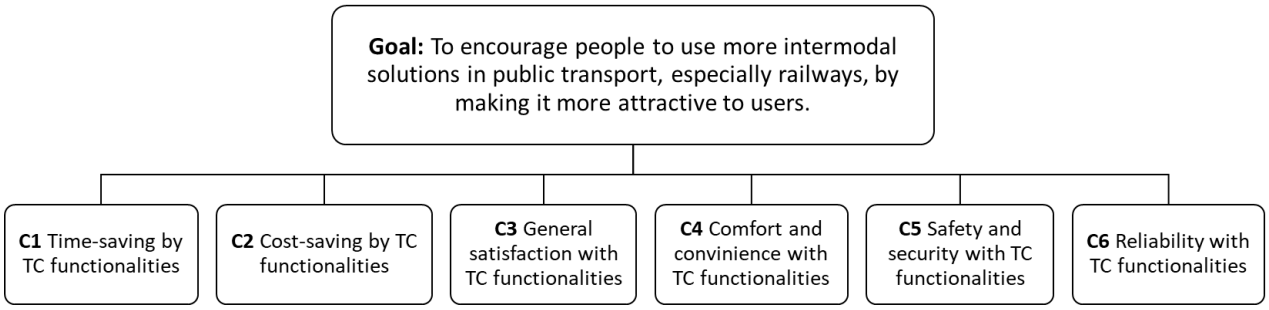


Figure 5. Hierarchical model for travellers (Warsaw)

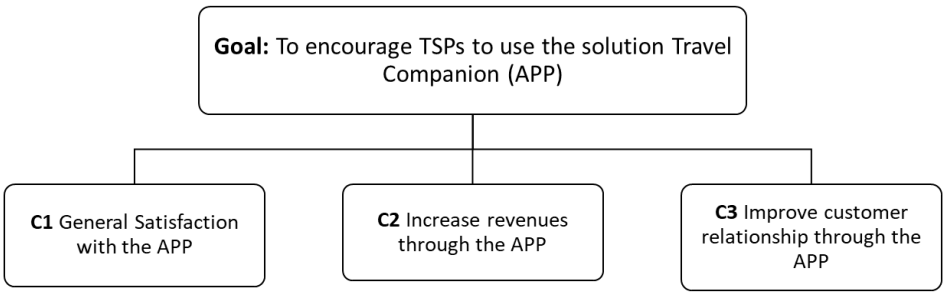


Figure 6. Hierarchical model for TSPs (Warsaw)

After removing inconsistent values from the data[16], the rank of each criterion (first level benefit[1]) considering its weight and a graphical representation is shown in Tables 19 and 20 and Figures 7 and 8 respectively:

[16] Those with CR>0.01. See Eq. 1 in Deliverable D 6.2 TOOL FOR PERFORMANCE ASSESSMENT

Table 20. Global weights of travellers in AHP (Warsaw)

CL1 (Travellers)	Description	Weight	Rank
C1	Time-saving by TC functionalities	0.26	1
C2	Cost-saving by TC functionalities	0.19	3
C3	General satisfaction with TC functionalities	0.08	5
C4	Comfort with TC functionalities	0.04	6
C5	Safety and Security with TC functionalities	0.19	4
C6	Reliability with TC functionalities	0.21	2

Table 21. Global weights of TSPs in AHP (Warsaw)

CL1 (TSPs)	Description	Weight	Rank
C1	General Satisfaction with the APP	0.16	3
C2	Increased revenues through the APP	0.26	2
C3	Improve customer relationships through the APP	0.56	1

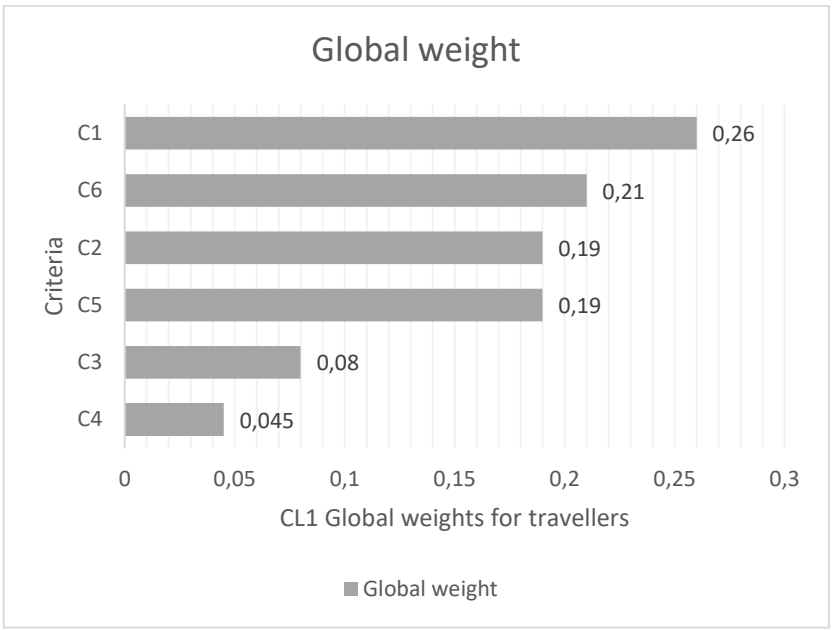


Figure 7. Graphical representation of global weight for travellers (Warsaw)

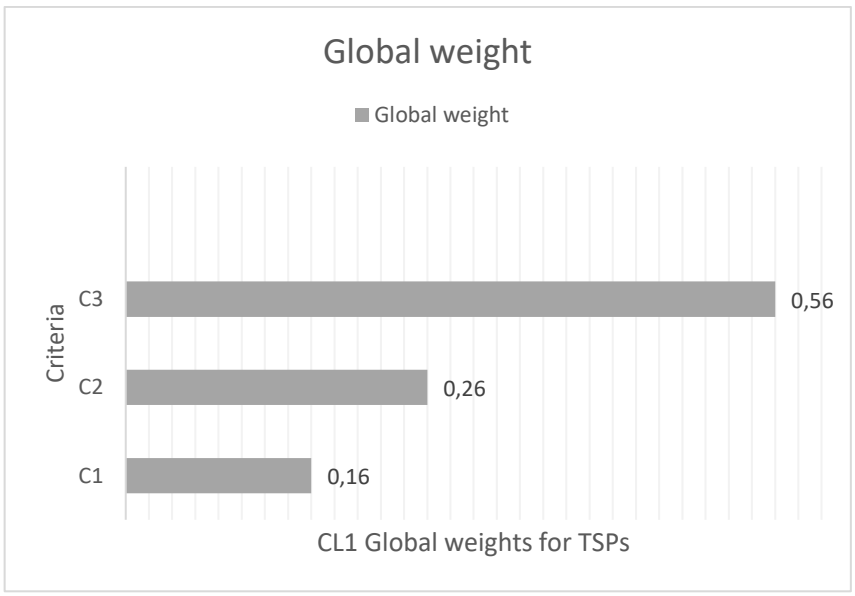


Figure 8. Graphical representation of global weight for TSPs (Warsaw)

Considering the above data for **Warsaw:**

For TRAVELLERS: Time-saving, reliability and Cost-saving benefits, with the Travel Companion (TC) APP have got the highest importance and weights among other criteria or first-level factors. For **TSPs: Improving customer relationships, General satisfaction,** and **Increased revenues through the TC APP** were the most significant criteria.

8.4.2. Results regarding Module 2: Regression analysis

As detailed in D6.2[3], the regression analysis is done as a previous step to identify **Second level Benefits**[17] highly correlated in a way that the heuristic process followed by the Bayesian Network analysis (Module 3) already starts from learned networks, achieving better results in less time. The p-value in the following two pair variables is less than 0.05 (p-value<0.05), which means there is a high correlation between them.

The results of this Regression analysis are based on data gathered through **USI Travellers surveys** and they are shown in the following for the case of the **Warsaw** demo site:

- As it is shown in the figure, increasing the "General satisfaction with **Traveller's feedback** function for all profiles" will increase indirectly the "Encouraging to participate in Public Transport Service's offers and submit comments and feedback through APP with **Traveller's feedback** function for all profiles".

- As it is shown in the figure, an increase in the "Giving easier access to the basic function of TC APP with **Guest user** function for **Elderly**" will increase indirectly the "Helping travellers to make appropriate travel decisions with **Journey planning** function for **all profiles**".

- As is shown in the figure, an increase in the "General satisfaction with **Navigation** function for **all profiles**" will increase indirectly the "Time-saving with **Navigation** function for **all profiles**".

[17] **Second level benefits** are more detailed factors, clustered inside each of the first level benefits or factors level 1, with an influence on the usage of IP4 functionalities.

- As it is shown in the figure, an increase in the "Making the boarding easier by using smartphone with using **digital onboarding** function for **all profiles**" will increase indirectly the "General satisfaction with **digital onboarding** function for **all profiles**".

- As it is shown in the figure, an increase in the "Giving easier access to the basic function of TC APP with **Guest user** function for **Elderly**" will increase indirectly the "Helping to find most cost-efficient route with **Journey planning** for **low-income profiles**".

The output from regression analysis will now be introduced as a forced connection into the BN analysis. This is done to establish consistency in the correlations in the output generated by the BN analysis since the operation is done on a limited number of iterations to produce combinations and relationships among variables in the BN analysis. Considering what has been discussed so far, based on the output of regression analysis the correlations established between variables do not contradict the correlation established by the BN analysis, since the operation is done on the same data values for each variable respectively. Hence, there is no possibility of the graph from the BN analysis to have cyclic connections between the variables upon the introduction of forced connections.

8.4.3. Results regarding Module 3: Bayesian network analysis and BELLMAN shortest path

The output of BN analysis from the **Warsaw** demo site indicates what are the **more influent second level benefits**[3] for the acceptance by **users** of IP4 functionalities offered by TSPs considered in the **Warsaw** demo site, taking into consideration the **Bayes score** and **cumulative weights** (Table 21):

Table 22. Top second-level benefits according to BN analysis in the Warsaw demo site

Normalized Weight	Code of factors	Definition of factors
0.013	r1J11q2	Providing safe trips with trip sharing function for all profiles
0.012	r1J11q1	General satisfaction with trip sharing function for all profiles
0.012	r1J11q3	Willing to pay for trip sharing function for all profiles
0.012	r1J1KPI1	The average number of modes involved in the journey with the journey planning function
0.012	r1J21q1	General satisfaction with the travel arrangement function for all profiles
0.012	r3J1q7	Providing safety with journey planning function for disabled profiles

Impact assessment/predictions of correlated variables:

The main reason for identifying and analysing correlations among various factors associated with respective demo sites is to carry out an impact assessment of these variables individually through predictive simulations. These simulations give us an insight into assessing the overall impact of an investment made on improving a certain factor at a demo site. The study through these simulations becomes the basis of decision-making at a high level for various stakeholders involved in the project. The methodology used in these predictive simulations is as follows:

1. Identification of the most impactful variables/factors.
The first step in the process is to find out the variables/factors with the highest weight from the BN and AHP analysis.

2. Among the top second-level variables, the top 3 variables with the highest weight are set aside and used as the factors to focus on to see the impact of each of them on the other remaining variables.

3. One by one, each of the three chosen variables are selected and simulations are conducted to see the impact of this factor on the other correlated variables when the factor through investment and improvement of service are improved. The range of simulation begins with "Most probable value before investment" (Their original score - 1, 2, 3, 4, based on the survey data) and goes all the way up to "Most probably score after investment" (The highest score of 5)

4. Based on the above simulations the assessment tries to find out if the investment to improve this factor has a positive or a negative impact on the other correlated factors.

The above methodology of simulations has been designed to work with changing and scaling datasets in the future. The design of simulations makes them easily replicable to new demo sites and new factors as they get introduced in the future.

8.4.4. Results regarding Module 4: the ANOVA test

ANOVA test (Analysis of Variance) for Travellers is applied in this analysis to determine if some **socio-demographic profiles** (per age, gender, incomes level, residential area, travelling with a dependent person, professional status, disability, and familiarity with technology) show significant differences regarding the satisfaction with **second level benefits**[3] based on the data gathered through the **USI travellers survey**. Table 22 shows the socio-demographic profiles and the second-level benefits with significant differences regarding satisfaction:

Table 23. Significant socio-demographic variables and their associated factors among the top 10 variables in the ANOVA test (Warsaw)

Significant socio-demographic factors (profiles)	Significant factors
Profession status	Increase safety with Journey planning function for disabled profiles
Disability	Increase safety with Journey planning function for disabled profiles
Profession status	Providing a safe trip from a Covid-19 perspective for elderly profiles with Journey planning function
Disability	Providing a safe trip from a Covid-19 perspective for elderly profiles with Journey planning function

8.4.5. Results regarding Module 5: USI travellers, TSPs, and EFFECTIVENESS

As detailed in D3.3, values of USI travellers and USI TSPs are required for the calculation of the Effectiveness.

8.4.5.1. Results of USI travellers

After applying the Eq. 2 of D3.3[18] for the calculation of the variable "**USI Travellers**", which mainly considers the average of the satisfaction with relevant benefits shown by travellers (through the **USI Travellers survey)** belonging to several profiles regarding functionalities offered by involved TSPs**,** it can be concluded that those sets (profiles, functionality, TSP) achieving the highest satisfaction are the next:

Table 24. Values of the top 10 sets (Profiles, Functionality, TSP) regarding the USI Traveller in the Warsaw demo site

No.	Name of variable	Value
1	USI Traveller_r3J21K10	1
2	USI Traveller_r3J21K8	1
3	USI Traveller_r3J1K10	0.83
4	USI Traveller_r1J12K10	0.81
5	USI Traveller_r1J21K10	0.80
6	USI Traveller_r4J12K8	0.8
7	USI Traveller_r4J12K10	0.8
8	USI Traveller_r1J12K8	0.79

[18] $USI_{Traveller_{rjk}} = \frac{\sum_{w=1}^{m_{rjk}} \sum_{v=1}^{n_{1jk}+n_{2jk}{}^{r}} Score\ question_{wv}}{m_{rjk} \cdot (n_{1jk} + n_{2jk}{}^{r}) \cdot 5}$

9	USI Traveller_r1J12K9	0.79
10	USI Traveller_r1J21K9	0.79

As it is shown in the aforementioned table Table 23, the highest values of USI travellers belong to, the **Travel arrangement** functionality provided by **SKM** and **MZA** for **disabled profiles** (r3J21K10) and (r3J21K8) respectively, the **Journey planning** functionality provided by **SKM** for **disabled profiles** (r3J1K10), the **Guest user** functionality provided by **SKM** for **all profiles** (r1J12K10), the **Travel arrangement** functionality provided by **SKM** for **all profiles** (r1J21K10), the **Guest user** provided by **MZA and SKM** for **elderly profiles** (r4J12K8) and (r4J12K10) respectively, the **Guest user** functionality provided by **MZA and TW** for **all profiles** (r1J12K8) and (r1J12K9) respectively, and the **Travel arrangement** functionality provided by **TW** for **all profiles** (r1J21K9).

8.4.5.2. Results of USI TSPs

After applying the Eq.3 of D3.3[19] for the calculation of the variable "**USI TSP**", which mainly considers the average of the satisfaction with relevant benefits shown by TSPs (through the **USI TSP survey)** regarding functionalities of the Travel Companion**,** it can be concluded that those sets (functionality, TSP) achieving the highest satisfaction are the next:

Table 25. Values of the top set (functionality, TSP)regarding USI TSPs in the Warsaw demo site

No.	Name of variable	Value
1	USI TSP_J23K8	0.61

As it is shown in the aforementioned table Table 24, the value of USI TSPs belongs to, the **Asset manager tool** provided to **MZA** (J23K8).

8.4.5.3. Results of EFFECTIVENESS

Considering the values of **USI traveller**, **USI TSPs,** and **operational KPIs** in the **Athens** demo site, and applying Eq.1 in D3.3[20], those sets (Profile, Functionality, TSP) with the highest values of the "Effectiveness" are the next:

Table 26. Values of the top 10 sets (Profile, Functionality, TSP) in terms of Effectiveness in Warsaw (travellers functionalities)

No.	Name of Variable	Value
1	Effectiveness_r3J21K8	1
2	Effectiveness_r3J21K10	1
3	Effectiveness_r1J21K10	0.90

[19] $USI_{TSP_{jK}} = \frac{\sum_1^{m_{jk}} \sum_{v=1}^{n_j} Score\ question_v}{m_{jk} \cdot n_j \cdot 5}$

[20] $Effectiveness_{rjk} = \frac{\sum_{n=1}^{N} KPI_{n_{jk}} + USI_{Traveler_{rjk}} + USI_{TSP_{jk}}}{N + \delta_{Traveller} + \delta_{TSP}}$

4	Effectiveness_r1J21K9	0.89
5	Effectiveness_r1J21K8	0.89
6	Effectiveness_r2J1K9	0.84
7	Effectiveness_r1J1K9	0.82
8	Effectiveness_r3J1K9	0.82
9	Effectiveness_r5J1K9	0.82
10	Effectiveness_r1J12K10	0.81

As it is shown in the aforementioned table (Table 25), the **top 10 variables**, in terms of **Effectiveness**, for the **TC functionalities** that are provided to **travellers** belong to, the **Travel arrangement** functionality provided by **MZA and SKM** for **disabled profiles** (r3J21K8) and (r3J21K10) respectively, the **Travel arrangement** functionality provided by **SKM, TW, and MZA** for **all profiles** (r1J21K10), (r1J21K9), (r1J21K8) respectively, the **Journey planning** functionality provided by **TW** for **low-income people** (r2J1K9), the **Journey planning** provided by **TW** for **all profiles** (r1J1K9), the **Journey planning** functionality provided by **TW** for **disabled profiles and women profiles** (r3J1K9) and (r5J1K9) and, the **Guest user** provided by **SKM** for **all** profiles (r1J12K10).

On the other hand, taking into account the values of **USI traveller** , **USI TSPs,** and **operational KPIs** in the **Athens** demo site, the **top 10 variables in terms of the concept of Effectiveness** for the case of TSPs are shown in the following table (**Error! Reference source not found.**):

Table 27. Value of the variable in terms of Effectiveness in the Warsaw (TSPs functionalities)

No.	Name of Variable	Value
1	Effectiveness_J23K8	0.80

As it is illustrated in the abovementioned table (Table 26), in terms of **Effectiveness**, the **TC functionalities** that are provided to **TSPs** belong to, the **Asset Manager tool** provided to **MZA** (J23K8).

8.5. The results of the Liberec demo site phase II

8.5.1. Results regarding Module 1: AHP (Analytic Hierarchy Process) and pairwise comparison matrix

In the following figures the hierarchical model for both travellers and TSPs in the Liberec demo site is illustrated:

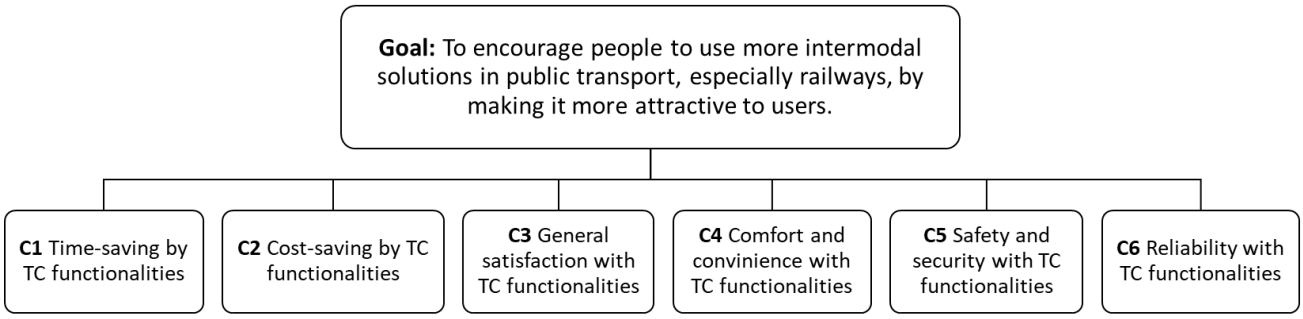


Figure 9. Hierachical model for travellers (Liberec)

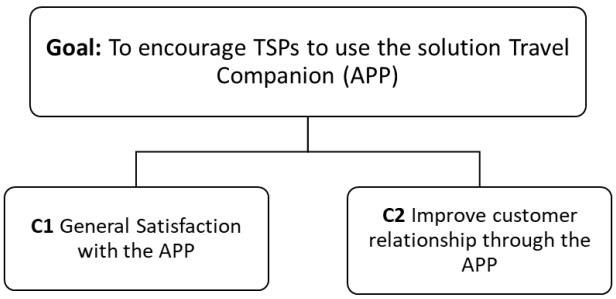


Figure 10. Hierarchical model for TSPs (Liberec)

After removing inconsistent values from the data[21], the rank of each criterion (first level benefit[1]) considering its weight and a graphical representation is shown in Table 27 and Figure 11 respectively:

[21] Those with CR>0.01. See Eq. 1 in Deliverable D 6.2 TOOL FOR PERFORMANCE ASSESSMENT

Table 28. Global weights of travellers in AHP (Liberec)

CL1 (Travellers)	Description	Weight	Rank
C1	Time-saving by TC functionalities	0.26	1
C2	Cost-saving by TC functionalities	0.23	2
C3	General satisfaction with TC functionalities	0.11	5
C4	Comfort with TC functionalities	0.04	6
C5	Safety and Security with TC functionalities	0.15	3
C6	Reliability with TC functionalities	0.13	4

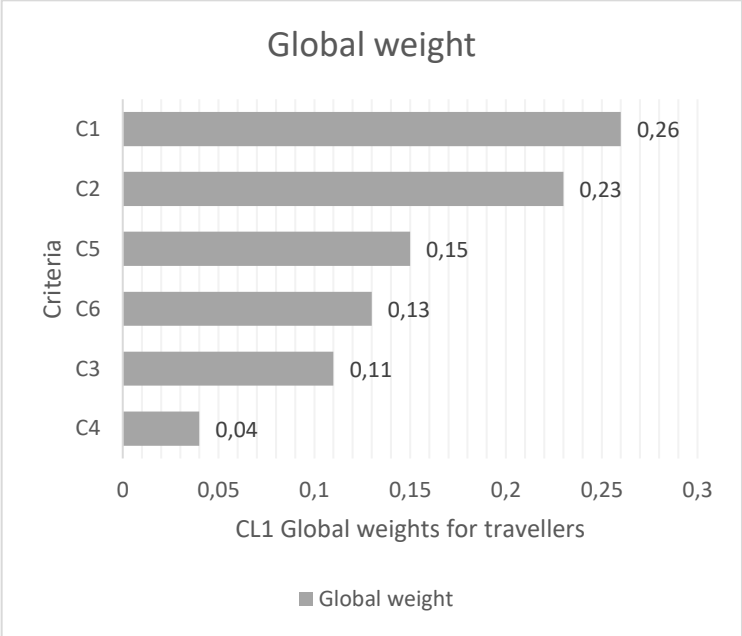


Figure 11. Graphical representation of global weight for travellers (Liberec)

Since in the calculation of the "Consistency Ratio," the Values of the Random Index (RI) for 2 criteria are equal to 0, and the value of the consistency ratio will be equal to indeterminate, the global weights for TSPs, in AHP analysis, for the Liberec demo site is not calculated.

$$CR = \frac{(\lambda max - n)/(n-1)}{RI}$$

Considering the above data for **Liberec:**

For TRAVELLERS: Time-saving, Cost-saving, and safety and security benefits, with the Travel Companion (TC) APP have got the highest importance and weights among other criteria or first-level factors.

8.5.2. Results regarding Module 2: Regression analysis

As detailed in D6.2[3], the regression analysis is done as a previous step to identify **Second level Benefits**[22] highly correlated in a way that the heuristic process followed by the Bayesian Network analysis (Module 3) already starts from learned networks, achieving better results in less time. The p-value in the following two pair variables is less than 0.05 (p-value<0.05), which means there is a high correlation between them.

The results of this Regression analysis are based on data gathered through **USI Travellers surveys** and they are shown in the following for the case of the **Liberec** demo site:

⇧	Providing safe trips and avoid crowds from perspective of the Covid-19 by **Journey planning** function for **elderly**	⟷	Providing comfort and comfortable trip with providing solutions by **trip tracking orchestration function** for **elderly**	⇧

- As it is shown in the figure, the increase in the "Providing safe trips and avoiding crowds from the perspective of the Covid-19 by **Journey planning** function for **elderly**" will increase indirectly the "Providing comfort and comfortable trip with providing solutions by **trip tracking orchestration** function for **elderly**".

⇧	Increase safety by **Journey planning** for **disabled profiles**	⟷	Providing comfort and comfortable trip with providing solutions by trip **tracking orchestration** function for **elderly**	⇧

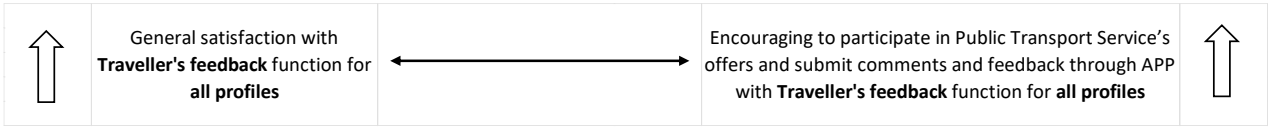
- As it is shown in the figure, an increase in the "Increase safety by **Journey planning** for **disabled profiles**" will increase indirectly the "Providing comfort and comfortable trip with providing solutions by **trip tracking orchestration** function for **elderly**".

⇧	Increase safety by **Journey planning** for **disabled profiles**	⟷	Providing safe trips and avoid crowds from perspective of the Covid-19 by **Journey planning** function for **elderly**	⇧

[22] **Second level benefits** are more detailed factors, clustered inside each of the first level benefits or factors level 1, with an influence on the usage of IP4 functionalities.

- As is shown in the figure, an increase in the "Increase safety by **Journey planning** for **disabled profiles**" will increase indirectly the "Providing safe trips and avoid crowds from the perspective of the Covid-19 by **Journey planning** function for **elderly**".

- As is shown in the figure, an increase in the "General satisfaction with **Smart location** function **for all profiles**" will increase indirectly the "Time-saving with **Smart location** for **all profiles**".



- As it is shown in the figure, an increase in the "General satisfaction with **Traveller's feedback** function for **all profiles**" will increase indirectly the "Encouraging to participate in Public Transport Service's offers and submit comments and feedback through APP with **Traveller's feedback** function for **all profiles**".

- As it is shown in the figure, an increase in the "Average number of shopped offers with **Journey planning**" will increase indirectly the "Increase safety by **Trip sharing** for **disabled profiles**".

- As is shown in the figure, an increase in the "General satisfaction with **Navigation** function for **all profiles**" will increase indirectly the "Time-saving with **Navigation** function for **all profiles**".

- As is shown in the figure, an increase in the "General satisfaction with **Navigation** function for **all profiles**" will increase indirectly the "Time-saving with **Navigation** function for **all profiles**".

- As is shown in the figure, an increase in the "General satisfaction with **Trip sharing** function for **all profiles**" will increase indirectly the "Willing to pay for **Trip sharing** function for **all profiles**".

- As it is shown in the figure, an increase in the "Average number of shopped offers with **Journey planning**" will increase indirectly the "Increase safety with **Journey planning** function for **disabled profiles**".

The output from regression analysis will now be introduced as a forced connection into the BN analysis. This is done to establish consistency in the correlations in the output generated by the BN analysis since the operation is done on a limited number of iterations to produce combinations and relationships among variables in the BN analysis. Considering what has been discussed so far, based on the output of regression analysis the correlations established between variables do not contradict the correlation established by the BN analysis, since the operation is done on the same data values for each variable respectively. Hence, there is no possibility of the graph from the BN analysis to have cyclic connections between the variables upon the introduction of forced connections.

8.5.3. Results regarding Module 3: Bayesian network analysis and BELLMAN shortest path

The output of BN analysis from the **Liberec** demo site indicates what are the **more influent second level benefits**[3] for the acceptance by **users** of IP4 functionalities offered by TSP considered in the **Liberec** demo site, taking into consideration the **Bayes score** and **cumulative weights** (Table 28):

Table 29. Top second-level benefits according to BN analysis in the Liberec demo site

Normalized Weight	Code of factors	Definition of factors
0.027	r3J21q5	Providing a convenient tool by TC APP for the people who take care of dependent people with travel arrangement function for disabled profiles
0.026	r1J21q3	Providing a convenient tool for families, kids, and the elderly to support them while travelling with a travel arrangement function for all profiles
0.026	r3J6q4	Providing convenient and comfortable trips with trip tracking orchestration function for disabled profiles
0.026	r4J21q6	Providing a convenient tool for families, especially the elderly to support them while travelling with travel arrangement function for elderly profiles
0.025	r1J11q2	Providing safe trips with trip sharing function for all profiles

Impact assessment/predictions of correlated variables:

The main reason for identifying and analysing correlations among various factors associated with respective demo sites is to carry out an impact assessment of these variables individually through predictive simulations. These simulations give us an insight into assessing the overall impact of an investment made on improving a certain factor at a demo site. The study through these simulations becomes the basis of decision-making at a high level for various stakeholders involved in the project. The methodology used in these predictive simulations is as follows:

1. Identification of the most impactful variables/factors.
The first step in the process is to find out the variables/factors with the highest weight from the BN and AHP analysis.

2. Among the top second-level variables, the top 3 variables with the highest weight are set aside and used as the factors to focus on to see the impact of each of them on the other remaining variables.

3. One by one, each of the three chosen variables are selected and simulations are conducted to see the impact of this factor on the other correlated variables when the factor through investment and improvement of service are improved. The range of simulation begins with “Most probable value before investment” (Their original score - 1, 2, 3, 4, based on the survey data) and goes all the way up to “Most probably score after investment” (The highest score of 5)

4. Based on the above simulations the assessment tries to find out if the investment to improve this factor has a positive or a negative impact on the other correlated factors.

The above methodology of simulations has been designed to work with changing and scaling datasets in the future. The design of simulations makes them easily replicable to new demo sites and new factors as they get introduced in the future.

8.5.4. Results regarding Module 4: the ANOVA test

ANOVA test (Analysis of Variance) for Travellers is applied in this analysis to determine if some socio-demographic profiles (per age, gender, incomes level, residential area, travelling with a dependent person, professional status, disability, and familiarity with technology) show significant differences regarding the satisfaction with second level benefits based on the data gathered

through the USI travellers survey. Table 29 shows the socio-demographic profiles and the second-level benefits with significant differences regarding satisfaction:

Table 30. Significant socio-demographic variables and their associated factors among the top 10 variables in the ANOVA test (Liberec)

Significant socio-demographic factors (profiles)	Significant factors
Residential area	Helping travellers to find the most cost-efficient route with Journey planning for low-income profiles
Age	Helping travellers to find the most cost-efficient route with Journey planning for low-income profiles
Profession status	Helping travellers to find the most cost-efficient route with Journey planning for low-income profiles
Disability	Helping travellers to find the most cost-efficient route with Journey planning for low-income profiles
Residential area	Making a convenient and comfortable trip by providing a solution without knowledge of the local environment for disabled profiles
Profession status	Making a convenient and comfortable trip by providing a solution without knowledge of the local environment for disabled profiles
Disability	Making a convenient and comfortable trip by providing a solution without knowledge of the local environment for disabled profiles
Familiarity with technology and mobile applications	Making a convenient and comfortable trip by providing a solution without knowledge of the local environment for disabled profiles
Residential area	Providing a convenient tool for people who take care of dependent persons with Travel arrangement for disabled profiles

8.5.5. Results regarding Module 5: USI travellers, TSPs, and EFFECTIVENESS

As detailed in D3.3, values of USI travellers and USI TSPs are required for the calculation of the Effectiveness.

8.5.5.1. Results of USI travellers

After applying the Eq. 2 of D3.3[23] for the calculation of the variable "**USI Travellers**", which mainly considers the average of the satisfaction with relevant benefits shown by travellers (through the **USI Travellers survey)** belonging to several profiles regarding functionalities offered by involved TSPs**,** it can be concluded that those sets (profiles, functionality, TSP) achieving the highest

[23] $USI_{Traveller_{rjk}} = \frac{\sum_{w=1}^{m_{rjk}} \sum_{v=1}^{n_{1jk}+n_{2jk}{}^{r}} Score\ question_{wv}}{m_{rjk} \cdot (n_{1jk} + n_{2jk}{}^{r}) \cdot 5}$

satisfaction are the next:

Table 31. Values of the top 10 sets (Profiles, Functionality, TSP) regarding the USI Traveller in the Liberec demo site

No.	Name of variable	Value
1	USI Traveller_r1J5K7	0.85
2	USI Traveller_r4J21K7	0.84
3	USI Traveller_r1J18K7	0.78
4	USI Traveller_r1J10K7	0.78
5	USI Traveller_r1J16K7	0.76
6	USI Traveller_r1J21K7	0.75
7	USI Traveller_r1J12K7	0.75
8	USI Traveller_r1J9K7	0.73
9	USI Traveller_r5J3K7	0.72
10	USI Traveller_r1J7K7	0.70

As it is shown in the aforementioned table Table 30, the highest values of USI travellers belong to, the **Validation and inspection** functionality provided by **KORID** for **all profiles** (r1J5K7), the **Travel arrangement** functionality provided by **KORID** for **elderly** profiles (r4J21K7), the **Smart location** functionality provided by **KORID** for **all profiles** (r1J18K7), the **Traveller's feedback** functionality provided by **KORID** for **all profiles** (r1J10K7), the **Travel Companion Web-portal functionality** provided by **KORID** for **all profiles** (r1J16K7), the **Travel arrangement** functionality provided by **KORID** for **all profiles** (r1J21K7), the **Guest user** functionality provided by **KORID** for **all profiles** (r1J12K7) and the **Navigation** functionality provided by **KORID** for **all profiles** (r1J9K7), the **Issuing** functionality provided by **KORID** for **women profiles** (r5J3K7), and the **Alternative calculation** functionality provided by **KORID** for **all profiles** (r1J7K7).

8.5.5.2. Results of USI TSPs

After applying the Eq.3 of D3.3[24] for the calculation of the variable "**USI TSP**", which mainly considers the average of the satisfaction with relevant benefits shown by TSPs (through the **USI TSP survey)** regarding functionalities of the Travel Companion**,** it can be concluded that those sets (functionality, TSP) achieving the highest satisfaction are the next:

Table 32. Values of the top set (functionality, TSP)regarding USI TSPs in the Liberec demo site

No.	Name of variable	Value
1	USI TSP_J23K7	1.0

[24] $USI_{TSP_{jK}} = \frac{\sum_1^{m_{jk}} \sum_{v=1}^{n_j} Score\ question_v}{m_{jk} \cdot n_j \cdot 5}$

As it is shown in the aforementioned table **Error! Reference source not found.**, the value of USI TSPs belongs to, the **Asset manager tool** provided to **KORID** (J23K7).

8.5.5.3. Results of EFFECTIVENESS

Considering the values of **USI traveller**, **USI TSPs,** and **operational KPIs** in the **Athens** demo site, and applying Eq.1 in D3.3[25], those sets (Profile, Functionality, TSP) with the highest values of the "Effectiveness" are the next:

Table 33. Values of the top 10 sets (Profile, Functionality, TSP) in terms of Effectiveness in Liberec (travellers functionalities)

No.	Name of Variable	Value
1	Effectiveness_r3J21K7	1
2	Effectiveness_r4J21K7	0.92
3	Effectiveness_r1J21K7	0.87
4	Effectiveness_r5J3K7	0.86
5	Effectiveness_r1J5K7	0.85
6	Effectiveness_r1J3K7	0.84
7	Effectiveness_r1J2K7	0.81
8	Effectiveness_r1J18K7	0.78
9	Effectiveness_r1J16K7	0.76
10	Effectiveness_r1J12K7	0.75

As it is shown in the aforementioned table (Table 32), the **top 10 variables**, in terms of **Effectiveness**, for the **TC functionalities** that are provided to **travellers** belong to, the **Travel arrangement** functionality provided by **KORID** for **disabled, elderly, and general profiles,** (r3J21K7) and (r3J21K7) and (R1J21K7) respectively, the **Issuing** functionality provided by **KORID** for **women** (r5J3K7), the **Validation and inspection** functionality provided by **KORID** for **all profiles** (r1J5K7), the **Issuing function** provided by **KORID** for **all profiles** (r1J3K7), the **Booking** functionality provided by **KORID** for **all profiles** (r1J2K7), the **Smart location** provided by **KORID** for **all profiles** (r1J18K7), the **Travel Companion web-portal** function provided by **KORID** for **all profiles** (r1J16K7) and the **Guest user** function provided by **KORID** for **all profiles** (r1J12K7).

On the other hand, taking into account the values of **USI traveller** , **USI TSPs,** and **operational KPIs** in the **Liberec** demo site, **in terms of the concept of Effectiveness** for the case of TSPs are shown in the following table (**Error! Reference source not found.**):

[25] $Effectiveness_{rjk} = \frac{\sum_{n=1}^{N} KPI_{n_{jk}} + USI_{Traveler_{rjk}} + USI_{TSP_{jk}}}{N + \delta_{Traveller} + \delta_{TSP}}$

Table 34. Value of the variable in terms of Effectiveness in the Liberec (TSPs functionalities)

No.	Name of Variable	Value
1	Effectiveness_J23K7	1

As it is illustrated in the abovementioned table (Table 33), in terms of **Effectiveness**, the **TC functionalities** that are provided to **TSPs** belong to, the **Asset Manager tool** provided to **KORID** (J23K7).

8.6. The results of the Osijek demo site phase II

8.6.1. Results regarding Module 1: AHP (Analytic Hierarchy Process) and pairwise comparison matrix

In the following figures the hierarchical model for both travellers and TSPs in the Osijek demo site is illustrated:

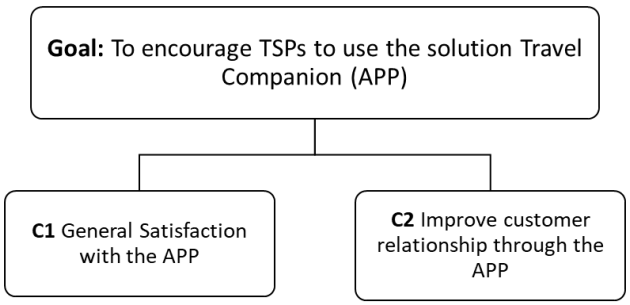


Figure 12. Hierarchical model for TSPs (Osijek)

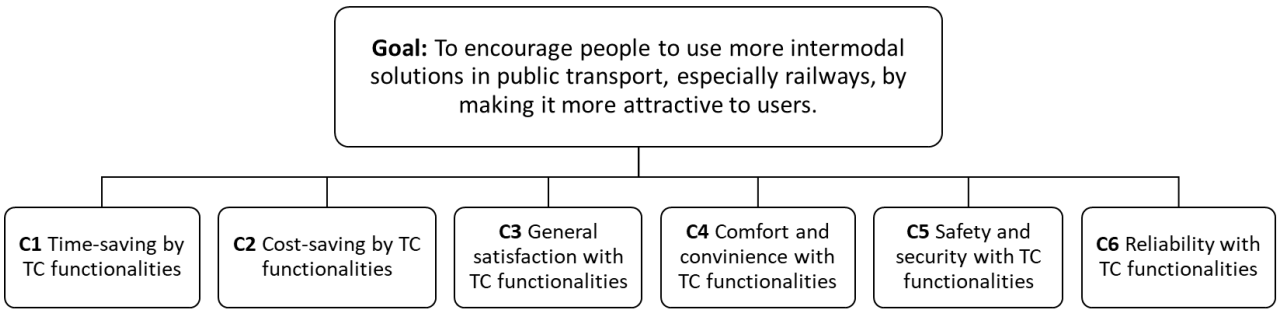


Figure 13. Hierarchical model for travellers (Osijek)

After removing inconsistent values from the data[26], the rank of each criterion (first level benefit[1]) considering its weight and a graphical representation is shown in Table 34 and Figure 14 respectively:

[26] Those with CR>0.01. See Eq. 1 in Deliverable D 6.2 TOOL FOR PERFORMANCE ASSESSMENT

Table 35. Global weights of travellers in AHP (Osijek)

CL1 (Travellers)	Description	Weight	Rank
C1	Time-saving by TC functionalities	0.26	1
C2	Cost-saving by TC functionalities	0.23	2
C3	General satisfaction with TC functionalities	0.11	5
C4	Comfort with TC functionalities	0.04	6
C5	Safety and Security with TC functionalities	0.14	4
C6	Reliability with TC functionalities	0.20	3

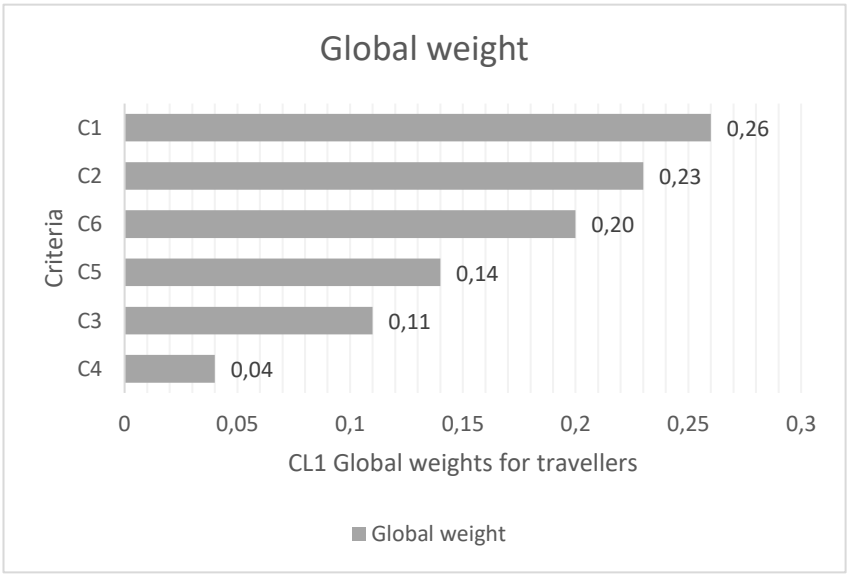


Figure 14. Graphical representation of global weights of travellers in AHP (Osijek)

Since in the calculation of the "Consistency Ratio," the Values of the Random Index (RI) for 2 criteria are equal to 0, and the value of the consistency ratio will be equal to indeterminate, the global weights for TSPs, in AHP analysis, for the Osijek demo site is not calculated.

$$CR = \frac{(\lambda max - n)/(n-1)}{RI}$$

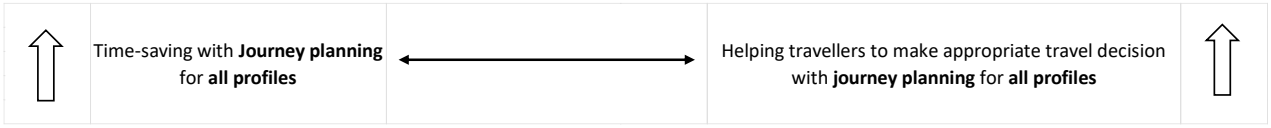
Considering the above data for **Osijek:**

For TRAVELLERS: Time-saving, Cost-saving, and reliability with the Travel Companion (TC) APP have got the highest importance and weights among other criteria or first-level factors.

8.6.2. Results regarding Module 2: Regression analysis

As detailed in D6.2[3], the regression analysis is done as a previous step to identify **Second level Benefits**[27] highly correlated in a way that the heuristic process followed by the Bayesian Network Analysis (Module 3) already starts from learned networks, achieving better results in less time. The p-value in the following two pair variables is less than 0.05 (p-value<0.05), which means there is a high correlation between them.

The results of this Regression analysis are based on data gathered through **USI Travellers surveys** and they are shown in the following for the case of the **Osijek** demo site:



- As is shown in the figure, an increase in the "Time-saving with **Journey planning** for **all profiles**" will increase indirectly the "Helping travellers to make appropriate travel decision with **journey planning** for **all profiles**".

- As is shown in the figure, an increase in the "General satisfaction with **Journey planning** for all **profiles**" will increase indirectly the "Helping travellers to make appropriate travel decision with **journey planning** for **all profiles**".

[27] **Second level benefits** are more detailed factors, clustered inside each of the first level benefits or factors level 1, with an influence on the usage of IP4 functionalities.

- As it is shown in the figure, an increase in the "Providing more convenient and comfortable trip and more accessible route with **Journey planning** for **disabled profiles**" will increase indirectly the "Helping to find more secure route in off-peak hours with **Journey planning** for **women profiles**".

- As is shown in the figure, an increase in the "Helping travellers to make appropriate travel decision with **journey planning** for **all profiles**" will increase indirectly the "General satisfaction with **Navigation** function for **all profiles**".

- As is shown in the figure, an increase in the "Helping to find more secure route in off-peak hours with **Journey planning** for **women profiles**" will increase indirectly the "Average number of modes involved in the journey with **Journey planning**".

- As it is shown in the figure, increase in the "Helping to find more secure route in off-peak hours with **Journey planning** for **women profiles**" will increase indirectly the "Number of TSPs integrated with the pilot with **Journey planning**".

- As is shown in the figure, increase in the "Helping to find more secure route in off-peak hours with **Journey planning** for **women profiles**" will increase indirectly the "Average number of shopped offers with **Journey planning**".

- As is shown in the figure, an increase in the "Time-saving with **Journey planning** function for **all profiles**" will increase indirectly the "General satisfaction with **Navigation** function for **all profiles**".

- As is shown in the figure, an increase in the "Cost-saving with **Journey planning** function for **all profiles**" will increase indirectly the "Average number of modes involved in the journey with **Journey planning** function".

- As is shown in the figure, increase in the "Cost-saving with **Journey planning** function for **all profiles**" will increase indirectly the "Number of TSPs integrated with the pilot with **Journey planning** function".

The output from regression analysis will now be introduced as a forced connection into the BN analysis. This is done to establish consistency in the correlations in the output generated by the BN analysis since the operation is done on a limited number of iterations to produce combinations and relationships among variables in the BN analysis. Considering what has been discussed so far, based on the output of regression analysis the correlations established between variables do not contradict the correlation established by the BN analysis, since the operation is done on the same data values for each variable respectively. Hence, there is no possibility of the graph from the BN analysis to have cyclic connections between the variables upon the introduction of forced connections.

8.6.3. Results regarding Module 3: Bayesian network analysis and BELLMAN shortest path

The output of BN analysis from the **Osijek** demo site indicates what are the **more influent second level benefits**[3] for the acceptance by **users** of IP4 functionalities offered by TSPs considered in the **Osijek** demo site, taking into consideration the **Bayes score** and **cumulative weights** (Table 35):

Table 36. Top second-level benefits according to BN analysis in the Osijek demo site

Normalized Weight	Code of factors	Definition of factors
0.072	r1J1KPI3	Number of TSPs integrated with Journey planning
0.072	r1J1KPI2	Average number of shopped offers with Journey planning
0.072	r1J1KPI1	The average number of modes involved in the journey with Journey planning
0.067	r5J1q9	Helping travellers to find more secure routes in off-peak hours for women's profiles
0.056	r1J1q3	Cost-saving with Journey planning for all profiles
0.046	r1J1q2	Time-saving with Journey planning for all profiles
0.038	r1J1q1	General satisfaction with Journey planning for all profiles

Impact assessment/predictions of correlated variables:

The main reason for identifying and analysing correlations among various factors associated with respective demo sites is to carry out an impact assessment of these variables individually through predictive simulations. These simulations give us an insight into assessing the overall impact of an investment made on improving a certain factor at a demo site. The study through these simulations becomes the basis of decision-making at a high level for various stakeholders involved in the project. The methodology used in these predictive simulations is as follows:

1. Identification of the most impactful variables/factors.
The first step in the process is to find out the variables/factors with the highest weight from the BN and AHP analysis.

2. Among the top second-level variables, the top 3 variables with the highest weight are set aside and used as the factors to focus on to see the impact of each of them on the other remaining variables.

3. One by one, each of the three chosen variables are selected and simulations are conducted to see the impact of this factor on the other correlated variables when the factor through investment and improvement of service are improved. The range of simulation begins with “Most probable value before investment” (Their original score - 1, 2, 3, 4, based on the survey data) and goes all the way up to “Most probably score after investment” (The highest score of 5)

4. Based on the above simulations the assessment tries to find out if the investment to improve this factor has a positive or a negative impact on the other correlated factors.

The above methodology of simulations has been designed to work with changing and scaling datasets in the future. The design of simulations makes them easily replicable to new demo sites and new factors as they get introduced in the future.

8.6.4. Results regarding Module 4: the ANOVA test

ANOVA test (Analysis of Variance) for Travellers is applied in this analysis to determine if some **socio-demographic profiles** (per age, gender, incomes level, residential area, travelling with a dependent person, professional status, disability, and familiarity with technology) show significant differences regarding the satisfaction with **second level benefits**[3] based on the data gathered through the **USI travellers survey**. Table 36 shows the socio-demographic profiles and the second-level benefits with significant differences regarding satisfaction:

Table 37. Significant socio-demographic variables and their associated factors among the top 10 variables in the ANOVA test (Osijek)

Significant socio-demographic factors (profiles)	Significant factors
Gender	General satisfaction with the Journey planning function for all profiles
Familiarity with technology and mobile applications	General satisfaction with the Journey planning function for all profiles
Gender	Time-saving with Journey planning function for all profiles
Income	Making a convenient and comfortable trip and providing the most accessible route from the available options with Journey planning function for disabled profiles
Gender	helping traveller to make appropriate travel decisions with Journey planning for all profiles
Familiarity with technology and mobile applications	helping traveller to make appropriate travel decisions with Journey planning for all profiles
Gender	Helping women to find more secure routes in off-peak hours with Journey planning for women's profiles
Familiarity with technology and mobile applications	General satisfaction with the Navigation function for all profiles
Familiarity with technology and mobile applications	Time-saving with a Navigation function for all profiles

8.6.5. Results regarding Module 5: USI travellers, TSPs, and EFFECTIVENESS

As detailed in D3.3, values of USI travellers and USI TSPs are required for the calculation of the Effectiveness.

8.6.5.1. Results of USI travellers

After applying the Eq. 2 of D3.3[28] for the calculation of the variable "**USI Travellers**", which mainly considers the average of the satisfaction with relevant benefits shown by travellers (through the **USI Travellers survey)** belonging to several profiles regarding functionalities offered by involved TSPs**,** it can be concluded that those sets (profiles, functionality, TSP) achieving the highest satisfaction are the next:

Table 38. Values of the top 5 sets (Profiles, Functionality, TSP) regarding the USI Traveller in the Osijek demo site

No.	Name of variable	Value
1	USI Traveller_r1J9K11	0.76
2	USI Traveller_r1J9K12	0.76
3	USI Traveller_r2J1K11	0.76
4	USI Traveller_r2J1K12	0.76
5	USI Traveller_r1J1K11	0.74

As it is shown in the aforementioned table Table 37, the highest value of USI travellers belongs to, the **Navigation** functionality provided by **GPP PT and GPP sharing mobility (nextbike)** for **all profiles** (r1J9K11) and (r1J9K12) respectively, the **Journey planning** functionality provided by **GPP PT and GPP sharing mobility (nextbike)** for **low-income profiles** (r2J1K11) and (r2J1K12) respectively, the **Journey planning** functionality provided by **GPP PT** for **all profiles** (r1J1K11).

8.6.5.2. Results of USI TSPs

After applying the Eq.3 of D3.3[29] for the calculation of the variable "**USI TSP**", which mainly considers the average of the satisfaction with relevant benefits shown by TSPs (through the **USI TSP survey)** regarding functionalities of the Travel Companion**,** it can be concluded that those sets (functionality, TSP) achieving the highest satisfaction are the next:

Table 39. Values of the set (functionality, TSP)regarding USI TSPs in the Osijek demo site

No.	Name of variable	Value
1	USI TSP_J32K11	0.6

As it is shown in the aforementioned table Table 38, the value of USI TSPs belongs to, the **CRM portal** provided to **GPP PT** (J32K11).

8.6.5.3. Results of EFFECTIVENESS

Considering the values of **USI traveller**, **USI TSPs,** and **operational KPIs** in the **Athens** demo site,

[28] $USI_{Traveller_{rjk}} = \frac{\sum_{w=1}^{m_{rjk}} \sum_{v=1}^{n_{1jk}+n_{2jk}{}^{r}} Score\ question_{wv}}{m_{rjk} \cdot (n_{1jk} + n_{2jk}{}^{r}) \cdot 5}$

[29] $USI_{TSP_{jK}} = \frac{\sum_{1}^{m_{jk}} \sum_{v=1}^{n_j} Score\ question_v}{m_{jk} \cdot n_j \cdot 5}$

and applying Eq.1 in D3.3[30], those sets (Profile, Functionality, TSP) with the highest values of the "Effectiveness" are the next:

Table 40. Values of the top 10 sets (Profile, Functionality, TSP) in terms of Effectiveness in Athens (travellers functionalities)

No.	Name of Variable	Value
1	Effectiveness_r1J9K11	0.76
2	Effectiveness_r1J9K12	0.76
3	Effectiveness_r2J1K11	0.44
4	Effectiveness_r2J1K12	0.44
5	Effectiveness_r1J1K11	0.43

As it is shown in the aforementioned table (**Error! Reference source not found.**), the **top 5 variables**, in terms of **Effectiveness**, for the **TC functionalities** that are provided to **travellers** belong to, the **Navigation** functionality provided by **GPP PT and GPP sharing mobility (nextbike)** for **all profiles** (r1J9K11) and (r1J9K12) respectively, the **Journey planning** functionality provided by **GPP PT and GPP sharing mobility (nextbike)** for **low-income profiles** (r2J1K11) and (r2J1K12), and the **Journey planning** functionality provided by **GPP PT** for **all profiles** (r1J1K11).

On the other hand, taking into account the values of **USI traveller**, **USI TSPs,** and **operational KPIs** in the **Osijek** demo site, **in terms of the concept of Effectiveness** for the case of TSPs are shown in the following table (**Error! Reference source not found.**):

Table 41. Value of the variable in terms of Effectiveness in the Osijek (TSPs functionalities)

No.	Name of Variable	Value
1	Effectiveness_J32K11	0.6

As it is illustrated in the abovementioned table (**Error! Reference source not found.**), in terms of **Effectiveness**, the **TC functionalities** that are provided to **TSPs** belong to, the **CRM portal tool** provided to **GPP PT** (J32K11).

[30] $Effectiveness_{rjk} = \frac{\sum_{n=1}^{N} KPI_{njk} + USI_{Traveler_{rjk}} + USI_{TSP_{jk}}}{N + \delta_{Traveller} + \delta_{TSP}}$

8.7. The results of the Barcelona demo site phase II

8.7.1. Results regarding Module 1: AHP (Analytic Hierarchy Process) and pairwise comparison matrix

In the following figures, the hierarchical model for both travellers and TSPs in the Barcelona demo site is illustrated:

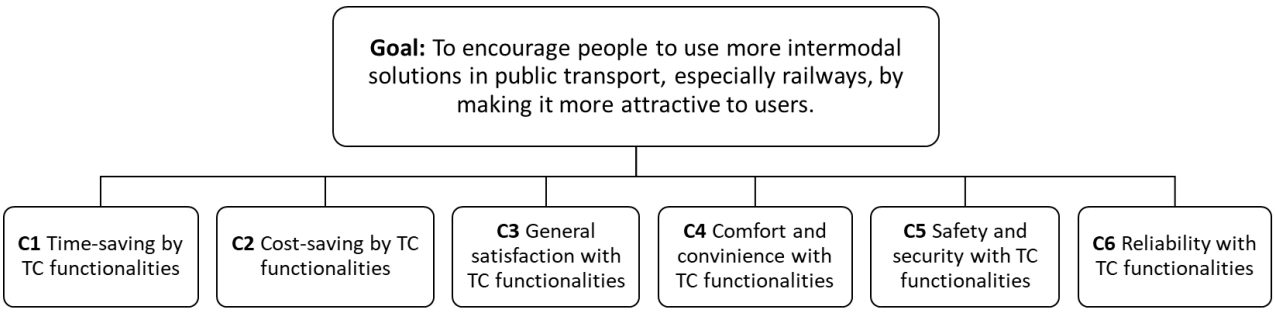


Figure 15. Hierarchical model for travellers (Barcelona)

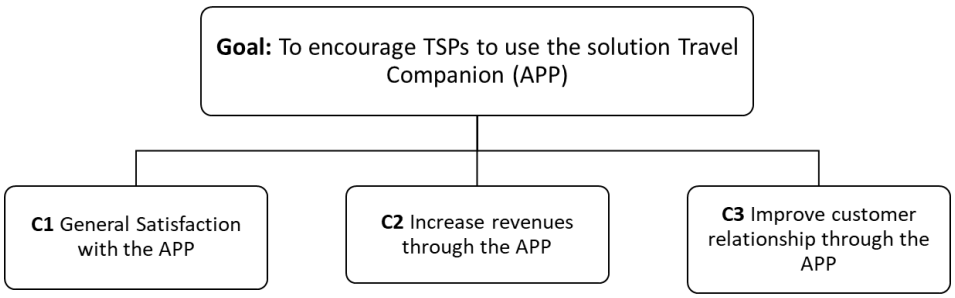


Figure 16. Hierarchical model for TSPs (Barcelona)

After removing inconsistent values from the data[31], the rank of each criterion (first level benefit[1]) considering its weight and a graphical representation is shown in Tables 41 and 42 and Figures 17 and 18 respectively:

[31] Those with CR>0.01. See Eq. 1 in Deliverable D 6.2 TOOL FOR PERFORMANCE ASSESSMENT

Table 42. Global weights of travellers in AHP (Barcelona)

CL1 (Travellers)	Description	Weight	Rank
C1	Time-saving by TC functionalities	0.24	1
C2	Cost-saving by TC functionalities	0.19	2
C3	General satisfaction with TC functionalities	0.18	3
C4	Comfort with TC functionalities	0.11	5
C5	Safety and Security with TC functionalities	0.11	6
C6	Reliability with TC functionalities	0.14	4

Table 43. Global weights of TSPs in AHP (Barcelona)

CL1 (TSPs)	Description	Weight	Rank
C1	General Satisfaction with the APP	0.29	2
C2	Increase revenues through the APP	0.23	3
C3	Improve customer relationships through the APP	0.47	1

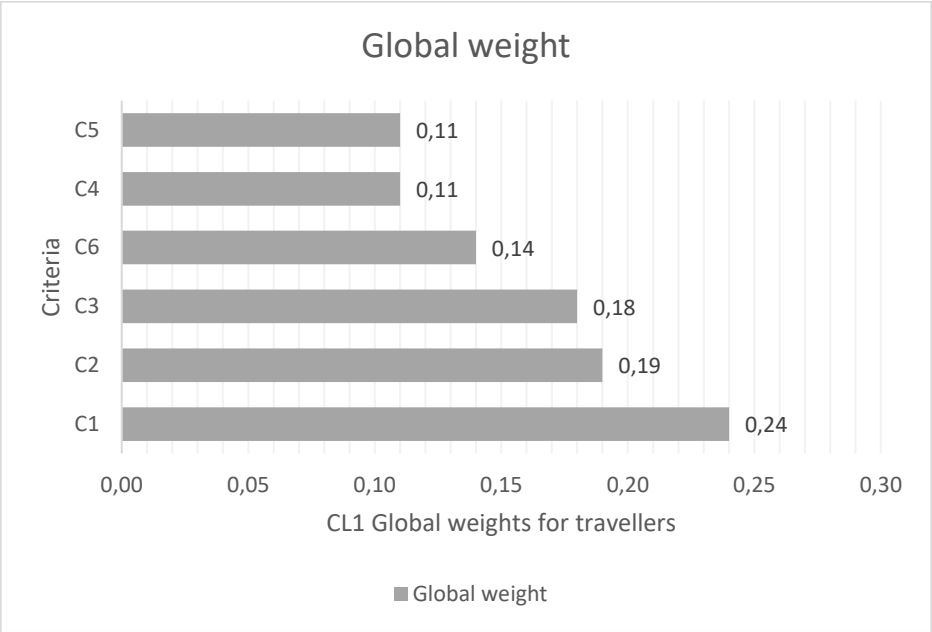


Figure 17. Graphical representation of global weights of travellers in AHP (Barcelona)

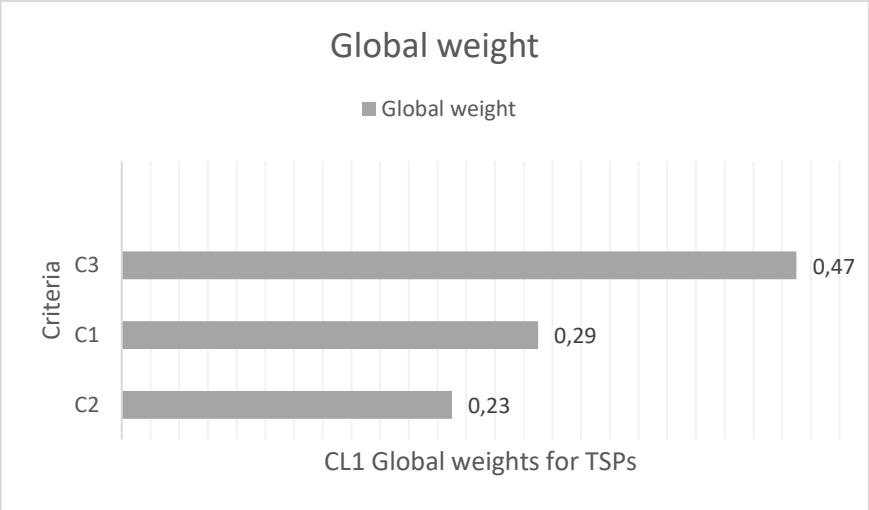


Figure 18. Graphical representation of global weights of TSPs in AHP (Barcelona)

Considering the above data for **Barcelona:**

For TRAVELLERS: Time-saving, Cost-saving, and general satisfaction with the Travel Companion (TC) APP have got the highest importance and weights among other criteria or first-level factors. For **TSPs: Improving customer relationships, and General satisfaction** with **the TC APP** were the most significant criteria.

8.7.1. Results regarding Module 2: Regression analysis

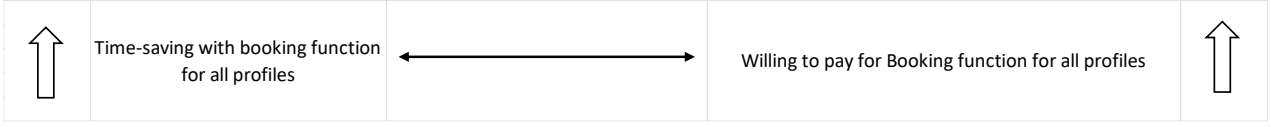
As detailed in D6.2[3], the regression analysis is done as a previous step to identify **Second level Benefits**[32] highly correlated in a way that the heuristic process followed by the Bayesian Network Analysis (Module 3) already starts from learned networks, achieving better results in less time. The p-value in the following two pair variables is less than 0.05 (p-value<0.05), which means there is a high correlation between them.

The results of this Regression analysis are based on data gathered through **USI Travellers surveys** and they are shown in the following for the case of the **Barcelona** demo site:

- As is shown in the figure, an increase in the "Providing optimal route in case of delay with Collaborative space portal for all profiles" will increase indirectly the "Helping travellers to choose an optimal route based on real-time feedback with Collaborative space portal for all profiles".

- As is shown in the figure, an increase in the "General satisfaction with Preferences and profiles function for all profiles" will increase indirectly the "Helping travellers to choose an optimal route based on real-time feedback with Collaborative space portal for all profiles".

- As is shown in the figure, an increase in the "General satisfaction with Preferences and profiles function for all profiles" will increase indirectly the "Willing to pay for Booking function for all profiles".

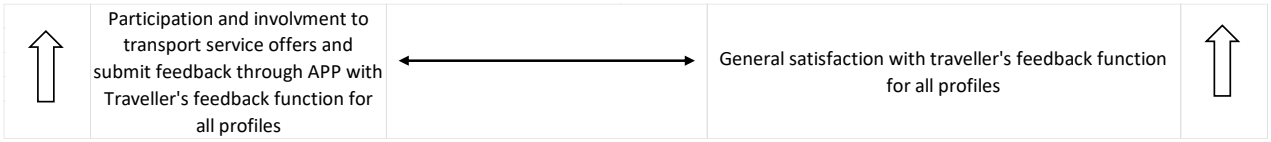


- As is shown in the figure, an increase in the "Time-saving with booking function for all profiles" will increase indirectly the "Willing to pay for Booking function for all profiles".

[32] **Second level benefits** are more detailed factors, clustered inside each of the first level benefits or factors level 1, with an influence on the usage of IP4 functionalities.

- As is shown in the figure, an increase in the "General satisfaction with Collaborative space portal for all profiles" will increase indirectly the "Willing to pay for Booking function for all profiles".

- As is shown in the figure, an increase in the "General Satisfaction with Booking function for all profiles" will increase indirectly the "Willing to pay for Booking function for all profiles".



- As is shown in the figure, an increase in the "Participation and involvement to transport service offers and submit feedback through APP with Traveller's feedback function for all profiles" will increase indirectly the "General satisfaction with traveller's feedback function for all profiles".

- As is shown in the figure, an increase in the "Willing to pay for booking function for all profiles" will increase indirectly the "Time-saving with Booking function for all profiles".

- As is shown in the figure, an increase in the "General satisfaction with Preferences and profiles function for all profiles" will increase indirectly the "General satisfaction with digital onboarding function for all profiles".

- As is shown in the figure, an increase in the "General satisfaction with Navigation function for all profiles" will increase indirectly the "Time-saving with Navigation function for all profiles".

The output from regression analysis will now be introduced as a forced connection into the BN analysis. This is done to establish consistency in the correlations in the output generated by the BN analysis since the operation is done on a limited number of iterations to produce combinations and relationships among variables in the BN analysis. Considering what has been discussed so far, based on the output of regression analysis the correlations established between variables do not contradict the correlation established by the BN analysis, since the operation is done on the same data values for each variable respectively. Hence, there is no possibility of the graph from the BN analysis to have cyclic connections between the variables upon the introduction of forced connections.

8.7.2. Results regarding Module 3: Bayesian network analysis and BELLMAN shortest path

The output of BN analysis from the **Barcelona** demo site indicates what are the **more influent second level benefits**[3] for the acceptance by **users** of IP4 functionalities offered by TSPs considered in the **Barcelona** demo site, taking into consideration the **Bayes score** and **cumulative weights** (Table 43):

Table 44. Top second-level benefits according to BN analysis in the Barcelona demo site

Normalized Weight	Code of factors	Definition of factors
0.019	r1J1KPI2	Average number of shopped offers with the journey planning function
0.019	r1J1q2	Time-saving with Journey planning function for all profiles
0.019	r1J4KPI6	Number of mobility packages offered by TSP with Mobility packages function
0.016	r1J2q3	Time-saving with the Booking function for all profiles
0.016	r1J13q1	General satisfaction with Preferences and profiles function for all profiles
0.015	r1J2q1	General satisfaction with the Booking function for all profiles
0.015	r1J1q1	General satisfaction with the Journey planning function for all profiles

Impact assessment/predictions of correlated variables:

The main reason for identifying and analysing correlations among various factors associated with respective demo sites is to carry out an impact assessment of these variables individually through predictive simulations. These simulations give us an insight into assessing the overall impact of an investment made on improving a certain factor at a demo site. The study through these simulations becomes the basis of decision-making at a high level for various stakeholders involved in the project. The methodology used in these predictive simulations is as follows:

1. Identification of the most impactful variables/factors.
The first step in the process is to find out the variables/factors with the highest weight from the BN and AHP analysis.

2. Among the top second-level variables, the top 3 variables with the highest weight are set aside and used as the factors to focus on to see the impact of each of them on the other remaining

variables.

3. One by one, each of the three chosen variables are selected and simulations are conducted to see the impact of this factor on the other correlated variables when the factor through investment and improvement of service are improved. The range of simulation begins with "Most probable value before investment" (Their original score - 1, 2, 3, 4, based on the survey data) and goes all the way up to "Most probably score after investment" (The highest score of 5)

4. Based on the above simulations the assessment tries to find out if the investment to improve this factor has a positive or a negative impact on the other correlated factors.

The above methodology of simulations has been designed to work with changing and scaling datasets in the future. The design of simulations makes them easily replicable to new demo sites and new factors as they get introduced in the future.

8.7.3. Results regarding Module 4: ANOVA test

Among the top 10 variables in the Barcelona demo site, no significant socio-demographic profiles and significant variable was found.

8.7.4. Results regarding Module 5: USI travellers, TSPs, and EFFECTIVENESS

As detailed in D3.3, values of USI travellers and USI TSPs are required for the calculation of the Effectiveness.

8.7.4.1. Results of USI travellers

After applying the Eq. 2 of D3.3[33] for the calculation of the variable "**USI Travellers**", which mainly considers the average of the satisfaction with relevant benefits shown by travellers (through the **USI Travellers survey)** belonging to several profiles regarding functionalities offered by involved TSPs**,** it can be concluded that those sets (profiles, functionality, TSP) achieving the highest satisfaction are the next:

Table 45. Values of the top 10 sets (Profiles, Functionality, TSP) regarding the USI Traveller in the Barcelona demo site

No.	Name of variable	Value
1	USI Traveller_r1J20K14	0.9
2	USI Traveller_r1J20K15	0.9

[33] $USI_{Traveller_{rjk}} = \frac{\sum_{w=1}^{m_{rjk}} \sum_{v=1}^{n_{1jk}+n_{2jk}{}^{r}} Score\ question_{wv}}{m_{rjk} \cdot (n_{1jk} + n_{2jk}{}^{r}) \cdot 5}$

3	USI Traveller_r1J20K13	0.9
4	USI Traveller_r4J1K13	0.84
5	USI Traveller_r1J16K14	0.76
6	USI Traveller_r4J12K13	0.75
7	USI Traveller_r4J12K15	0.75
8	USI Traveller_r4J12K14	0.75
9	USI Traveller_r1J11K13	0.7
10	USI Traveller_r1J11K14	0.7

As it is shown in the aforementioned table Table 44, the highest value of USI travellers belongs to, the **Digital onboarding** functionality provided by **BUSUP, AMTU, and TMB** for **all profiles** (r1J20K14), (r1J20K15) and (r1J20K13) respectively, the **Journey planning** functionality provided by **TMB** for **elderly profiles** (r4J1K13), the **Travel Companion web-portal** functionality provided by **BUSUP** for **all profiles** (r1J16K14), the **Guest user** functionality provided by **TMB, AMTU, and BUSUP** for **elderly profiles** (r3J12K13), (r4J12K15) and (r4J12K14) respectively, the **Trip sharing** provided by **TMB and BUSUP** for **all profiles** (r1J11K13) and (r1J11K14).

8.7.4.2. Results of USI TSPs

After applying the Eq.3 of D3.3[34] for the calculation of the variable "**USI TSP**", which mainly considers the average of the satisfaction with relevant benefits shown by TSPs (through the **USI TSP survey)** regarding functionalities of the Travel Companion**,** it can be concluded that those sets (functionality, TSP) achieving the highest satisfaction are the next:

Table 46. Values of the top sets (functionality, TSP)regarding USI TSPs in the Barcelona demo site

No.	Name of variable	Value
1	USI TSP_J25K14	0.44
2	USI TSP_J23K14	0.35

As it is shown in the aforementioned table **Error! Reference source not found.**, the highest value of USI TSPs belongs to, the **Contractual Management Market Place and Asset Manager** tool provided to **BUSUP** (J25K14) and (J23K14) respectively.

8.7.4.3. Results of EFFECTIVENESS

Considering the values of **USI traveller**, **USI TSPs,** and **operational KPIs** in the **Athens** demo site, and applying Eq.1 in D3.3[35], those sets (Profile, Functionality, TSP) with the highest values of the "Effectiveness" are the next:

[34] $USI_{TSP_{jK}} = \frac{\sum_1^{m_{jk}} \sum_{v=1}^{n_j} Score\ question_v}{m_{jk} \cdot n_j \cdot 5}$

[35] $Effectiveness_{r_{jk}} = \frac{\sum_{n=1}^{N} KPI_{n_{jk}} + USI_{Traveler_{rjk}} + USI_{TSP_{jk}}}{N + \delta_{Traveller} + \delta_{TSP}}$

Table 47. Values of the top 10 sets (Profile, Functionality, TSP) in terms of Effectiveness in Barcelona (travellers functionalities)

No.	Name of Variable	Value
1	Effectiveness_r1J20K13	0.9
2	Effectiveness_r1J20K14	0.9
3	Effectiveness_r1J20K15	0.9
4	Effectiveness_r1J16K14	0.76
5	Effectiveness_r4J12K13	0.75
6	Effectiveness_r4J12K14	0.75
7	Effectiveness_r4J12K15	0.75
8	Effectiveness_r1J4K14	0.7
9	Effectiveness_r1J4K15	0.71
10	Effectiveness_r1J11K13	0.7

As it is shown in the aforementioned table (Table 46), the **top 10 variables**, in terms of **Effectiveness**, for the **TC functionalities** that are provided to **travellers** belong to, the **Digital onboarding** functionality provided by **TMB, BUSUP, and AMTU** for **all profiles** (r1J20K13), (r1J20K14) and (r1J20K15) respectively, the **Travel Companion Web-portal** functionality provided by **BUSUP** for **all profiles** (r1J16K14), the **Guest user** functionality provided by **TMB, BUSUP, and AMTU** for **elderly profiles** (r4J12K13), (r4J12K14) and (r4J12K15) respectively, the **Mobility packages** provided by **BUSUP and AMTU** for **all profiles** (r1J4K14) and (r1J4K15) respectively and the **Trip sharing** functionality provided by **TMB** for **all profiles** (r1J11K13).

On the other hand, taking into account the values of **USI traveller**, **USI TSPs,** and **operational KPIs** in the **Barcelona** demo site, **in terms of the concept of Effectiveness** for the case of TSPs are shown in the following table (**Error! Reference source not found.**):

Table 48. Value of the variables in terms of Effectiveness in the Barcelona (TSPs functionalities)

No.	Name of Variable	Value
1	Effectiveness_J23K14	0.67
2	Effectiveness_J25K14	0.44

As it is illustrated in the abovementioned table (**Error! Reference source not found.**), in terms of **Effectiveness**, the **TC functionalities** that are provided to **TSPs** belong to, the **Asset manager tool** and **Contractual Management Market Place** provided to **BUSUP** (J23K14) and (J25K14) respectively.

8.8. Transferability of IP4MaaS performance assessment toolbox to other projects and assessments:

The scripts have been designed for easy adoption in other projects with similar end goals. While the scripts operate on the codified representation of the traveller profiles, functionalities, and service providers, there is no restriction on the type of codification used. The only factor that the scripts assume is the order of the variables introduced for codification. That is the traveller profile variable (wherever applicable), followed by the Functionality variable, followed by the Service Provider variable. As long as the order is maintained, the scripts self-analyze the number of variables representing the traveller profiles, functionalities, and service providers, and perform calculations (USI, Effectiveness) and analysis (Regression and BN), Hence, in a similar framework, the scripts may be used for performing data analysis on a large data set with no restriction on the number of functionalities, service providers or subsets of traveller profiles. Documented Scripts can be found in a downloadable ZIP file attached[36] to this document.

Concerning the **extrapolation and transferability** of **Module 1 (AHP analysis)**, for a new assessment or project, the **number of criteria** should be adapted to the **hierarchical model**. As it was shown, to start the **Module 1_ AHP analysis**, in the first step, a hierarchical model should be prepared for both travellers and TSPs. This hierarchical model should be **validated and confirmed** by a group of project members so-called "**expert panel**". In the next step according to the hierarchical model a "**pairwise comparison matrix**" will be prepared and it will be sent to each member of the expert panel, and they will be asked to **fill out the matrices according to their idea**. The main important point in these matrices is to **make a comparison** (according to the table of Saaty) and **check which criteria have higher importance than the other one**. After filling out all the matrices and collecting the opinions of all expert panels, some formulations will be implemented in these matrices(formulas are defined manually in Excel) which are useful to calculate the **rank, global weight, and consistency ratio** of each criterion.

Concerning the extrapolation and transferability of **Module 2 (Regression analysis)** all documented scripts can be found in the attached file: Module 2_Regression analysis>> Documented Script – Regression. All the required documentation for the case of transferability and reusing this method is indicated with "#" in the attached files.

Concerning the extrapolation and transferability of **Module 3 (Bayesian Network analysis)** all documented scripts can be found in the attached file: Module 3_ BN analysis_Graphs and weights>> Documented_K2Algorithm_Updated_Forced_Connections. All the required documentation for the case of transferability and reusing this method is indicated with "#" in the attached files.

[36] All the matrials, script and additional data are avaible for download in the library of IP4MaaS website (https://www.ip4maas.eu/library/), and IP4MaaS Zenodo community (https://zenodo.org/communities/ip4maas/).

Concerning the extrapolation and transferability of **Module 4 (ANOVA test)**, the codes and scripts are developed in Excel files and Macros (VBA). The scripts are defined and introduced for different socio-demographic profiles to calculate the "p-value" per each socio-demographic profile of age, gender, income, professional status, residential area, disability, traveling with disabled people, and familiarity with technology and mobile phones. As an example, the scripts for the case of "Gender" is defined in the following. For other characteristics the scripts will remain the same only according to the variables (options in question) the variables will be changed. All Macros and documented scripts regarding this analysis can be found in the attached folders[37]: Module 4_Calculation of ANOVA test>>Documented scripts_ANOVA. All the required documentation for the case of transferability and reusing this method is indicated with "#" in the attached files.

Concerning the extrapolation and transferability of **Module 5 (Calculation of USI travellers, USI TSP and Effectiveness)**, all documented scripts can be found in the attached file: Module 5_Results and outputs of USI Travellers, TSPs, Effectiveness and average of Effectiveness>>Documented Script - USI and Effectiveness V3. All the required documentation for the case of transferability and reusing this method is indicated with "#" in the attached files.

8.9. The Final results and conclusion of the performance assessment in the IP4MaaS project

An **assessment methodology** and a **5 Modules Toolbox** have been presented in this deliverable to assess the **Travel Companion APP/IP4 ecosystem more in general**[7].

By applying this **5 Modules Toolbox** it has answered to the following research questions:

1. What features of this **ecosystem** are more **relevant** for the **users** (TOP 10 benefits) (MODULE 1 to 3)?
2. Which **features** of this ecosystem have the **highest Effectiveness** based on **satisfaction** and **operational KPIs** for **all** kinds of profiles and **specific** profiles (MODULE 5)?
3. What features of this ecosystem show **significant** differences regarding **socio-demographic** profiles (MODULE 4)?

This **methodology** and the "**5-Modules Toolbox**" can be **applied** to other **Software and IT innovations**; and can be also applied to the **Travel Companion APP/IP4 ecosystem** in other demo sites in the future.

Regarding the **BN analysis (Module 3)** the following results have been achieved. As it is shown in **Error! Reference source not found.** the top 3 factors in each demo site are as follows:

[37] All the matrials, script and additional data are avaible for download in the library of IP4MaaS website (https://www.ip4maas.eu/library/), and IP4MaaS Zenodo community (https://zenodo.org/communities/ip4maas/).

Table 49. Top 3 factors in each IP4MaaS demo site according to BN analysis

Factors	Demo sites					
	Athens	**Padua**	**Warsaw**	**Liberec**	**Osijek**	**Barcelona**
Main factor	General satisfaction with intermodal fare optimization for all profiles	Average number of shopped offers with the journey planning function	Providing safe trips with trip sharing function for all profiles	Providing a convenient tool by TC APP for the people who take care of dependent people with travel arrangement function for disabled profiles	Number of TSPs integrated with Journey planning	Average number of shopped offers with the journey planning function
Second Main factor	Cost-saving with intermodal fare optimization for low-income profiles	Giving instant and fast access to TC APP without registration with guest user function for all profiles	General satisfaction with trip sharing function for all profiles	Providing a convenient tool for families, kids, and the elderly to support them while travelling with travel arrangement function for all profiles	Average number of shopped offers with Journey planning	Time-saving with Journey planning function for all profiles
Third main factor	Making traveller's trips more comfortable and providing more accessible routes with journey planning for disabled profiles	The average number of modes involved in the journey with the journey planning function	Willing to pay for trip sharing function for all profiles	Providing convenient and comfortable trips with trip tracking orchestration function for disabled profiles	The average number of modes involved in the journey with Journey planning	Number of mobility packages offered by TSP with Mobility packages function

According to the result of **Effectiveness** in all of the IP4MaaS demo sites the **top 10 variables** and factors are listed in the following table (**Error! Reference source not found.**):

Table 50. The average value of Effectiveness in all demo sites

No.	Variables	Linked to	The average value of Effectiveness across all profiles and all IP4MaaS demo sites
1	**Mobility packages** function for **low-income** profiles	Traveller	0.91
2	**Asset manager** tool	TSP	0.90
3	**Travel arrangement** function for **all profiles**	Traveller	0.89
4	**Digital onboarding** function for **all profiles**	Traveller	0.84
5	**Intermodal fare optimization** for **low-income** profiles	Traveller	0.83
6	**Intermodal fare optimization** for **all profiles**	Traveller	0.82
7	**Mobility packages** function for **all profiles**	Traveller	0.82
8	**Map content** function for **all profiles**	Traveller	0.79
9	**Guest user** function for **all profiles**	Traveller	0.78
10	**Smart location** function for **all profiles**	Traveller	0.77

The performance assessment toolbox has the capability to be used in a future project assessing different IP4 innovations or functionalities in different demo sites. This toolbox has the potential to be implemented in different circumstances and considers several socio-demographic profiles and evaluates the satisfaction level of both general profiles and specific (sensitive) profiles.

The "**Performance Assessment Toolbox**" and its scripts, codes, modules, and macros have been **exclusively** and **specifically** developed and prepared for the **IP4MaaS project**.

9. Impact assessment

In the deliverable D6.1[4] the main aspects of the impact assessment have been presented and its main characteristics, as effectiveness and efficiency, have been underlined. Furthermore, the project's targets have been listed and the structure of the assessment approach has been analysed. The impact assessment here carried out takes into account the environmental and socio-economic areas. With respect to the methodology previously presented, the data elaborated in the present document do not show the usual comparison between baseline and project scenario, because of lack of sufficient data. The baseline has been replaced with a threshold reflecting the "maximum desired state", and the percentage of achievement reflects the assessment against this maximum value. In order to assess the impact of the IP4 technologies during the implementation of the Demo sites, the data values and the USI survey results have been analysed, similarly to what has been reported for the Performance assessment. Indeed, the degree of satisfaction has been used to determine the results for the Impact KPIs. Furthermore, the absolute values of the KPIs have combined with the USI survey results in order to make a qualitative analysis of IP4 technologies impact on Demo sites contexts.

9.1. Evolution of the Macro-model

In deliverable *D6.1 Assessment Methodology* [4] a macro-model based on Cost-Benefits Analysis (CBA) analysis was presented in order to obtain standardized data to compare. The development of the pilot cases in the following months has made aware that the methodology previously proposed needed an update. In fact, in accordance with timeline, duration of the demos, data availability and the high number of data comparisons needed in every demo, CBA has been not considered the best option anymore. Therefore, the Multi-Criteria Analysis (MCA) and Analytic Hierarchy Process (AHP) methodologies described in D6.1 have been used and integrated with a correlated methodology recently used in FENIX project[38]. This "7-steps methodology" allows to achieve the same goal of CBA: obtain standardised data to be compared among Pilot Cases and have a tool allowing to determine the improvements achieved thanks to IP4 technologies. In the remaining of the paragraph, after a summary of the MCA and AHP methodology, already presented in D6.1, the "7-steps methodology" is introduced.
MCA is a support tool for cross-comparisons, improving the efficiency of the evaluation process and allowing, in a nutshell:

- To define a hierarchical scale of possible alternatives and their different combinations
- To organically synthesize the opinions expressed by the various players in the evaluation process with regards to subjective data.

The **MCA** allows to evaluate, in a comparative way, criteria and indicators that can be expressed in objective and subjective terms, such as number of travel solutions shown and user satisfaction of the Journey Planner.
With the elements of MCA in this context, the evaluation criteria have been identified and then the attribution of the weights, using elements of the **AHP** method, have been carried out. The method is based on the values and judgments expressed by individual decision makers regarding

[38] FENIX NETWORK project - Deliverable 5.4 "Impact Assessment Report", 2023

the (relative) importance of the various possible objectives pursued by an intervention or a mobility solution.
In particular, the AHP allows to attribute the importance of each criterion through the participation of potentially interested stakeholders thanks to the "pairwise comparison".
The subsequent steps of the MCA allow the classification of KPIs through the steps of assigning the values of the indicators, the weighting of the scores for the importance of each indicator and criterion (or the importance they assume for the surveyed decision makers), and the definition of a summary ranking of the KPIs results.
The "7-step methodology" allows to apply MCA and AHP theories in an efficient way in IP4MAAS. In fact, the methodology allows to obtain standardized results and then to compare them thought different Demo sites. The aim is to have a tool to measure the impact of IP4 technologies and to order Demo sites according to their level of impact.
The steps of this methodology are:

- **1 - Decision problem**: the first step is to focus on the problem to solve and figure out what the results should be in order to have positive or negative impact.
- **2 - Define evaluation criteria**: the second step is to define the evaluation criteria. In our case, KPIs are used to determine the positive or negative impact from the data collected.
- **3 - Define alternatives**: the third step consists in defining the different alternatives to compare, with the aim to classify them in accordance with the results. In our case, there is only one alternative that we can considered as a unique Use Case.
- **4 - Performance evaluation**: the fourth step consists in the evaluation of the performance, that is the data collected. In our case, the values of the KPI measurements are the values of the data in comparison with the correspondent thresholds.
- **5 - Criterion weights**: the fifth step consists in making a weighted list of the importance of the different KPIs, in accordance with Demo sites preferences. In our case, a pairwise comparison of the KPIs has been performed though AHP methodology.
- **6 - Decision rules**: the sixth step consists in the decision of the rule to adopt in order to obtain standardised data and be able to compare the different KPIs in the different Demo sites, including KPIs with different kind of measurements.
- **7 - Aggregation matrix**: the last step consists in putting together all the results obtained by the various calculation in each Demo site. In this way, it is possible to obtain at unique result referred to each single demo sites and then to conclude if the impact of the IP4 technologies has been positive or negative.

9.2. Measurement process of impact assessment

The measurement process carried out for the impact assessment includes two steps:

1. Selection of the KPI's.
2. MCA and AHP procedures introduced in the paragraph 9.1 with regard to the "7-step methodology" to obtain the aggregation matrix and finally the Impact indicators.

The methodological aspects of these two steps are described in the following subparagraphs and then applied in the following for each Demo Site.

9.2.1. Methodology for selecting and monitoring KPIs

Six demonstrations sites have been deployed in order to facilitate and coordinate IP4 technologies demonstrations, which propose offers of seamless experiences of multimodal travel. The IP4 technologies employed in IP4MAAS project allow to address cases of commuters, tourists and other users who would be attracted to public and shared transport services. The six demonstration sites have been deployed in two different contexts: urban (Barcelona, Athens and Warsaw) and rural (Padua, Liberec and Osijek).

The methodology presented in D6.1 represents an efficient procedure to implement the impact assessment, according to both literature and past European research projects. However, during the last months of IP4MaaS project it has become clear that the lack of data availability would have complicated the implementation of this methodology. For this reason, to achieve the goals of the impact assessment, updates and adaptations have been done according to IP4MAAS Demo sites conditions.

Below the steps and the considerations done thorough the process are shown, in order to make clear the decisions that have guided the selection of the final impact KPIs.

9.2.1.1. KPIs selection

The starting point is the table presented in the D6.1 where 30 impact KPIs were listed in order to be selected by the Demo sites. Table **51** shows the 13 KPIs selected from the original list. The choice has been made taking in account the most relevant KPIs in accordance with the specific context of the Demo sites. Furthermore, the aim of the choice has been the identification of the KPIs that well represent the environmental and socio-economic areas.

Table 51: KPIs selected from the original list presented in deliverable 6.1

ID	Indicator name	Indicator definition	Evaluation areas
1	**Increase of capacity of railway segments**	% Increase the capacity of railway segments to meet increased demand for passenger and freight railway services compared to "State-of-the-art" 2014	Socio-Economic
2	**CFMs Members**	All partners TSPs have been successfully onboarded by CFMs.	Socio-Economic
3	**Local dissemination events**	Number of participants in local events	Socio-Economic
5	**Quality of service**	Perception of quality of service	Socio-Economic
6	**Attitudes towards PT, sharing, etc.**	Number of persons declaring their opinion about the different modes of transport	Socio-Economic
10	**Total Trips**	Total number of trips made	Socio-Economic Environmental
11	**Transport Modal shift**	% of trips made by each transport mode	Socio-Economic Environmental
12	**Travel experience**	Description and opinions on efficiency	Socio-Economic

ID	Indicator name	Indicator definition	Evaluation areas
		of the journey	
15	**User segments**	Type of users according with age, gender or their characteristics (men/women, young/old, ...)	Socio-Economic
16	**CO2 emissions**	CO2 per vkm by type	Environmental
24	**IT interoperability**	Number of data exchange processes among operators (transport providers, IT operators, etc.) in the MaaS scheme	Socio-Economic
26	**Interoperability between MaaS and Journey Planners**	Number of Journey Planners provided by or connected to the MaaS operator platform	Socio-Economic
28	**Multimodal Integrated ticketing**	Number of ticket involving more than one mode of transport sold via the integrated ticketing channel out of the total	Socio-Economic

However, due to the lack of data, these KPIs couldn't be directly assessed. Indeed, the available data from the Demo sites are the values of the operational KPIs and the USI survey results. Therefore, the alternative solution applied was to take advantage of these data to explain and assess the impact KPIs. Furthermore, each operational KPIs is linked to a certain IP4 technology, evaluated in the USI survey.
Considering that:

- IP4MaaS Project aims at demonstrating the benefits of Innovation Programme 4 (IP4) thanks to the use of IP4 technologies.
- D6.3 aims to assess the IP4 technologies impact thanks to their implementation in the Demo sites.

It is possible to derive the Impact KPIs from Operational KPIs that, their turn, have been collected using IP4 Technologies and USI surveys. It is therefore possible to use the USI survey results to assign a quantitative result to the Impact KPIs by grouping them into four different classes:

- **USER ACCEPTANCE**: this class of KPI measures the level of User Acceptance of proposed modes of transport implemented thanks to the IP4 technologies. The final result is mainly influenced by the combination of feedback received from the users, the total tickets purchased from the users and from the profiles handles by the apps involved in the journey planning.
- **STAKEHOLDER ACCEPTANCE**: this class of KPI measures the level of Stakeholder Acceptance of proposed modes of transport implemented thanks to the IP4 technologies. The final result is mainly influenced by the combination of the stakeholder involved in the journey planning and from the mobility packages handles (different travel solutions proposed).
- **QUALITY OF SERVICE**: this class of KPI measures the level of quality of service perceived by the actors involved. The general quality of service of the system is related to the surveys collected from travellers and TSPs.

- **MULTIMODALITY**: this class of KPI measures the level of multimodality achieved thanks to the use of the proposed modes of transport implemented thanks to the IP4 technologies. The multimodality is mainly influenced by the combinations of the number of modes of transport involved and the different multimodal solutions proposed to the user during the journey planning.

Using these classes, the combinations of USI survey results can be reliably used in order to assess the impact of IP4 technologies implemented in the Demo sites.
Indeed, the USI survey evaluates the level of importance and satisfaction related to each IP4 technology for the specific implementation in the Demo site.
The following Table **52** shows which impact KPIs are related with the operational KPIs and, in turn, which IP4 technology is involved in the impact assessment, so to identify the USI survey results to use[39].

Table 52: relations between impact KPIs, operational KPIs and IP4 technologies

IMPACT KPIs	OPERATIONAL KPIs	IP4 TECHNOLOGY	CLASS OF IMPACT KPIs	AREA
Attitudes towards PT, sharing, etc.	Number of feedbacks received	10-Traveller's feedback	**USER ACCEPTANCE**	**SOCIO-ECONOMIC**
Total Trips	Total Number of Tickets purchased	5-Validation and Inspection		
Increase of capacity of railway segments	Number of profiles handled	13-Preferences and profiles		
User segments				
CFMs Members	Number of involved stakeholders	19-Contractual management and marketplace	**STAKEHOLDER ACCEPTANCE**	
Local dissemination events				
IT interoperability	Number of mobility packages handled	18-Contractual management and marketplace		
Travel experience	USI survey (travellers)		**QUALITY OF SERVICE**	
Quality of service	USI survey (TPSPs)			
Transport Modal shift	Number of involved modes of transport in	1-Journey Planner/Offer	**MULTIMODALITY**	

[39] Theoretically speaking, here a correlation between IP4 technologies and USI surveys is presented in this section in order to link them to a certain Impact KPI. However, further questions related to other IP4 technologies can be included in accordance with data availability to improve the significance of the values. Furthermore, USI surveys are not the same for all the Demo Sites. When certain USI survey questions are missing (therefore the correspondent IP4 technology is not assessed), other questions/IP4 technologies are taking in account in the final evaluation.

IMPACT KPIs	OPERATIONAL KPIs	IP4 TECHNOLOGY	CLASS OF IMPACT KPIs	AREA
Multimodal Integrated ticketing	the trip (multimodality)	Builder		
Interoperability between MaaS and Journey Planners	Available travel solutions or options issued by TSP for travellers to reach their destination (due to the integration of transport modes)	1-Journey Planner/Offer Builder		**ENVIROMENTAL**[40]

In order to make clear these correlations, a brief explanation is presented:

- **USER ACCEPTANCE**: the IP4 technologies selected in order to evaluate this class of Impact KPIs are:
  - Traveller's feedback: it can be related to the operational KPI "Number of feedback responses received". Since the specific USI survey questions give the satisfaction of the users for the services implemented, it can be linked to the impact KPI "Attitudes towards PT, sharing, etc.". Furthermore, the question "Am I willing to pay for this function", which is done for several functionalities, is always considered as an assessment for the traveller's attitude.
  - Validation and Inspection: it can be related to the operational KPI "Total Number of Tickets purchased". Since the direct link between the tickets and the trips carried out, this is easily linked to the Impact KPI "Total trips".
  - Preferences and profiles: it can be related to the operational KPI "Number of profiles handled". Since the specific USI survey questions give the perception of the travellers share who use the services as well as they collect the personal data of the users, it can be linked to the impact KPIs "Increase of capacity of railway segments" and "User segments".
- **STAKEHOLDER ACCEPTANCE**: the IP4 technology selected in order to evaluate this class of Impact KPIs is:
  - Contractual management and marketplace: it can be related to the operational KPIs "Number of involved stakeholders" and "Number of mobility packages handled". Since the specific USI survey questions give the satisfaction and the level of participation of TSPs as well as the level of development of services offered, they can be linked to the impact KPIs "CFMs Members", "Local dissemination events" and "IT interoperability".

[40] MULTIMODALITY is inserted in the Environmental area because it is related to sustainable mobility, and it aims to reduce the use of private vehicles. Therefore, even if indirectly, it can be a tool that contributes to assess the environmental situation in the Pilot Site.

- **QUALITY OF SERVICE**: this class of KPI can be directly assess by the USI survey questions related to the satisfaction of every IP4 technologies. Therefore, both for travellers and TSPs (stakeholders), the specific question "In general terms, I am satisfied with this function" is taken for each functionality when available. Therefore, in the end, it is possible to link this result with the assessment of the quality of service for both travellers and stakeholders. Finally, it is possible to assess the impact KPIs "Travel experience" and "Quality of service".
- **MULTIMODALITY**: the IP4 technology selected in order to evaluate this class of Impact KPIs is:
    - Journey Planner/Offer Builder: it can be related to the operational KPI "Number of involved modes of transport in the trip (multimodality)" and "Available travel solutions or options issued by TSP for travellers to reach their destination (due to the integration of transport modes)". Since the specific USI survey questions give the satisfaction related to the level of multimodality, they can be linked to the impact KPIs "Transport Modal shift", "Multimodal Integrated ticketing" and "Interoperability between MaaS and Journey Planners".

Finally, beyond the data collected with the USI survey, the data related to the values collected for the operational KPIs are used to make a qualitative analysis. However, the operational KPIs evaluated in each Demo site are not homogeneous. Therefore, for each Demo site a specific analysis is done in accordance with the data availability.

9.2.1.2. WEIGHTS calculation

As introduced above, the pairwise comparison has been carried out to identify the weight of each KPI. A pairwise comparison survey has been proposed to the stakeholders and 3 answers for each Demo site have been collected. Therefore, a total of 18 personal considerations, reporting individual experience, interests and perception, on the weights' assignation have been collected. In order to further consolidate the robustness of the final weights, it has been proposed the same pairwise comparison survey to a "control group" formed by experts in the topics of sustainable mobility, public transports and urban logistics. The answer received are 9. The following tables show the average results of both stakeholders and control group results.

Table 53: Average of pairwise comparison values from Stakeholder's survey

PAIRWISE COMPARISON VALUES (STAKEHOLDER)				
CRITERION	**USER ACCEPTANCE**	**STAKEHOLDER ACCEPTANCE**	**QUALITY OF SERVICE**	**MULTIMODALITY**
USER ACCEPTANCE	1,00	2,13	1,60	2,42
STAKEHOLDER ACCEPTANCE	0,47	1,00	1,22	1,42
QUALITY OF SERVICE	0,63	0,82	1,00	2,35
MULTIMODALITY	0,41	0,70	0,43	1,00

TOT.	**2,51**	**4,65**	**4,25**	**7,19**

Table 54: Average of pairwise comparison values from control group's survey

PAIRWISE COMPARISON VALUES (CONTROL GROUP)				
CRITERION	**USER ACCEPTANCE**	**STAKEHOLDER ACCEPTANCE**	**QUALITY OF SERVICE**	**MULTIMODALITY**
USER ACCEPTANCE	1,00	2,24	1,27	0,58
STAKEHOLDER ACCEPTANCE	0,45	1,00	0,85	0,65
QUALITY OF SERVICE	0,79	1,18	1,00	0,79
MULTIMODALITY	1,71	1,53	1,27	1,00
TOT.	**3,95**	**5,96**	**4,38**	**3,03**

In order to increase the consistency of these results, the two tables above have been combined to obtain more significant results, reported in the following table:

Table 55: combinations of the two pairwise comparison surveys

PAIRWISE COMPARISON VALUES				
CRITERION	**USER ACCEPTANCE**	**STAKEHOLDER ACCEPTANCE**	**QUALITY OF SERVICE**	**MULTIMODALITY**
USER ACCEPTANCE	1,00	2,19	1,43	1,36
STAKEHOLDER ACCEPTANCE	0,46	1,00	1,02	0,94
QUALITY OF SERVICE	0,70	0,98	1,00	1,54
MULTIMODALITY	0,74	1,06	0,65	1,00
TOT.	**2,89**	**5,23**	**4,10**	**4,84**

According to the "7 steps methodology" above presented the pairwise comparison values have been normalized with the final weights calculated and the weights sum values used to check the consistency of the weights.

Table 56: normalised pairwise comparison values

PAIRWISE COMPARISON VALUES (normalized)					
CRITERION	**USER ACCEPTANCE**	**STAKEHOLDER ACCEPTANCE**	**QUALITY OF SERVICE**	**MULTIMODALITY**	**WEIGHTS**
USER ACCEPTANCE	0,35	0,42	0,35	0,28	**0,35**
STAKEHOLDER ACCEPTANCE	0,16	0,19	0,25	0,20	**0,20**
QUALITY OF SERVICE	0,24	0,19	0,24	0,32	**0,25**
MULTIMODALITY	0,26	0,20	0,16	0,21	**0,21**
TOT.	1,00	1,00	1,00	1,00	

Table 57: sum of weights' values

WEIGHTED COLUMNS					
CRITERION	**USER ACCEPTANCE**	**STAKEHOLDER ACCEPTANCE**	**QUALITY OF SERVICE**	**MULTIMODALITY**	**WEIGHTS SUM**
USER ACCEPTANCE	0,35	0,43	0,35	0,28	**1,42**
STAKEHOLDER ACCEPTANCE	0,16	0,20	0,25	0,19	**0,80**
QUALITY OF SERVICE	0,24	0,19	0,25	0,32	**1,00**
MULTIMODALITY	0,26	0,21	0,16	0,21	**0,83**

Now, it is possible to calculate the λ_{max}.

$$\lambda_{max} = \frac{\frac{1,42}{0,35}+\frac{0,80}{0,20}+\frac{01,00}{0,25}+\frac{0,83}{0,21}}{4} = 4,06$$

and the Consistency Index (CI):

$$CI = \frac{4,06-4}{3} = 0,018$$

Finally, the Consistency Ratio (CR) is calculated dividing the CI for the Random-Like Matrix (RI):

$$CR = \frac{0,018}{0,89} = 0,02$$

Since CR<0,1 the weights are consistent and can be used for the calculations.

Finally, the final weights used to find the impact assessment indicator are:

Table 58: weights used to find the impact assessment indicator

CRITERION	WEIGHTS
USER ACCEPTANCE	**0,35**
STAKEHOLDER ACCEPTANCE	**0,20**
QUALITY OF SERVICE	**0,25**
MULTIMODALITY	**0,21**

9.2.1.3. Thresholds, USI values and impact assessment indicator values

Once the weighs are established, it is possible to carry out the procedure in which the USI values and the weights are correlated in order to calculate the impact indicator of each class of Impact KPI.

First of all, the **threshold** to evaluate the level of impact of the impact KPI has been fixed to 5, that is the maximum value that can be achieved in the USI survey. In accordance with the sixth step of the "7-steps methodology" explained in section 9.2, the chosen decision rule was to use the linear function and the maximum value (5) is the benchmark case. In other words, the impact assessment indicators will be normalized values in which 1 (100%) is achieved if the USI survey result is 5; therefore, to find the impact indicator the USI value of each class of impact KPI is divided for the maximum value possible.

On the other hand, the **USI values** are calculated thanks to the average of values related to the questions selected.

Finally, the thresholds to establish **the level of impact of the IP4 technologies** in the Demo sites, in accordance with the impact assessment indicators calculated, are shown in the following table:

Table 59: impact indicator scale

IMPACT INDICATOR SCALE					
IMPACT	No impact	Low impact	Medium impact	High impact	Huge impact
NORMALIZED VALUE	0,00-0,20	0,21-0,40	0,41-0,60	0,61-0,80	0,81-1,00

9.2.2. 7 STEP PROCEDURE

As introduced above, this procedure allows to calculate standardized and unique values to be compared in order to identify the impact of IP4 technologies as well as to classify the results of each Demo site. The 7 steps are presented in details hereafter.

1 - Decision problem

The first step is to identify the decision problem. In other words, what is the question that the procedure aims to answer?

According to IP4MAAS objective, the project aims at demonstrating the benefits of Innovation Programme 4 (IP4) technologies. Specifically, D6.3 aims to show impact assessment results in order to demonstrate the positive impacts of IP4 technologies thanks to their implementation in the Demo sites. Therefore, the main problem is to compare different results and the decision problem can be settled as follows: **how the implementation of IP4 technologies in the Demo sites of IP4MAAS can be assessed using a single parameter** combining all variables and providing a standardized and comparable (cross-site) result.

2 - Define evaluation criteria

The second step is the definition of the evaluation criteria. As already said, in this context **evaluation criteria are the KPIs.** The KPIs will give the impact of a certain measure in each Demo site. However, setting the KPIs as evaluation criteria raises the following issues:

- The same KPIs could be measured in different ways.
- The same KPIs could have different way of measure and duration among the Demo sites.

Despite these are common problems, in IP4MAAS the KPIs are related to the performance and the impact assessment. For the latter, the KPIs are related to environmental and socio-economic aspects, data are collected from the same sources used for performance assessment but differently combined to address impact-related questions, which solve the issues above introduced. The final list of the KPIs analysed for the impact assessment has been generated starting from the KPIs list presented in the D6.1. This list has been reduced and combined with the operational KPIs used for the performance assessment in order to obtain few but significant impact KPIs.

3 - Define alternatives

The third step is the definition of the alternatives. As already said, in this context **there is a single Use Case for each Demo site** consisting in the user experience tested during the experimentations**.** For this reason, there is a basic situation which allows to exclude issues as:

- Different number of Uses Cases among the Demo sites.
- Subjectivity given by the Different weight usually assigned to the Use Cases.

4 - Performance evaluation

The fourth step is the evaluation of the performance, usually the comparison between baseline and project scenario results. However, as already said, in this context there is only the project scenario. Therefore, **the performance evaluation should be represented by the achieved level of KPIs values against the level of the thresholds established.**

Specifically, to evaluate the KPIs, the USI survey results have been considered. Therefore, the thresholds established are related to the maximum value of the survey. At the end, the single parameter to assess the impact of the IP4 technologies for each Demo Case the **impact assessment indicator**.

5 - Criterion weights

The fifth step is the calculation of the weights to assign to each KPI in order to obtain a weighted average in accordance with stakeholders' ranking. The procedure starts with the **pairwise comparison performed by the involved stakeholders**.

Practically, the pairwise comparison of the *n* KPIs used in each Demo site is done through a survey administered to stakeholders to rank KPIs and reported in the matrix shown in Table **60**: the values reports the rank, resulting from the survey, of each KPI in row against the one in column in a scale from 1 (same relevant) to 5 (much more relevant). In the table below the cell [1;2] reports a value of 4, meaning that KPI1 has been considered 4 times more relevant than KPI2 and, symmetrically, the cell [2;1] reports a value of ¼ meaning that KPI2 is 4 times less relevant than KPI1.

Table 60: example of pairwise comparison among the KPIs

CRITERION	KP1	KPI 2	KPI 3
KPI 1	1	4	3
KPI 2	$\frac{1}{4}$ =0,25	1	$\frac{1}{2}$=0,50
KPI 3	$\frac{1}{3}$ =0,33	2	1
TOT.	1,58	7	4,50

Afterwards, the matrix is normalized dividing each value of a column by the total sum of that column.

Table 61: normalized values of the pairwise comparison

CRITERION	KP1	KPI 2	KPI 3
KPI 1	$\frac{1}{1,58} = 0,63$	$\frac{4}{7} = 0,57$	$\frac{3}{4,50} = 0,67$
KPI 2	$\frac{0,25}{1,58} = 0,16$	$\frac{1}{7} = 0,14$	$\frac{0,5}{4,50} = 0,11$
KPI 3	$\frac{0,33}{1,58} = 0,21$	$\frac{2}{7} = 0,29$	$\frac{1}{4,50} = 0,22$
TOT.	1	1	1

Then, **the average of each row of the normalized matrix gives the weights** for the respective KPI in that row.

Table 62: weights for the each KPI

CRITERION	KP1	KPI 2	KPI 3	WEIGHTS
KPI 1	0,63	0,57	0,67	**0,62**
KPI 2	0,16	0,14	0,11	**0,14**
KPI 3	0,21	0,29	0,22	**0,24**

A consistency analysis is done in order to figure out the reliability of the calculated weights.
The values of each KPI (column) in Table **60** are multiplied with the correspondent weights reported in the last column of Table **62**. Then, with the obtained values the weighted sum is calculated for each KPI, the values are shown in the following table.

Table 63: weighted sum values

CRITERION	KP1	KPI 2	KPI 3	WEIGHTED SUM
KPI 1	0,62	0,55	0,72	**1,89**
KPI 2	0,16	0,14	0,12	**0,41**
KPI 3	0,21	0,27	0,24	**0,72**

Now, the average of the three values obtained dividing each value of the weighted sum column with the respective value of the weights.

$$\lambda_{max} = \frac{\frac{1,89}{0,62}+\frac{0,41}{0,14}+\frac{0,72}{0,24}}{3} = 3,02$$

The consistency is analysed through a Consistency Index (CI), calculated with the following formula:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

where *n* is the number of KPIs. Therefore, in our example CI = (3,02-3)/(3-1)=0,01.
Finally, the Consistency Ratio (CR) is calculated dividing the CI for the Random-Like Matrix (RI), that is the average CI of 500 randomly filled in matrices. RI has fix values in accordance with the number of objects compared[41].

Table 64: values of Random-Like Matrix (RI)

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0,52	0,89	1,11	1,25	1,35	1,4	1,45	1,49

In this case, for n=3 the value is RI=0,52. So, the final step is CR=CI/RI. In our example is CR=0,01/0,52=0,02. **If CR<0,1 then the weights are consistent and can be used for the calculations.**

6 - Decision rules
The sixth step regards definition of the decision rule, that is the way in which the results are standardized. In other words, **the decision rule establishes how the results of the performance evaluation are transformed in a standardized scale**. Usually, the scale is a number between 0 and 1, where 0 means no changes (no impact, worst performance) and 1 means optimal change (great impact, best performance).
This transformation is performed thanks to a Single-Attribute Value Functions (SAVF), which allows to indicate the relevant performance according to the stakeholders for every Demo site. **In this context a linear function, which increases linearly from 0 to 1, has been used**.
The first thing to decide is the threshold for which 1 is achieved. In this context, **the benchmark case has been used**. In other words, 1 means the best possible result for that specific KPI. In order to find the right value through the linear function, for each KPI the measure of the value (performance evaluation) must be divided by the correspondent threshold. The closer the KPI value is to the threshold, the closer the value obtained is to 1.

[41] Saaty, T.L. and Sodenkamp, M. (2008). "Making decisions in hierarchic and network systems." International Journal Applied Decision Sciences, vol. 1 (no. 1): pp. 24-79.

7 - Aggregation matrix

Usually, the last step is the aggregation of all the results of the Use Cases for Demo site. However, **since there is only a single Use Case, this step has a basic and simple situation**. Therefore, it will be enough to consider the impact assessment indicator of each Demo site and compare these values in order to obtain the impact assessment of IP4 technologies in each Demo site.

9.3. Impact assessment for Demo sites

According to the methodology introduced in the previous subsections, the following paragraphs reports the impact assessment resulting for each Demo site.

9.3.1. Barcelona

9.3.1.1. Demo site Overview

The location of the demo Site is Barcelona metropolitan area, in Spain, including urban and suburban areas. The available transit opportunities cover a distance of 23-50km, from the city centre of Barcelona to medium sized cities. The TSPs involved are:

- **TMB**, which is the main public transport operator and operates metro and several bus lines in the urban metropolitan area .
- **BusUp**, which uses a booking platform to link bus operators and its customers for ride-sharing services and on demand services.
- **AMTU**, which is a MaaS operator and a transport operator who developed demand responsive system and the correlate application.
- **SocialCar**, which is sharing and car renting company with the main role to cover first mile and last mile allowing travellers to reach and use public transport services. Social Car has not be integrated in the ecosystem but was involved in the demo supporting the leader, as per amendment 1 submitted and accepted in August-September 2022.

The demo aims, though the reduction of vehicles and an improvement of people communication for travelling from home to different locations with share modes, to optimize the use of multi-modal travel thanks to IP4 ecosystem.
The achievement of shared mobility solution for peripheral urban areas and a unique seamless journey as well as the development of individual mobility offers and services are the main expectations for the demo Site of Barcelona.
Two main use-cases have been deployed: a) Same starting point - different destination, about people who live in a village, residential area nearby Barcelona but work in Barcelona, in different destinations; b) Different starting point - same destination, focused on people working for the same company, which is located in a relatively remote location.

9.3.1.2. Impact KPIs results

The following table shows the operational KPIs and the correspondent values collected during the demo implementation:

Table 65: Operational KPIs results for Barcelona Demo site

Innovative technology (IP4)	Linked to	Units	Values
Journey planning (journey planner)	Traveller	Average number of modes involved in the journey per trip	2
Journey planning (journey planner)	Traveller	Number of TSP integrated	3
Journey planning (journey	Traveller	Average number of shopped offers	1771

planner)			
Booking	Traveller	Average number of booked offers per day	1
Traveller's feedback	Traveller	Number/day	16
Asset manager	TSP	Number of services integrated with the pilot	3

The User Segments[42] resulted from the USI survey are reported in the following tables

Table 66: User Segments of Barcelona Demo site organized per different categories

AGE		
18-24 years old	0	0,00%
25-44 years old	6	54,55%
45-64 years old	4	36,36%
65 years old or more	1	9,09%
Prefer not to answer	0	0,00%

INCOME		
Less than 11,999 €	0	0,00%
12,000-40,999 €	7	63,64%
More than 41,000 €	1	9,09%
Prefer not to answer	3	27,27%

HAVING A PROBLEM, DIABILITY OR IMPAIRMENT THAT AFFECTS TRAVELING		
No	10	90,91%
Person on a wheelchair	1	9,09%
Person with reduced mobility	0	0,00%
Person with visual impairment	0	0,00%
Hearing impaired	0	0,00%
Other	0	0,00%
Prefer not to answer	0	0,00%

GENDER		
Male	7	63,64%
Female	4	36,36%
Other	0	0,00%
Prefer not to answer	0	0,00%

RESIDENTIAL AREA		
A rural environment	1	9,09%
An urban environment	9	81,82%
A suburban environment	0	0,00%
Abroad/tourist	1	9,09%

TRAVELLING WITH DEPENDENT PERSON		
No	11	100,00%
Preschool age children (under 5 years old)	0	0,00%
School-age children (5-16 years old)	0	0,00%
Elderly relative	0	0,00%
Disabled person	0	0,00%
Prefer not to answer	0	0,00%

[42] Barcelona Pilot Site has had a low participation level. For this reason, the consistency and significance of these results are considered not reliable.

PROFESSIONAL STATUS		
Non-paid work	0	0,00%
Paid work	10	90,91%
Student	0	0,00%
Housekeeper, homemaker	0	0,00%
Retired	1	9,09%
Unemployed	0	0,00%
Prefer not to answer	0	0,00%

FAMILIARITY WITH TECHNOLOGY AND MOBILE APPLICATION		
Expert	7	63,64%
Familiar	4	36,36%
Not so familiar	0	0,00%
I am having many troubles using mobile apps in general	0	0,00%

From these tables, we can see that:

- About 91% of the users are between 25 and 64 years old.
- About 72% of the users have a middle-high or high income. About 27% have preferred to not answer
- About 91% of the users don't have any disability or other impairment that affects traveling.
- About 36% of the users are male, while about 64% are female.
- About 82% of the users live in the urban environment.
- 100% of the users travels without dependent persons.
- About 91% of the users own a paid job.
- 100% of the users have a good level of familiarity with technology and mobile application.

In accordance with the IP4 technologies assessed and the data availability, the following Table **67** shows the questions have been selected from the USI survey in order to establish the values to calculate the impact assessment indicator.
The -Table **68**, indeed, shows the procedure that, starting from the USI values collected for each class of impact KPIs, brings to the impact assessment indicator.

Table 67: USI survey results selected for Barcelona Demo site

BARCELONA DEMO SITE						
ID	**IP4 Technology**	**Question**	**USER ACCEPTANCE**	**STAKEHOLDER ACCEPTANCE**	**QUALITY OF SERVICE**	**MULTIMODALITY**
J10q2	Travellers' feedback	It has encouraged me to participate and be more involved in the public transport services' offers and rate the trips and submit comments and feedback through the application	2,33			
J2q2	Booking	It will encourage me to use buses, trains, and public transport systems more frequently	3,00			
J9q2	Navigation function	It has saved me time and made it easier for me to reach my destination	2,57			
J2q4	Booking	I am willing to pay for this function	2,27			
J4q3	Mobility packages					
J11q3	Trip sharing					
J16q3	Travel companion web-portal					
J23q4	Asset manager					
J25q5	Contractual management marketplace					
J23q2	Asset manager	It has allowed me to know better my services offer and technology level		2		
J25q2	Contractual management marketplace	It has increased the number of intermodal trips		2		
J25q3	Contractual management marketplace	It has developed my business in financial terms		2		
J25q4	Contractual management marketplace	It has increased the level of TSPs' cooperation		2		
J1q1	Journey planning	In general terms, I am satisfied with this function (travellers)			3,67	
J2q1	Booking					
J4q1	Mobility packages					
J9q1	Navigation					
J10q1	Travellers' feedback					
J11q1	Trip sharing					
J12q1	Guest user					
J13q1	Preferences and profiles					
J15q1	Collaborative space portal travellers					

J16q1	Travel companion web-portal					
J20q1	Map content					
J23q1	Asset manager	In general terms, I am satisfied with this function (TSPs)			3,00	
J25q1	Contractual management marketplace					
J1q2	Journey planning	It has saved me time				3,44
J1q3	Journey planning	It has saved me money				3,00
J1q4	Journey planning	It has helped me to make appropriate travel decisions				4,38
USI VALUE			**2,54**	**2,00**	**3,33**	**3,60**

-Table 68: Impact Assessment indicators for Barcelona Demo site

BARCELONA DEMO SITE		
USER ACCEPTANCE	USI Value	2,54
	Threshold	5,00
	Weights	0,35
	Indicator	**0,51**
STAKEHOLDER ACCEPTANCE	USI Value	2,00
	Threshold	5,00
	Weights	0,20
	Indicator	**0,40**
QUALITY OF SERVICE	USI Value	3,33
	Threshold	5,00
	Weights	0,25
	Indicator	**0,67**
MULTIMODALITY	USI Value	3,60
	Threshold	5,00
	Weights	0,21
	Indicator	**0,72**
	IMPACT INDICATOR	**0,57**

9.3.1.3. Conclusions

In accordance with the values of the Impact KPIs indicators, we can conclude that:

- The IP4 Technologies implemented in the Barcelona Demo site have been a **medium impact** in the improvement of the **USER ACCEPTANCE**.
- The IP4 Technologies implemented in the Barcelona Demo site have been a **low impact** in the improvement of the **STAKEHOLDER ACCEPTANCE** (even if with a high value near to the medium impact threshold)
- The IP4 Technologies implemented in the Barcelona Demo site have been a **high impact** in the improvement of the **QUALITY OF SERVICE**.
- The IP4 Technologies implemented in the Barcelona Demo site have been a **high impact** in the improvement of the **MULTIMODALITY**.

Finally, multiplying the indicator of each class of KPIs for the respective weight and then calculating the average of this result, it is possible to obtain the impact assessment indicator. We can conclude that the implementation of IP4 technologies have had a medium-to-positive impact in the Barcelona Demo site. In fact, the **impact assessment indicator shows a Medium Impact** (57%) of the IP4 technologies implemented.

9.3.2. Athens

9.3.2.1. Demo site Overview

The location of the demo site is Athens urban areas, Greece. The TSPs involved are:

- **OASA**, which is an urban public transport and MaaS operator.
- **Miraklio**, the Municipality of Irakleio, providing the Municipal PT bus service
- **Taxiway**, which is a taxi company.
- **BrainBox**, which is a bike sharing service and a tourist transport provider; MIRAKLIO, which is the municipal PT service operator.

The demo aims to deploy a single application that, through integrated ticketing and journey planning, allows to enhance multimodality.
The reconfiguration of the MaaS provider services using knowledge about user needs will be the main expected impact. The identification of mobility patterns, the combination of modes and the localisation of transport services places will be the instruments to collect significant data.
Three main use-cases will be deployed: 1) Multimodal work trip Case 1, from central Athens to any other metro station outside central area; 2) MaaS for tourists Case 2, from Pireaus Port to any other metro station; 3) Rural - urban interfaces Case 3 – From central Athens to any other metro station or site, both for work and shopping/leisure trips.
The identification of mobility patterns, the combination of modes and the localization in which transport services should be provided will be the instruments to collect demo data for the neutral mobility platform.

9.3.2.2. Impact KPIs results

Athens Demo site is the first one implemented and the only Demo site where two phases have been carried out.
The following table shows the operational KPIs and the correspondent values collected during the demo implementation:

Table 69: Operational KPIs results for Athens Demo site

Innovative technology (IP4)	Linked to	Units	Values
Journey planning (journey planner)	Traveller	Average number of modes involved in the journey per trip	3
Journey planning (journey planner)	Traveller	Number of TSP integrated	4
Journey planning (journey planner)	Traveller	Average number of shopped offers	1238
Booking	Traveller	Average number of booked offers per day	39
Issuing	Traveller	Average number of issued offers per day	25
Mobility packages	Traveller	Number of mobility packages offered	1
Guest user	Traveller	Number of connections without password per day	1
Location-Based Experience (LBE)	TSP/Traveller	Number of entertainment services offered during the demo	3

Asset manager	TSP	Number of services integrated with the pilot	3
Contractual management marketplace	TSP	Number of mobility packages handled	1
Contractual management marketplace	TSP	Number of involved stakeholders	2

The User Segments resulted from the USI survey are reported in the following tables

Table 70: User Segments of Athens Demo site organized per different categories

AGE		
18-24 years old	4	10,53%
25-44 years old	21	55,26%
45-64 years old	12	31,58%
65 years old or more	0	0,00%
Prefer not to answer	1	2,63%

INCOME		
Less than 11,999 €	6	15,79%
12,000-40,999 €	18	47,37%
More than 41,000 €	9	23,68%
Prefer not to answer	5	13,16%

HAVING A PROBLEM, DIABILITY OR IMPAIRMENT THAT AFFECTS TRAVELING		
No	36	94,74%
Person on a wheelchair	0	0,00%
Person with reduced mobility	0	0,00%
Person with visual impairment	0	0,00%
Hearing impaired	0	0,00%
Other	0	0,00%
Prefer not to answer	2	5,26%

GENDER		
Male	14	36,84%
Female	21	55,26%
Other	1	2,63%
Prefer not to answer	2	5,26%

RESIDENTIAL AREA		
A rural environment	0	0,00%
An urban environment	34	89,47%
A suburban environment	4	10,53%
Abroad/tourist	0	0,00%

TRAVELLING WITH DEPENDENT PERSON		
No	32	84,21%
Preschool age children (under 5 years old)	2	5,26%
School-age children (5-16 years old)	2	5,26%
Elderly relative	0	0,00%
Disabled person	0	0,00%
Prefer not to answer	2	5,26%

PROFESSIONAL STATUS

Non-paid work	0	0,00%
Paid work	34	89,47%
Student	1	2,63%
Housekeeper, homemaker	0	0,00%
Retired	1	2,63%
Unemployed	1	2,63%
Prefer not to answer	1	2,63%

FAMILIARITY WITH TECHNOLOGY AND MOBILE APPLICATION		
Expert	22	57,89%
Familiar	12	31,58%
Not so familiar	4	10,53%
I am having many troubles using mobile apps in general	0	0,00%

From these tables, we can see that:

- About 87% of the users are between 25 and 64 years old.
- About 71% of the users have a middle-high or high income.
- About 95% of the users don't have any disability or other impairment that affects traveling.
- About 37% of the users are male, while about 55% are female.
- About 90% of the users live in the urban environment.
- About 84% of the users travels without dependent persons.
- About 89% of the users own a paid job.
- About 89% of the users have a good level of familiarity with technology and mobile application.

In accordance with the IP4 technologies assessed and the data availability, the following Table **71** shows the questions have been selected from the USI survey in order to establish the values to calculate the impact assessment indicator.
The Table **72**, indeed, shows the procedure that, starting from the USI values collected for each class of impact KPIs, brings to the impact assessment indicator.

Table 71: USI survey results selected for Athens Demo site

ATHENS DEMO SITE						
ID	**IP4 Technology**	**Question**	**USER ACCEPTANCE**	**STAKEHOLDER ACCEPTANCE**	**QUALITY OF SERVICE**	**MULTIMODALITY**
J10q2	Travellers' feedback	It has encouraged me to participate and be more involved in the public transport services' offers and rate the trips and submit comments and feedback through the application	4,00			
J2q2	Booking	It will encourage me to use buses, trains, and public transport systems more frequently	4,20			
J8q3	Location-based experience	It will encourage me to use different modes of transportation more frequently and to use my time more efficiently by identifying points aligned with my interest	3,82			
J2q4	Booking	I am willing to pay for this function	2,64			
J4q3	Mobility packages					
J8q4	Location-based experience					
J11q3	Trip sharing					
J16q3	Travel companion web-portal					
J23q4	Asset manager					
J24q6	LBE editor					
J25q5	Contractual management marketplace					
J30q3	Distributed ledger – Transaction anchoring					
J31q3	Distributed ledger – TSP inclusion					
J33q3	Specific messages					
J5q2	Validation and inspection	It has reduced the time in inspections and checking operations and made my trip more convenient and comfortable	3,59			
J24q2	LBE editor	It has the potential to increase the number of travellers using railways services	4			
J25q2	Contractual management marketplace	It has increased the number of intermodal trips		3,50		
J25q3	Contractual management marketplace	It has developed my business in financial terms		3,00		
J25q4	Contractual management marketplace	It has increased the level of TSPs' cooperation		4,00		

J1q1	Journey planning	In general terms, I am satisfied with this function (travellers)			3,97	
J2q1	Booking					
J3q1	Issuing					
J4q1	Mobility packages					
J5q1	Validation and inspection					
J8q1	Location-based experience					
J9q1	Navigation					
J10q1	Travellers' feedback					
J11q1	Trip sharing					
J12q1	Guest user					
J13q1	Preferences and profiles					
J16q1	Travel companion web-portal					
J17q1	Intermodal fare optimization					
J18q1	Smart locations					
J19q1	Map content					
J23q1	Asset manager	In general terms, I am satisfied with this function (TSPs)			4,31	
J24q1	LBE editor					
J25q1	Contractual management marketplace					
J29q1	Travellers orchestration and supervision					
J30q1	Distributed ledger – Transaction anchoring					
J31q1	Distributed ledger – TSP inclusion					
J33q1	Specific messages					
J1q2	Journey planning	It has saved me time				3,44
J1q3	Journey planning	It has saved me money				3,00
J1q4	Journey planning	It has helped me to make appropriate travel decisions				4,38
USI VALUE			**3,71**	**3,50**	**4,14**	**3,74**

Table 72: Impact Assessment indicators for Athens Demo site

ATHENS DEMO SITE		
USER ACCEPTANCE	USI Value	3,71
	Threshold	5,00
	Weights	0,35
	Indicator	**0,74**
STAKEHOLDER ACCEPTANCE	USI Value	3,50
	Threshold	5,00
	Weights	0,20
	Indicator	**0,70**
QUALITY OF SERVICE	USI Value	4,14
	Threshold	5,00
	Weights	0,25
	Indicator	**0,83**
MULTIMODALITY	USI Value	3,74
	Threshold	5,00
	Weights	0,21
	Indicator	**0,75**
	IMPACT INDICATOR	**0,76**

9.3.2.3. Conclusions

In accordance with the values of the Impact KPIs indicators, we can conclude that:

- The IP4 Technologies implemented in the Athens Demo site have been a **high impact** in the improvement of the **USER ACCEPTANCE**.
- The IP4 Technologies implemented in the Athens Demo site have been a **high impact** in the improvement of the **STAKEHOLDER ACCEPTANCE**.
- The IP4 Technologies implemented in the Athens Demo site have been a **huge impact** (even if with a low value near to the high impact threshold) in the improvement of the **QUALITY OF SERVICE**.
- The IP4 Technologies implemented in the Athens Demo site have been a **high impact** in the improvement of the **MULTIMODALITY**.

Finally, multiplying the indicator of each class of KPIs for the respective weight and then calculating the average of this result, we can obtain the impact assessment indicator. We can conclude that the implementation of IP4 technologies have had a positive impact in the Athens Demo site. In

fact, the **impact assessment indicator shows a High Impact** (76%) of the IP4 technologies implemented.

9.3.3. Warsaw

9.3.3.1. Demo site Overview

The location of the demo site is Warsaw metropolitan area, Poland. The TSPs involved are:

- **MIASTO WARSZAWA**, which is the coordinator of PT services for the municipality; MZA, which is municipal bus operator.
- **TRAM WARSAW**, which is the tramway operator.

The demo aims to assess all services and IP4 functionalities under the IP4MaaS project, including user profiling, ticketing, travel reports or MaaS schemes.
The implementation of MaaS principles and the improvement of the entire ecosystem, specifically its technological platform are the main expected impacts. To reflect currently ongoing organizational and social changes in Warsaw, the demo will be focused on different typed of mobility, integrated by public transport nodes.

9.3.3.2. Impact KPIs results

The following table shows the operational KPIs and the correspondent values collected during the demo implementation:

Table 73: Operational KPIs results for Warsaw Demo site

Innovative technology (IP4)	Linked to	Units	Values
Journey Planner (JP)/ Offer Builder	Traveller	Average number of transport modes per trip	7
Journey Planner (JP)/ Offer Builder	Traveller	Number of TSP integrated	2
Journey planning (journey planner)	Traveller	Average number of shopped offers	9655
Traveller's feedback	Traveller	Number/day	9
Asset manager	TSP	Number/year	3
Travel Arrangement	traveller	number per pilot	7

The User Segments resulted from the USI survey are reported in the following tables

Table 74: User Segments of Warsaw Demo site organized per different categories

AGE		
18-24 years old	33	15,87%
25-44 years old	108	51,92%
45-64 years old	58	27,88%
65 years old or more	8	3,85%
Prefer not to answer	1	0,48%

INCOME		
Less than 11,999 €	41	19,71%
12,000-40,999 €	113	54,33%
More than 41,000 €	2	0,96%
Prefer not to answer	52	25,00%

HAVING A PROBLEM, DIABILITY OR IMPAIRMENT THAT AFFECTS TRAVELING		
No	199	95,67%
Person on a wheelchair	0	0,00%
Person with reduced mobility	4	1,92%
Person with visual impairment	1	0,48%
Hearing impaired	0	0,00%
Other	1	0,48%
Prefer not to answer	3	1,44%

GENDER		
Male	136	65,38%
Female	69	33,17%
Other	1	0,48%
Prefer not to answer	2	0,96%

RESIDENTIAL AREA		
A rural environment	6	2,88%
An urban environment	176	84,62%
A suburban environment	26	12,50%
Abroad/tourist	0	0,00%

TRAVELLING WITH DEPENDENT PERSON		
No	179	86,06%
Preschool age children (under 5 years old)	8	3,85%
School-age children (5-16 years old)	18	8,65%
Elderly relative	1	0,48%
Disabled person	0	0,00%
Prefer not to answer	2	0,96%

PROFESSIONAL STATUS		
Non-paid work	2	0,96%
Paid work	163	78,37%
Student	27	12,98%
Housekeeper, homemaker	1	0,48%
Retired	3	1,44%
Unemployed	2	0,96%
Prefer not to answer	10	4,81%

FAMILIARITY WITH TECHNOLOGY AND MOBILE APPLICATION		
Expert	32	15,38%
Familiar	161	77,40%
Not so familiar	15	7,21%
I am having many troubles using mobile apps in general	0	0,00%

From these tables, we can see that:

- About 80% of the users are between 25 and 64 years old.

- About 20% of the users have a low income, while about 52% have middle-high income.
- About 95% of the users don't have any disability or other impairment that affects traveling.
- About 65% of the users are male, while about 33% are female.
- About 85% of the users live in the urban environment, while about 13% live in the suburban environment.
- About 86% of the users travels without dependent persons, while about 8% travel with school-age children.
- About 78% of the users own a paid job, while about 13% are students.
- About 93% of the users have a good level of familiarity with technology and mobile application.

In accordance with the IP4 technologies assessed and the data availability, the following Table **75** shows the questions have been selected from the USI survey in order to establish the values to calculate the impact assessment indicator.
The Table **76**, indeed, shows the procedure that, starting from the USI values collected for each class of impact KPIs, brings to the impact assessment indicator.

Table 75: USI survey results selected for Warsaw Demo site

ATHENS DEMO SITE						
ID	**IP4 Technology**	**Question**	**USER ACCEPTANCE**	**STAKEHOLDER ACCEPTANCE**	**QUALITY OF SERVICE**	**MULTIMODALITY**
J10q2	Travellers' feedback	It has encouraged me to participate and be more involved in the public transport services' offers and rate the trips and submit comments and feedback through the application	3,57			
J12q2	Guest user function	It has given me the freedom to use the application in a confidential way	4,07			
J11q3	Trip sharing	I am willing to pay for this function	2,35			
J23q4	Asset manager					
J5q2	Validation and inspection	It has reduced the time in inspections and checking operations and made my trip more convenient and comfortable	3,59			
J24q2	LBE editor	It has the potential to increase the number of travellers using railways services	4			
J15q2	Collaborative space portal travellers	It gave me the ability to choose the optimal route in case of delays in the services	3,66			
J15q3	Collaborative space portal travellers	It gave me the ability to choose an optimal route based on real-time user feedback	3,64			
J23q2	Asset manager	It has allowed me to know better my services offer and technology level		3,33		
J23q3	Asset manager	It will update the services if changes have occurred in an easy way		3,33		
J1q1	Journey planning	In general terms, I am satisfied with this function (travellers)			3,82	
J9q1	Navigation					
J10q1	Travellers' feedback					
J11q1	Trip sharing					
J12q1	Guest user					
J15q1	Collaborative space portal travellers					
J20q1	Digital onboarding					
J21q1	Travel Arrangement					
J23q1	Asset manager	In general terms, I am satisfied with this function (TSPs)			3,00	
J1q2	Journey planning	It has saved me time				3,56
J1q3	Journey planning	It has saved me money				3,93
J1q4	Journey planning	It has helped me to make appropriate travel decisions				3,66
USI VALUE			**3,46**	**3,33**	**3,41**	**3,72**

Table 76: Impact Assessment indicators for Warsaw Demo site

WARSAW DEMO SITE		
USER ACCEPTANCE	USI Value	3,46
	Threshold	5,00
	Weights	0,35
	Indicator	**0,69**
STAKEHOLDER ACCEPTANCE	USI Value	3,33
	Threshold	5,00
	Weights	0,20
	Indicator	**0,67**
QUALITY OF SERVICE	USI Value	3,41
	Threshold	5,00
	Weights	0,25
	Indicator	**0,68**
MULTIMODALITY	USI Value	3,72
	Threshold	5,00
	Weights	0,21
	Indicator	**0,74**
	IMPACT INDICATOR	**0,70**

9.3.3.3. Conclusions

In accordance with the values of the Impact KPIs indicators, we can conclude that:

- The IP4 Technologies implemented in the Warsaw Demo site have been a **high impact** in the improvement of the **USER ACCEPTANCE**.
- The IP4 Technologies implemented in the Warsaw Demo site have been a **high impact** in the improvement of the **STAKEHOLDER ACCEPTANCE**.
- The IP4 Technologies implemented in the Warsaw Demo site have been a **high impact** in the improvement of the **QUALITY OF SERVICE**.
- The IP4 Technologies implemented in the Warsaw Demo site have been a **high impact** in the improvement of the **MULTIMODALITY**.

Finally, multiplying the indicator of each class of KPIs for the respective weight and then calculating the average of this result, we can obtain the impact assessment indicator. We can conclude that the implementation of IP4 technologies have had a positive impact in the Warsaw Demo site. In

fact, the **impact assessment indicator shows a High Impact (70%)** of the IP4 technologies implemented.

9.3.4. Padua

9.3.4.1. Demo site Overview

The location of the demo site is Padua urban & suburban areas and Veneto Region, Italy. The TSPs involved are:

- **Trenitalia**, which is the national railway operator.
- **BusItalia**, which is a bus company.

The demo aims to spread new mobility management services to individual passengers as well as city administrations, companies and universities through the digitalization of multiple mobility services managed by FSI train and bus operators. Furthermore, the demo goal is the integration of all mobility options available throughout the Padova Region into mobility packages which consider specific requirements of citizens daily activities.
The improvement of mobility planning and management services of the Ferrovie dello Stato Group and the offer to institutional customers of new services through the integration of IP4 technical features will be the main expected impacts.

9.3.4.2. Impact KPIs results

The following table shows the operational KPIs and the correspondent values collected during the demo implementation:

Table 77: Operational KPIs results for Padua Demo site

Innovative technology (IP4)	Linked to	Units	Values
Journey planning (journey planner)	Traveller	Average number of modes involved in the journey per trip	2
Journey planning (journey planner)	Traveller	Average number of shopped offers	129
Journey planning (journey planner)	Traveller	Number of TSP integrated	1
Booking	Traveller	Average number of booked offers per day	1
Asset manager	TSP	Number of services integrated with the pilot	3

The User Segments[43] resulted from the USI survey are reported in the following tables

[43] Padua Demo Site has had a low participation level. For this reason, the consistency and significance of these results are considered not reliable.

Table 78: User Segments of Padua Demo site organized per different categories

AGE		
18-24 years old	9	69,23%
25-44 years old	4	30,77%
45-64 years old	0	0,00%
65 years old or more	0	0,00%
Prefer not to answer	0	0,00%

INCOME		
Less than 11,999 €	8	61,54%
12,000-40,999 €	3	23,08%
More than 41,000 €	0	0,00%
Prefer not to answer	2	15,38%

HAVING A PROBLEM, DIABILITY OR IMPAIRMENT THAT AFFECTS TRAVELING		
No	13	100,00%
Person on a wheelchair	0	0,00%
Person with reduced mobility	0	0,00%
Person with visual impairment	0	0,00%
Hearing impaired	0	0,00%
Other	0	0,00%
Prefer not to answer	0	0,00%

GENDER		
Male	6	46,15%
Female	6	46,15%
Other	0	0,00%
Prefer not to answer	1	7,69%

RESIDENTIAL AREA		
A rural environment	6	46,15%
An urban environment	5	38,46%
A suburban environment	2	15,38%
Abroad/tourist	0	0,00%

TRAVELLING WITH DEPENDENT PERSON		
No	13	100,00%
Preschool age children (under 5 years old)	0	0,00%
School-age children (5-16 years old)	0	0,00%
Elderly relative	0	0,00%
Disabled person	0	0,00%
Prefer not to answer	0	0,00%

PROFESSIONAL STATUS		
Non-paid work	0	0,00%
Paid work	2	15,38%
Student	10	76,92%
Housekeeper, homemaker	0	0,00%
Retired	0	0,00%
Unemployed	1	7,69%
Prefer not to answer	0	0,00%

FAMILIARITY WITH TECHNOLOGY AND MOBILE APPLICATION		
Expert	8	61,54%
Familiar	5	38,46%
Not so familiar	0	0,00%
I am having many troubles using mobile apps in general	0	0,00%

From these tables, we can see that:

- 100% of the users are between 18 and 44 years old.
- About 84% of the users have a low income or middle-high income.

- 100% of the users don't have any disability or other impairment that affects traveling.
- About 46% of the users are male, and also about 46% are female.
- About 46% of the users live in the rural environment, about 39% live in urban environment, and about 15% live in the suburban environment.
- 100% of the users travels without dependent persons.
- About 77% of the users are students, 15% of the users have a paid job, while 7% are unemployed.
- 100% of the users have a good level of familiarity with technology and mobile application.

In accordance with the IP4 technologies assessed and the data availability, the following Table **79** shows the questions have been selected from the USI survey in order to establish the values to calculate the impact assessment indicator.
The Table **80**, indeed, shows the procedure that, starting from the USI values collected for each class of impact KPIs, brings to the impact assessment indicator

Table 79: USI survey results selected for Padua Demo site

PADUA DEMO SITE						
ID	**IP4 Technology**	**Question**	**USER ACCEPTANCE**	**STAKEHOLDER ACCEPTANCE**	**QUALITY OF SERVICE**	**MULTIMODALITY**
J10q2	Travellers' feedback	It has encouraged me to participate and be more involved in the public transport services' offers and rate the trips and submit comments and feedback through the application	4,00			
J2q2	Booking	It will encourage me to use buses, trains, and public transport systems more frequently	3,63			
J3q2	Issuing	It will encourage me to use trains, buses, and generally public transport systems more frequently	4,00			
J2q4	Booking	I am willing to pay for this function	3,76			
J11q3	Trip sharing					
J23q4	Asset manager					
J28q3	Collaborative space portal					
J33q3	Specific messages					
J9q2	Navigation function	It has saved me time and made it easier for me to reach my destination	3,62			
J28q2	Collaborative space portal	This function has helped me to develop my business by monitoring travellers reports and fulfilling their needs and expectations of my services		4,00		
J33q2	Specific messages	It has helped me to guide travellers in case of crowdedness or disruption of service		3,00		
J1q1	Journey planning	In general terms, I am satisfied with this function (travellers)			3,97	
J2q1	Booking					
J3q1	Issuing					
J9q1	Navigation					
J10q1	Travellers' feedback					
J11q1	Trip sharing					
J12q1	Guest user					
J13q1	Preferences and profiles					
J15q1	Collaborative space portal travellers					
J23q1	Asset manager	In general terms, I am satisfied with this function (TSPs)			3,73	

J28q1	Collaborative space portal					
J33q1	Specific messages					
J1q2	Journey planning	It has saved me time				2,73
J1q3	Journey planning	It has saved me money				2,82
J1q4	Journey planning	It has helped me to make appropriate travel decisions				3,73
USI VALUE			**3,80**	**3,50**	**3,85**	**3,09**

Table 80: Impact Assessment indicators for Padua Demo site

PADUA DEMO SITE		
USER ACCEPTANCE	USI Value	3,80
	Threshold	5,00
	Weights	0,35
	Indicator	**0,76**
STAKEHOLDER ACCEPTANCE	USI Value	3,50
	Threshold	5,00
	Weights	0,20
	Indicator	**0,70**
QUALITY OF SERVICE	USI Value	3,85
	Threshold	5,00
	Weights	0,25
	Indicator	**0,77**
MULTIMODALITY	USI Value	3,09
	Threshold	5,00
	Weights	0,21
	Indicator	**0,62**
	IMPACT INDICATOR	**0,72**

9.3.4.3. Conclusions

In accordance with the values of the Impact KPIs indicators, we can conclude that:

- The IP4 Technologies implemented in the Padua Demo site have been a **high impact** in the improvement of the **USER ACCEPTANCE**.
- The IP4 Technologies implemented in the Padua Demo site have been a **high impact** in the improvement of the **STAKEHOLDER ACCEPTANCE**.
- The IP4 Technologies implemented in the Padua Demo site have been a **high impact** in the improvement of the **QUALITY OF SERVICE**.
- The IP4 Technologies implemented in the Padua Demo site have been a **high impact** (even if with a low value near to the medium impact threshold) in the improvement of the **MULTIMODALITY**.

Finally, multiplying the indicator of each class of KPIs for the respective weight and then calculating the average of this result, we can obtain the impact assessment indicator. We can conclude that the implementation of IP4 technologies have had a positive impact in the Padua Demo site. In fact, the **impact assessment indicator shows a High Impact** (72%) of the IP4 technologies implemented.

9.3.5. Liberec

9.3.5.1. Demo site Overview

The location of the demo site is Liberec Region and the Czech Republic, likely including to the entire area of Borderland CZ/D/PL comprising Liberec, Zittau and Bogatynia regions. The TSPs involved are:

- **KORID**, which is the regional Transport Authority.
- **ČSAD Liberec**, which is the local PTO and school-bus operator.
- **ARRIVA vlaky**, the main railway operator.

The demo aims to involve other local PTOs, cross-border regional authorities, municipalities and ridesharing (BlablaCar) services.
The improvement of services provided by the dispatching centre and the overcoming of barriers to cross-border ticketing unification are the main expected impacts.
Five main use-cases will be deployed, regarding different user segments, paths and destinations.

9.3.5.2. Impact KPIs results

The following table shows the operational KPIs and the correspondent values collected during the demo implementation:

Table 81: Operational KPIs results for Liberec Demo site

Innovative technology (IP4)	Linked to	Units	Values
Journey Planner (JP)/ Offer Builder	Traveller	Average number of transport modes per trip	3
Journey Planner (JP)/ Offer Builder	Traveller	Number of TSP integrated	1
Journey planning (journey planner)	Traveller	Average number of shopped offers	2036
Booking	Traveller	Number of trips booked per day	66
Issuing	Traveller	Number of issues per day	87
Traveller's feedback	Traveller	Number/day	4
Asset manager	TSP	Number/year	3
Travel Arrangement	traveller	number per pilot	7

The User Segments resulted from the USI survey are reported in the following tables

Table 82: User Segments of Liberec Demo site organized per different categories

AGE		
18-24 years old	30	24,59%
25-44 years old	50	40,98%
45-64 years old	29	23,77%
65 years old or more	10	8,20%
Prefer not to answer	3	2,46%

INCOME		
Less than 11,999 €	42	34,43%
12,000-40,999 €	48	39,34%
More than 41,000 €	4	3,28%
Prefer not to answer	28	22,95%

HAVING A PROBLEM, DIABILITY OR IMPAIRMENT THAT AFFECTS TRAVELING		
No	112	91,80%
Person on a wheelchair	0	0,00%
Person with reduced mobility	1	0,82%
Person with visual impairment	1	0,82%
Hearing impaired	1	0,82%
Other	2	1,64%
Prefer not to answer	5	4,10%

GENDER		
Male	58	47,54%
Female	63	51,64%
Other	0	0,00%
Prefer not to answer	1	0,82%

RESIDENTIAL AREA		
A rural environment	24	19,67%
An urban environment	71	58,20%
A suburban environment	26	21,31%
Abroad/tourist	1	0,82%

TRAVELLING WITH DEPENDENT PERSON		
No	96	78,69%
Preschool age children (under 5 years old)	9	7,38%
School-age children (5-16 years old)	14	11,48%
Elderly relative	3	2,46%
Disabled person	0	0,00%
Prefer not to answer	0	0,00%

PROFESSIONAL STATUS		
Non-paid work	0	0,00%
Paid work	75	61,48%
Student	26	21,31%
Housekeeper, homemaker	1	0,82%
Retired	14	11,48%
Unemployed	1	0,82%
Prefer not to answer	5	4,10%

FAMILIARITY WITH TECHNOLOGY AND MOBILE APPLICATION		
Expert	38	31,15%
Familiar	65	53,28%
Not so familiar	18	14,75%
I am having many troubles using mobile apps in general	1	0,82%

From these tables, we can see that:

- About 25% of the users are between 18 and 24 years old, about 41% are between 25 and 44 years old, about 25% are between 25 and 44 years old, about 25% are between 45 and 64 years old, about 8% are over 64 years old.
- About 74% of the users have a low income or middle-high income. It is underlined that about 23% preferred to not answer.
- About 92% of the users don't have any disability or other impairment that affects traveling.
- About 47% of the users are male, and about 52% are female.
- About 20% of the users live in the rural environment, about 58% live in urban environment, and about 21% live in the suburban environment.
- About 79% of the users travels without dependent persons, while about 7% travel with preschool-age children and 11% travel with school-age children.
- About 21% of the users are students, 61% of the users have a paid job, while 11% are retired.
- About 84% of the users have a good level of familiarity with technology and mobile application, while about 15% are not familiar with technology and mobile application.

In accordance with the IP4 technologies assessed and the data availability, the following Table **83** shows the questions have been selected from the USI survey in order to establish the values to calculate the impact assessment indicator.
The Table **84**, indeed, shows the procedure that, starting from the USI values collected for each class of impact KPIs, brings to the impact assessment indicator.

Table 83: USI survey results selected for Liberec Demo site

LIBEREC DEMO SITE						
ID	**IP4 Technology**	**Question**	**USER ACCEPTANCE**	**STAKEHOLDER ACCEPTANCE**	**QUALITY OF SERVICE**	**MULTIMODALITY**
J10q2	Travellers' feedback	It has encouraged me to participate and be more involved in the public transport services' offers and rate the trips and submit comments and feedback through the application	3,89			
J2q2	Booking	It will encourage me to use buses, trains, and public transport systems more frequently	3,22			
J12q2	Guest user	It has given me the freedom to use the application in a confidential way	4,00			
J2q4	Booking	I am willing to pay for this function	3,98			
J11q3	Trip sharing					
J16q3	Travel companion web-portal					
J23q4	Asset manager					
J5q2	Validation and inspection	It has reduced the time in inspections and checking operations and made my trip more convenient and comfortable	4,21			
J23q2	Asset manager	It has allowed me to know better my services offer and technology level		5,00		
J23q3	Asset manager	It will update the services if changes have occurred in an easy way		5,00		
J1q1	Journey planning	In general terms, I am satisfied with this function (travellers)			3,64	
J2q1	Booking					
J3q1	Issuing					
J5q1	Validation and inspection					
J6q1	Trip tracking orchestration					
J7q1	Alternatives calculation					
J9q1	Navigation					
J10q1	Travellers' feedback					
J11q1	Trip sharing					
J12q1	Guest user					
J16q1	Travel companion web-portal					
J18q1	Smart locations					

J21q1	Travel Arrangement					
J23q1	Asset manager	In general terms, I am satisfied with this function (TSPs)			5,00	
J1q2	Journey planning	It has saved me time				3,12
J1q3	Journey planning	It has saved me money				3,19
J1q4	Journey planning	It has helped me to make appropriate travel decisions				3,20
USI VALUE			**3,86**	**5,00**	**4,32**	**3,17**

Table 84: Impact Assessment indicators for Liberec Demo site

LIBEREC DEMO SITE		
USER ACCEPTANCE	USI Value	3,86
	Threshold	5,00
	Weights	0,35
	Indicator	0,77
STAKEHOLDER ACCEPTANCE	USI Value	5,00
	Threshold	5,00
	Weights	0,20
	Indicator	1,00
QUALITY OF SERVICE	USI Value	4,32
	Threshold	5,00
	Weights	0,25
	Indicator	0,86
MULTIMODALITY	USI Value	3,17
	Threshold	5,00
	Weights	0,21
	Indicator	0,63
	IMPACT INDICATOR	**0,81**

9.3.5.3. Conclusions

In accordance with the values of the Impact KPIs indicators, we can conclude that:

- The IP4 Technologies implemented in the Liberec Demo site have been a **high impact** in the improvement of the **USER ACCEPTANCE**.
- The IP4 Technologies implemented in the Liberec Demo site have been a **huge impact** in the improvement of the **STAKEHOLDER ACCEPTANCE**.
- The IP4 Technologies implemented in the Liberec Demo site have been a **huge impact** in the improvement of the **QUALITY OF SERVICE**.
- The IP4 Technologies implemented in the Liberec Demo site have been a **high impact** (even if with a low value near to the medium impact threshold) in the improvement of the **MULTIMODALITY**.

Finally, multiplying the indicator of each class of KPIs for the respective weight and then calculating the average of this result, we can obtain the impact assessment indicator. We can conclude that the implementation of IP4 technologies have had a positive impact in the Liberec Demo site. In

fact, the **impact assessment indicator shows a Huge Impact** (81%) of the IP4 technologies implemented[44].

9.3.6. Osijek

9.3.6.1. Demo site Overview

The location of the demo site is Osijek-Baranja County, Croatia. The TSPs involved are:

- **GPP Osijek**, which is the PTO managing tram and bus urban transport
- **HŽ Putnički prijevoz**, which is the national railway operator.

The demo aims: to test and demonstrate S2R IP4 functionalities by connecting different current back-end systems and providing added value to PT users; to test and demonstrate Journey planning, My trips, and Navigation and Location Based services with current PT services and new services currently in implementation; to utilize potential new functionalities for unified ticketing with railway passenger operator systems; to explore business analytics across different PT services portfolio.
A more integrated, easier-to-use and open system for better customer experience, seamless ticketing and multimodal services for one of the largest students' populations in Croatia (target group for innovative transport testing) is the main expected impact.

9.3.6.2. Impact KPIs results

The following table shows the operational KPIs and the correspondent values collected during the demo implementation:

Table 85: Operational KPIs results for Osijek Demo site

Innovative technology (IP4)	Linked to	Units	Values
Journey planning (journey planner)	Traveller	Average number of modes involved in the journey per trip	2
Journey planning (journey planner)	Traveller	Number of TSP integrated	2
Journey planning (journey planner)	Traveller	Average number of shopped offers	2277

The User Segments resulted from the USI survey are reported in the following tables

[44] The conclusions show a really positive situation with a huge impact of IP4 Technologies on Liberec Demo Site. However, the value is affected by the unique answer with the maximum value gathered from TSP.

Table 86: User Segments of Osijek Demo site organized per different categories

AGE		
18-24 years old	9	22,50%
25-44 years old	28	70,00%
45-64 years old	1	2,50%
65 years old or more	0	0,00%
Prefer not to answer	2	5,00%

INCOME		
Less than 11,999 €	13	32,50%
12,000-40,999 €	18	45,00%
More than 41,000 €	0	0,00%
Prefer not to answer	9	22,50%

HAVING A PROBLEM, DIABILITY OR IMPAIRMENT THAT AFFECTS TRAVELING		
No	40	100,00%
Person on a wheelchair	0	0,00%
Person with reduced mobility	0	0,00%
Person with visual impairment	0	0,00%
Hearing impaired	0	0,00%
Other	0	0,00%
Prefer not to answer	0	0,00%

GENDER		
Male	26	65,00%
Female	14	35,00%
Other	0	0,00%
Prefer not to answer	0	0,00%

RESIDENTIAL AREA		
A rural environment	3	7,50%
An urban environment	26	65,00%
A suburban environment	11	27,50%
Abroad/tourist	0	0,00%

TRAVELLING WITH DEPENDENT PERSON		
No	34	85,00%
Preschool age children (under 5 years old)	5	12,50%
School-age children (5-16 years old)	1	2,50%
Elderly relative	0	0,00%
Disabled person	0	0,00%
Prefer not to answer	0	0,00%

PROFESSIONAL STATUS		
Non-paid work	0	0,00%
Paid work	33	82,50%
Student	5	12,50%
Housekeeper, homemaker	0	0,00%
Retired	0	0,00%
Unemployed	0	0,00%
Prefer not to answer	2	5,00%

FAMILIARITY WITH TECHNOLOGY AND MOBILE APPLICATION		
Expert	15	37,50%
Familiar	24	60,00%
Not so familiar	1	2,50%
I am having many troubles using mobile apps in general	0	0,00%

From these tables, we can see that:

- About 92% of the users are between 18 and 44 years old.

- About 77% of the users have a low income or middle-high income. It is underlined that about 22% preferred to not answer.
- 100% of the users don't have any disability or other impairment that affects traveling.
- About 65% of the users are male, while about 35% are female.
- About 7,5% of the users live in the rural environment, about 65% live in urban environment, and about 27,5% live in the suburban environment.
- About 85% of the users travels without dependent persons, while about 12% travel with preschool-age children.
- About 12% of the users are students, 82% of the users have a paid job.
- About 97% of the users have a good level of familiarity with technology and mobile application.

In accordance with the IP4 technologies assessed and the data availability, the following Table **87** shows the questions have been selected from the USI survey in order to establish the values to calculate the impact assessment indicator.
The Table **88**, indeed, shows the procedure that, starting from the USI values collected for each class of impact KPIs, brings to the impact assessment indicator.

Table 87: USI survey results selected for Osijek Demo site

OSIJEK DEMO SITE						
ID	**IP4 Technology**	**Question**	**USER ACCEPTANCE**	**STAKEHOLDER ACCEPTANCE**	**QUALITY OF SERVICE**	**MULTIMODALITY**
J9q2	Navigation function	It has saved me time and made it easier for me to reach my destination	3,79			
J33q3	Specific messages	I am willing to pay for this function	3,00			
J32q2	CRM portal	It has helped me to check and observe recorded transactions, invoices, and user information		3,00		
J32q3	CRM portal	It has helped me to see, reply and validate claims		3,00		
J1q1	Journey planning	In general terms, I am satisfied with this function (travellers)			3,86	
J9q1	Navigation					
J32q1	CRM portal	In general terms, I am satisfied with this function (TSPs)			3,00	
J1q2	Journey planning	It has saved me time				3,72
J1q3	Journey planning	It has saved me money				3,60
J1q4	Journey planning	It has helped me to make appropriate travel decisions				4,04
USI VALUE			**3,79**	**3,00**	**3,43**	**3,79**

Table 88: Impact Assessment indicators for Osijek Demo site

OSIJEK DEMO SITE		
USER ACCEPTANCE	USI Value	3,40
	Threshold	5,00
	Weights	0,35
	Indicator	0,68
STAKEHOLDER ACCEPTANCE	USI Value	3,00
	Threshold	5,00
	Weights	0,20
	Indicator	0,60
QUALITY OF SERVICE	USI Value	3,43
	Threshold	5,00
	Weights	0,25
	Indicator	0,69
MULTIMODALITY	USI Value	3,79
	Threshold	5,00
	Weights	0,21
	Indicator	0,76
	IMPACT INDICATOR	**0,68**

9.3.6.3. Conclusions

In accordance with the values of the Impact KPIs indicators, we can conclude that:

- The IP4 Technologies implemented in the Osijek Demo site have been a **high impact** in the improvement of the **USER ACCEPTANCE**.
- The IP4 Technologies implemented in the Osijek Demo site have been a **medium impact** (even if with a high value near to the high impact threshold) in the improvement of the **STAKEHOLDER ACCEPTANCE**.
- The IP4 Technologies implemented in the Osijek Demo site have been a **high impact** in the improvement of the **QUALITY OF SERVICE**.
- The IP4 Technologies implemented in the Osijek Demo site have been a **high impact** in the improvement of the **MULTIMODALITY**.

Finally, multiplying the indicator of each class of KPIs for the respective weight and then calculating the average of this result, we can obtain the impact assessment indicator. We can conclude that the implementation of IP4 technologies have had a positive impact in the Osijek Demo site. In fact, the **impact assessment indicator shows a High Impact** (68%) of the IP4 technologies

implemented[45].

[45] The conclusions show a really positive situation with a huge impact of IP4 Technologies on Osijek Demo Site. However, the value is affected by the unique answer with the maximum value gathered from TSP.

10. Conclusions

This deliverable presented the results elaborated to evaluate the IP4MaaS demonstration activities. Results are shown for both performance and impact assessment according to the project objectives and to the methodology outlined in D6.1.

Despite a severe limitation encountered during the demonstration activities, namely the low number of participants, due to several reasons, including the complexity of the MaaS schemes and the maturity of IT services that impacted in the recruitment, a sound and extensive evaluation was conducted and presented.

The results for both types of assessment show positive feedback from both end-users and TSPs and these constitutes meaningful insights to continue development and integration efforts for both IP4 members and involved TSPs in EU cities.

In addition, this document provides a solid methodology and detailed data elaborations that could serve for future evaluation works in complex environments like MaaS schemes.

Broader considerations and recommendations derived by the results presented in this document are presented in the next deliverable D6.4: Final Assessment Report: conclusions about COHESIVE solutions efficiency and impact.

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