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D3.2 Megatrends validation and impact assessment

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Abbreviations

ANP	Analytic Network Process
CR	Consistency ratio
EC	European Commission
GUI	Graphical user interface
H2020	Horizon 2020 EU Research and Innovation Program
MCDM	Multi Criteria Decision Making methods
MySQL	My Structured Query Language
PCMs	Pair- wise Comparison Matrices
PHP7	Hypertext Preprocessor 7
SPSS	Statistical Package for the Social Sciences
SSL	Secure Sockets Layer
TCFP	Transport concept of the future for passenger transport
TCFF	Transport concept of the future for freight transport
VBA	Visual Basic Code
WP	Work Package

Executive summary

This document illustrates the findings regarding megatrend validation and impacts assessment on the transport concept of the future priorities. This deliverable has been elaborated by the Faculty of transport and traffic Engineering, the University of Belgrade as task leader and by the Coventry University Enterprises as a contributor.

A deliverable D3.2 gives validation of the megatrends as well as megatrends impact assessment on the transport concept of the future. The validation of the megatrends with the impact assessment of megatrends is the second component of the work conducted within WP3 "Identification of future challenges." The validation of the megatrends will be particularly useful in the Gap analysis, task 4.2. The results of impact assessments will enable to identify research needs, priorities and opportunities coming along with the transforming transport system in task 4.3.

The validation is carried out through the application of the Analytic network process (ANP). Analytic Network Process method taking into account clusters of megatrends (given in Task 3.1), political imperatives (elaborated in Task 2.3) and technological advances (from Task 2.1) and key transport concepts of the future (analyzed in Task 2.2).The tailored ANP networks for megatrend validation for passenger and freight transport were developed by a different group of respondents.

A sophisticated Limesurvey and ANP questionnaires were used for systematic data collection. Experts, from academia, policy-makers, and industry, were invited to participate in a survey session and ninety responses were received. Principal components analysis as a variable-reduction technique was used to reduce a broader set of elements into a smaller one, which accounts for most of the variance in the original set of elements. Finally the 13 key elements which are most likely to impact the future research needs and priorities per transport sectors were identified. These are:

No	Passenger transport Sector		Freight transport sector	
	Cluster	**Element**	**Cluster**	**Element**
1	Megatrends	Environmental challenges – climate change	Megatrends	Environmental challenges – climate change
2	Megatrends	Urbanization and megacities	Megatrends	Urbanization and megacities
3	Megatrends	Ageing society	Political imperatives	Vehicle efficiency
4	Megatrends	Energy demand and sources	Megatrends	Bigger world economy
5	Political imperatives	Innovative research system	Megatrends	Energy demand and sources
6	Megatrends	Changing lifestyles	Megatrends	Ageing society
7	Technological advances	Infrastructure	Political imperatives	Innovative research system
8	Political imperatives	Vehicle efficiency	Technological advances	Infrastructure

9	Technological advances	Automation	Technological advances	Automation
10	Political imperatives	Increasing connectivity, intermodal access, and fit-for-purpose network standards	Megatrends	Changing lifestyles
11	Political imperatives	Closer public and private cooperation	Political imperatives	Raising investment in infrastructure development
12	Political imperatives	Supporting modal shift	Political imperatives	Digitisation strategy/regulations/markets
13	Technological advances	Electrified vehicles/vessels	Political imperatives	Closer public and private cooperation

Further, the analysis includes relationships among those key elements. Considering the equal number of identified key elements (13) in both transport sectors, there is an equal number of possible relationships among them (78 per transport sector). Forty-eight sets of judgments matrices were generated after the analyzing the relationships between key elements and selected transport concepts of the future. Finally, two ANP networks were identified. The first one is the ANP network used to evaluate transport concepts for the future in passenger transport and the second one is for the evaluation of transport concepts for the future in freight transport. Implementation of the ANP method in INTEND is supported by the ANP Graphical user interface (GUI) application and software written in Python.

The megatrends validation for all respondents and by experts group has been carried out through the discussion of the results in two ways: (1) an analysis of the priorities of all elements within the transport concept of the futures and (2) by analyzing the diversity and similarity of the priorities of the elements within the cluster megatrends, political imperatives, and technological advances.

The outcomes from the ANP network for passenger transport are the following. The highest priority values of the transport concept of the future for passenger transport (TCFPs) has *High-speed rail*. Looking ahead, the second, third and fourth TCFP is very close to the first one, and these are *Personal air transportation*, *Automation,* and *Electrification*. Significantly stands out the influence of the megatrends *Changing lifestyle* and *Environmental Challenges*.

The question arises as to whether validation varies by individual groups, or are there significant differences in perception/thinking between academia, policy-makers, and industry? When it comes to TCFPs ranking, the only significant difference is shown in the *Superfast ground*. Respondents from academia ranked *Superfast Ground* considerably higher than respondents from policy-makers and industry. Such a ranking as a result of evaluating of respondents from academia, it can be interpreted that Superfast ground as an alternative to a conventional transport system, and as a technological solution, is a transport concept that needs to be further developed in the coming periods.

Regarding the ranking of megatrends, political imperatives, and technological advances, there is no significant difference in the estimation between the groups. It can even be noticed that sometimes all three groups of respondents evaluate the same some megatrends, such as the *Changing lifestyle* and *Environmental challenges - climate change.* These two megatrends according to the priorities of all groups of respondents take an important first or second place

so that they can be considered as the leading megatrends that influence the determination for future research needs.

Focusing on the priorities of transport concept of the future for freight transport (TCFFs) it showed that the *Automation is* dominant. TCFFs *Delivery drones* and *Shared mobility* ranked second and third, are with a significant difference in priority value compared to *Automation*. Significantly stands out the influence of the megatrends *Changing lifestyle*. The importance of this megatrend suggests that the change in the lifestyle generates new and in the transport of goods different demands for transportation, or different supply and demand.

The answer to the question of whether there are significant differences in the assessments of TCFFs among the groups of respondents is that the priorities does not differ significantly so that the priorities and ranking are the results of the concise and comprehensive validation of all groups respondents. The only significant difference is in ranking the transport concept of *Shared mobility*. *Shared mobility* encompasses several service models and basically are a concept that is mostly presented in passenger transportation. When it comes to freight transport, it is a business model that focuses on the supply side of goods to customers, which is accessed through a single "window." Representatives of policy-makers and industry ranked this concept lower than academics, which could be interpreted by the fact that new technologies and procedures for collected freight transport are only in the implementation phase.

At last but not at least, the outcomes from the sensitivity analysis illustrated that the most influential megatrends for passenger transport and for freight transport as well are: *Energy demand and sources* and *Urbanization and megacities*. Bearing in mind stability of the ANP model outcomes *Energy demand and sources megatrend* is the megatrend with the biggest influence on best ranking TCFs priorities.

In addition, the INTEND will develop an online platform, INTEND Synopsis tool, where the result of megatrends validation and impact assessment will be graphically presented. This will provide visualization of the ANP results.

1 Introduction

The overall objective of the INTEND project is to deliver an elaborated study of the research needs and priorities in the transport sector utilizing a systematic data collection method. One of the main elements of the INTEND project is the review of pertinent literature (EU and international research projects including strategic research agendas, studies or roadmaps) in order to identify future technologies for each transport mode (road, aviation, rail, maritime) as well as infrastructure and transport systems which will be treated horizontally. The INTEND project will also review past futurology projects and recent futurology studies in order to present future mobility concepts. To ensure the validity of the results, the Analytical Network Process (ANP) will be used to determine the prioritized elements in all clusters (technological advances, megatrends, and political imperatives) for successful implementation and realization of key transport concepts of the future. Finally, INTEND will develop a transport agenda that will pave the way to an innovative and competitive European Transport sector. The project is driven by three main objectives:

- to define the transport research landscape
- to define the Megatrends and their impact on research needs
- to identify the main transport research needs and priorities

In order to enable a wide range of stakeholders to gain access to the results, INTEND will develop an online platform, the INTEND Synopsis tool that will constitute a dynamic knowledge base repository on the major developments in the transport sector. This will provide a visualization of the INTEND's main outcomes. The basis for the platform will be Transport Synopsis Tool which is already developed under the project RACE2050 coordinated by TUB. The repository will be updated and integrated into the INTEND website to provide a comprehensive picture of all forward-looking studies focusing on technological developments, megatrends and policies.

This deliverable is intended to integrate the outcomes of two different types of researches. From one side, it takes into account the results related to identification and selection of technological advances, megatrends, political imperatives and key transport concepts of the future relevant for the future development of transportation system. In addition, these outcomes have been validated by the definition and application of the Analytic Network Process (ANP) methodology. In the evaluation of the ANP network, we collected opinions of transport experts from academia, industry, policy making, as INTEND’s targeted audience. Results of this process are the ranking of megatrends, as well as transport concepts of the future in relation to these megatrends, which will constitute an important input for defining the future transport research priorities.

1.1 The INTEND work structure

Figure 1.1 depicts the workflow of the INTEND project and the relationship between the process of validation and impact assessment of technological advances, megatrends, political imperatives of selected key transport concepts of the future from various perspectives of WP3 with the rest of the WPs.

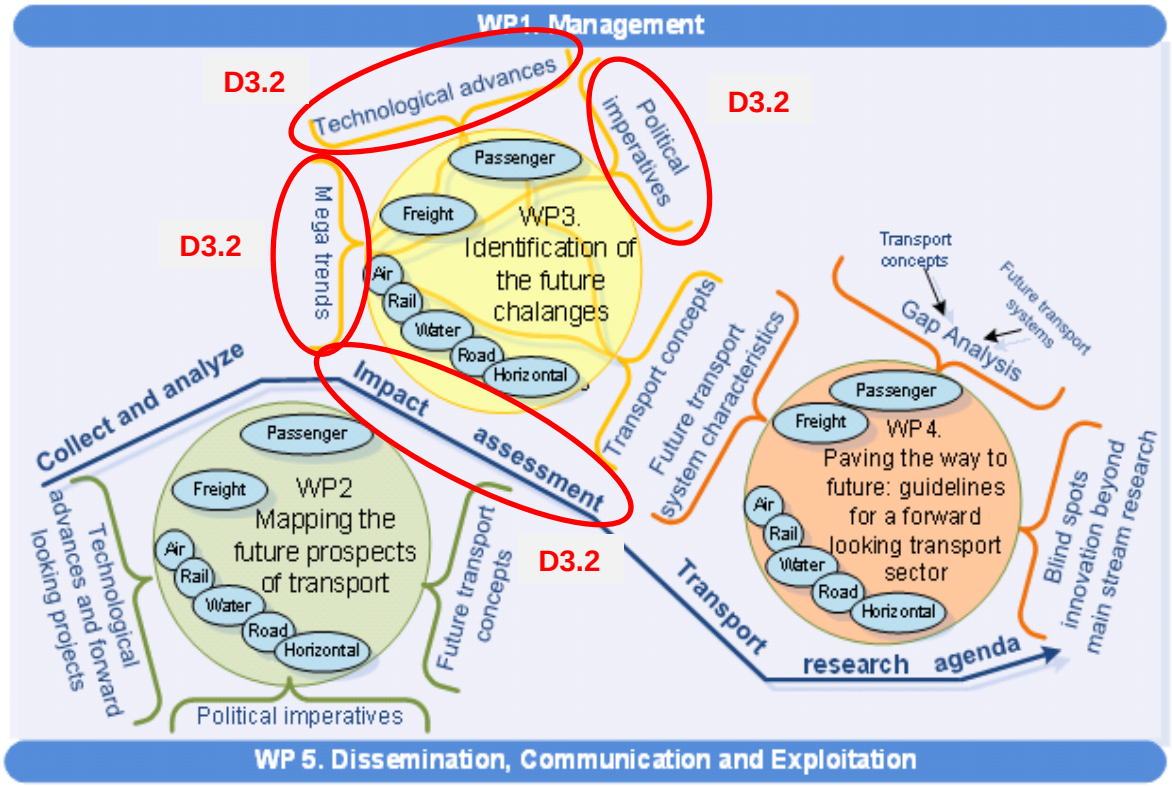


Figure 1.1 Workflow in INTEND and relations of task 3.2 with other WPs

1.2 The deliverable in the frame of INTEND work structure

D3.2 aims to present the outcomes of the validation and impact assessment of technological advances, megatrends, political imperatives on selected key transport concepts of the future from various perspectives. The analysis included the further elaboration of the outcomes from WP2 with particular emphasis on technological advances and political imperatives, as well as from Task 3.1 dealing with megatrends.

Results of D3.2 will be particularly useful in the process of identification of gaps between technological advances in the transport sector and development prospects of the transport and mobility systems influenced by megatrends, i.e., in T4.2 – Gap analysis. By taking into account impact assessments from Task 3.2, we will determine megatrends, technological advances and political imperatives which will have the most significant impact on overcoming the challenges and reaching the defined future transport system. It will enable us to identify research needs, priorities and opportunities coming along with the transforming transport system (T4.3).

1.3 Task 3.2: Megatrends validation and impact assessment

The main aim of T3.2 is development and application of a structured technique for validation of megatrends and analysis of the megatrends impact on the achievement of identified political imperatives as well as on the key passenger and freight transport concepts of the future. This structured approach was based on the application of the Analytic Network Process (ANP), i.e. on a network structure that took into account previously identified technological advances (from Task 2.1), megatrends (given in Task 3.1), political imperatives (elaborated in Task 2.3) and key transport concepts of the future (analyzed in Task 2.2).

As the first step in this process, technological advances in freight and passenger transport, political imperatives, and important key megatrends were clustered. These clusters can be considered as drivers for the future development of both European and global transport system and therefore relevant for the identification of future transport research priorities.

As a second step, relationships between elements in the clusters of technological advances, megatrends, and political importance were defined, as well as between these clusters and cluster of key transport concepts of the future. The dependences or independences relationship between elements in clusters, clusters themselves, and key transport concepts of the future were defined based on experts opinions obtained through one online questionnaire developed in the LimeSurvey software.

The application of ANP also required estimation of relationships (weights) between all elements in clusters and between the clusters. Therefore, after the network model has been constructed, the elements in one cluster (e.g., advances or megatrends or imperatives) were evaluated according to their relative importance, through pair-wise comparison, with respect to the elements in other clusters. Further, cluster of key transport concepts of the future was evaluated according to its relative importance by pair-wise comparison, with respect to other elements in the network.

The methodology for obtaining an evaluation of these relationships was based on a questionnaire survey and one explanatory webinar. Besides providing insights into relationships, the participant from the academia, industry, and policy-making sector were asked to validate defined relationships. ANP, as a participatory nature, was therefore used for consensus building.

The obtained matrices were analyzed by using appropriate software developed by FTTE's on Python programming language. Based on this analysis, the evaluation of key transport concepts of the future was gained. It means that after the evaluation of preferences among the different megatrends, technological advances and political imperatives have been done and once the weights have been defined, we determined the prioritized elements (megatrends, technological advances, and political imperatives) in all clusters for successful implementation and realization of key transport concepts of the future.

To ensure the stability of the outcome of our analysis, a stability and sensitivity analysis was conducted by increasing and decreasing pair-wise comparison merits. In such a way, the risk of an irreversible bad decision regarding future transport research priorities was prevented.

2 Objectives and approach to task 3.2

2.1 Objectives

The overall aim of the INTEND project is to deliver an elaborated study of the research needs and priorities in the transport sector and to develop a transport agenda that would pave the way to an innovative and competitive European Transport sector. Obviously, INTEND research needs require the participation of experts from the academia, industry and policy-making sector.

The main objective of task 3.2 is to validate the megatrends and assess its impact on the priorities of the transport concept of the future. The validation will be carried out through the application of the Analytic network process (ANP), and their impact will be defined by a discussion of the results.

2.2 Methodology- system approach

The validation and evaluation of the megatrends are challenging as transport itself is a complex environment. The results of the megatrends research in Deliverables 3.1, political imperatives (Deliverable 2.3) and technological advances (Deliverable 2.1), showed that their number is significant and to assess their impact it is necessary to systematically approach the assessment of their effects on transport concepts of the future. The systemic approach also means taking into account the limitations of human reasoning. Human thinking has limitations regarding the simultaneous use of data, or when their number is significant. In cases where a significant amount of data is used in the assessment and evaluation process at the same time, due to the inability of the human brain to follow it simultaneously, it is possible not to make useful solutions and decisions (Saaty, 2001). Especially when decision-makers need to make decisions and reach consensus between them. Analytic Network Process method proposed in INTEND project deal with the problem of validation of the megatrends impact taking into account clusters of key megatrends, political imperatives and technological advances as well as the relation between them. The priority of transport concept of the future as the result of the ANP network evaluation reflects the influence of megatrends and with political imperatives and technological advance relationship as well, on the future transport concepts. The tailored ANP network for megatrend validation was used by a different group of respondents and followed how the change of megatrend impacts the influence on what is currently perceived.

The Analytic Network Process ANP (first papers Saaty, 1996, Saaty and Vargas, 1998), represents a decision-making method which enables to present the dependence and feedback between elements, analyze the interaction between them as well as to synthesize their mutual influences through a network structure. This is a method that is used to determine priorities based on the relative relationship between elements, **which is a natural procedure for the human mind**. Also, this is an excellent method for presenting various stakeholders, decision-makers, whose influence and power are either known or assumed. ANP model combines advanced decision techniques and expert knowledge.

ANP network represents a combination of the graphic outline of the problem by elements and relationships between them. Relationships between the elements are the result of a combination of mathematical relations and mimic of human reasoning in the decision process. A basic, Saaty's fundamental priority scale is used to determine relative weights of each element in the network by using pair-wise comparison. INTEND surveys is implied to obtain the structure of ANP network.

The INTEND survey session help us to apply the Analytic Network Process (ANP) methodology and points out the megatrends, political imperatives, and technological advances impact on priorities of key transport concepts of the future.

The session is composed of two parts. The first part contains an online LimeSurvey that is aimed to determine the structure of the ANP network which consists of key megatrends, political imperatives, and technological advances and define relationships between them, for determination of future transport concept priorities.

The second part of the INTEND session will be organized through the webinar. The webinar includes the ANP questionnaire for assessment of Megatrends, Political imperatives, and Technological Advances impact on the key Transport Concepts of the Future prioritization. The main aim of the webinar will be to provide all participants instructions for estimation of relations between any two elements in the clusters and between the clusters themselves.

Therefore, The ANP method uses the experience of decision makers (experts) rather than statistical data, which are often not available. The decision makers first select key megatrends, political imperatives, and technological advances and corresponding relationship and finally evaluate the relationships between the elements of the defined network by using their professional experience to perform **pair-wise comparisons** and following the relationship established in the developed ANP network.

Why is ANP good for validation of the megatrends impact on the transport concept future priorities? ANP widens the understanding and validates megatrends, political imperatives and technological advances mutual impact and relations between them on transport concept of the future priorities. Second, it presents a systematic approach to the problem and enables decision makers to use their knowledge and make important decision systematically. The structure of the ANP model does not come from the numbers that are generated, but rather from the road-map that is designed.

At last but not at least according to LeShan and Marganau (1982) scientific theories must be verified: *'….scientific truth, that is to say, the validity of an accepted theory depends on two important kinds of factors: the guiding principles . . . and what we have called the process of empirical verification . . . these two factors are crucial in the establishment of any theory relating to any kind of knowledge*'. Whitaker (2007) conducted a study on validation examples of the ANP method, which revealed that this method is a useful tool for analyzing several levels of networks to enable informed strategic decisions.

2.3 Advantages and limitations of ANP

The advantage of the method relates to the *foresight* and lies with the reliability of predictions made with ANP. Kahneman and Tversky (1973) indicated that '*In making predictions and judgments under uncertainty, people do not appear to follow the calculus of chance or the statistical theory of prediction. Instead, they rely on a limited number of heuristics'*. To this end, the ANP offers a forecasting structure based on judgments to evaluate those heuristics in a coherent manner. (Niemira, M., Saaty, T., 2003)

In all Multi-Criteria methods, an important aspect is the weights typology of coefficients of importance and substitution rates (Munda et al., 2004). The weights in ANP represent '*the gain with respect to one variable allowing compensate loss (trade-offs) with respect to another'* (Munda, G., 2004; Belton, V., Stewart, N, 2002; Polatidis et al., 2006). This has significant importance in the evaluation of transport concepts of the future and design of policies because the elements within the transport concepts of the future along with the megatrends, political imperatives and technological advances to reach the optimum effect are interrelated. In the ANP method, the scaling of the criteria and the weights are connected and dependent, and as a result, if one changes, the other has to change consequently. Therefore, the soundness of the ANP use in this respect, relates with the aggregation procedure.

Dyer (1990) criticized ANP outlining as the major disadvantage of the method the *procedure* itself, which can lead to subjective rankings by the experts involved in the process. On the contrary, Saaty (1990) provides a different perspective on the issue of arguing. He pointed out that the method offers a way to convert that problem into a solution arising from the need to integrate subjective views to achieve the optimum solution: '*the evaluation of alternatives is dependent on all the others that are considered, so that the addition of new alternatives or deletion of others determines the restructuring of the decision problem, thus creating a new one'*.

Whitaker (2007) has also stated that the ANP is that it heavily relies on *experience and knowledge of the experts* and this can be turned into a drawback if the experts to not possess the necessary understanding on the subject. Therefore it is of imperative importance to select the right mixture of experts with the necessary knowledge on the issue examined.

To conclude, the ANP comes with some advantages and disadvantages. The reasons, however, for using the ANP analysis approach in the present work are as follows:

- ✓ the assessment of transport concepts of the future is a multi-criteria decision problem
- ✓ there are dependencies among the groups/clusters of factors/trends and between these and the alternative groups/clusters under evaluation
- ✓ the detailed description of the inter-relationships between clusters encourages the experts to reflect on their selected priorities carefully
- ✓ the method allows the consideration of qualitative criteria
- ✓ a huge pull of experienced participants has been possible to achieve. Therefore the prerequisite on the knowledge of the experts has been fulfilled

3 Data collection method

In this chapter is presented the method of collecting the data necessary for determining the validity of megatrends and assessing their impact on the priority of future transport concepts. Experts were invited to participate in a survey session after having completed a consent form which was available through the INTEND website; ninety responses were received. A sophisticated Limesurvey and ANP questionnaires were used for a thorough and systematic data collection.

The experts were recruited through a dissemination campaign, and they represented the main three expert groups – academia, policy-makers, and industry. Considering the confidence in the quality of the expected survey responses, it is important to highlight that the recruitment criteria ensured a high level of credibility in the sense of competence and knowledge regarding transport concepts of the future, recognition of megatrends, political imperatives and transport advances.

The academic, experts and policy community were invited through an announcement on the website and other scientific and public networks. Respondents were asked to assign the Consent form, and then they received access through the assignment of credentials to participate in the questionnaire for the selection of key elements of the network and definition relationship between them for the passenger and freight transport. The credentials were generated by a specially designed algorithm that ensured the privacy of participants by losing relation between its email address and given credentials.

For the first survey, we registered 67 respondents. After the second ANP questionnaires, the distribution of experts by groups as well as by transport sector are given in table 3.1.

Table 3.1 Distribution of the responses by INTEND survey

Experts affiliation	Transport sector (%)	
	Passenger	Freight
academia	50.5	51.0
policy-makers	25.0	27.0
Industry	24.5	22.0
Sum (%)	100.0	100.0

Based on the Kruskal-Wallis test, it has been found that there are no significant differences between the responses of different groups, divided by affiliations, but there are differences in the transport sectors. Bearing this in mind when decomposing the problem to an ANP network, two ANP networks are pursued: for passenger and freight transport.

With the same credential, respondents access the second ANP questionnaire. The ANP questionnaire was used to evaluate the relationship between elements in the ANP network. In other words, the quantification of the respondent perceptions of the effects of the elements.

However, about the validation of megatrends impact and the influence of the environment (political imperatives and technological advances trends) on the priority of transport concepts of the future, different preference for each of the groups can be expected. The academy looks at the directions from a scientific and research perspective, while the policy-makers and industry ways of observing are based on decision results in a more strategic manner.

Thus, the problem of the megatrends validation and impact assessment of transport concepts in the future by the different groups can be analyzed on ANP networks that are defined for passenger and freight transport separately.

3.1 The identification of key global megatrends, political imperatives and technological advances – the survey technology

Having always in mind the delivery of credible results that can assist in policy making, the design of the survey, ensured the efficient processing of the responses and the use of corresponding results within the second (ANP) survey (main screens are given in Annex 3).

The first-stage survey design concept consisted of two phases:

1) Iterative selection performed with the aim to refine larger set of elements (clusters of global megatrends, political imperatives, and technological advances) to smaller ones (named as a set of important elements) and finally to the smallest set consisted of the most important (key) elements, according to the perception of experts.

2) Collection the expert's opinions regarding the relationships between chosen key elements, which would be needed for megatrends validation and impact assessment on the transport concept of the future, at the second-stage (ANP questionnaire). In this sense, there are two types of relationships: the relationship between two elements, which belong to the same cluster, as well as the relationship between two elements, which belong to different clusters. Also, the relationship could be dependent or independent.

In the meaning of relation, it should be (Figure 3.1):

- **one way** - A is in a relationship with B (A→B)
- **feedback** - A and B have a mutual relationship (A↔B)
- **opposite way** - B is in a relationship with A (A←B)
- **no** – A and B have not a relationship

The example of the question that precedes the selection of relationship in general is: What is the relationship between element A and element B looking to the future transport needs?

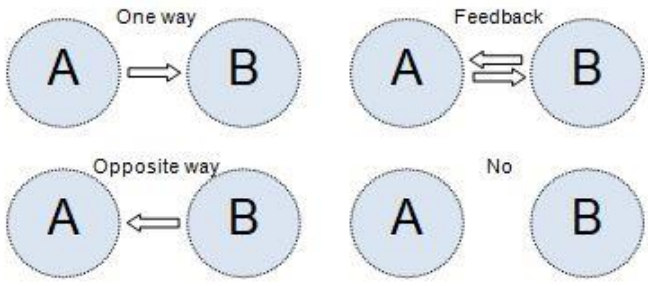


Figure 3.1 Relationships between elements

The nature of such survey activities implies conditional appearance of particular questions depending on previous responses. For this purpose, the data branching logic model with several complex sets of conditions has been designed, as shown in Figure 3.2. The logic complexity of the model depends on the three dimensions: (1) the number of transport sectors (2), the number of clusters (3) and the total numbers of elements within each of clusters.

Considering flexibility and scalability needs, custom coding features, data import/export features, as well as a set of additional security and privacy demands, the Limesurvey open-source survey platform has been chosen for developing purposes. In order to generate the script that is consisted of such a large number of questions with corresponding sets of conditions and related logic, a special Microsoft VBA coded tool is designed. The tool is also used to import the survey structure data in the platform database. The results of the survey are exported in IBM SPSS data format by using the Limesurvey platform export features regarding the need for statistical analysis. In order to be converted in a data format that corresponds to the second-stage ANP survey database, the analysis results are post-processed by another Microsoft Excel VBA custom coded tool.

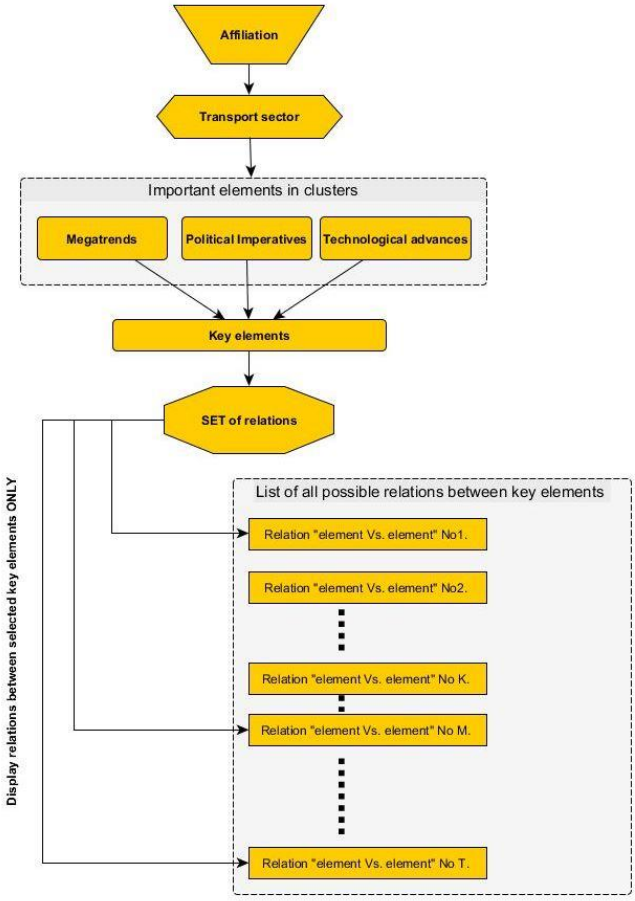


Figure 3.2 The first-stage survey - data branching logic general model

The second-stage (ANP) survey is designed to evaluate the relationships between elements in the ANP network. It is developed to support experts with a special *ANP intelligence* feature that evaluates the consistency of the responses on the observed set of relationships. If the *ANP intelligence* (background) module automatically detects the response inconsistency that is above the acceptable level, the interface will mark those responses, which have largest influence on the inconsistency level, also suggesting new fully consistent responses. Then, the respondent has an option to accept corresponding suggestions or to give new responses otherwise, which will be tested by the same module again, until the needed consistency level is reached. Considering the process mentioned above demands, the whole ANP survey platform is originally designed by FTTE IT research team. The second-stage (ANP) survey frontend was implemented using MySQL and PHP7 technology, while *ANP intelligence* module and survey backend were implemented using a combination of Python, MySQL, and PHP7. All abovementioned security and privacy mechanisms are implemented in the second-stage (ANP) survey, as well. Also, the survey and webinar servers are physically secured in rooms where access is allowed only to authorized personnel. All processes related to survey and webinar are exclusively hosted by these servers strictly excluding the use of any external (3rd party) services and their servers. Complete communication is SSL encrypted, using digital certificates issued by the relevant CA (Certified Authority) institutions.

The first LimeSurvey with the information announced on the project website and other public networks was launched on 31st May and closed on 6th June. The time frame of seven days was provided for response to the questionnaire. The second, ANP survey started with the Webinar

launch on 25th June 2018. The webinar was not mandatory to reply to the ANP questionnaire, but it was useful to understand how the questionnaire works as the ANP questionnaire is very specific. It is the result of a comprehensive approach to the problem of validation of megatrends and involvement of specific community group. The time frame of three weeks for a response to the questionnaire was provided.

3.1.1 Statistical analysis and results

The research aims to determine those key global megatrends, political imperatives and technological advances (denoted as key elements), as well as their corresponding relationships, which are most important according to the experts' opinions. The nature of the problem suggests that transport concept of the future problems should be solved by knowledge exchange and integrated professional and academic views separately for passenger and freight transport sectors. To achieve the goals mentioned above, the analysis was performed with respect to experts' affiliation and the chosen transport sector. Statistical analysis of the questionnaire results was performed by processing survey data with the IBM SPSS software tool, while some additional post-processing procedures were done with Microsoft Excel VBA custom coded tools.

The first step was to determine the key elements, among those chosen by the participants, which are most likely to impact on the future research needs and priorities in the area of passenger and freight transport. Since the key elements are classified by the transport sector, the complete statistical analysis was conducted for these two corresponding sets of elements and their relationships.

In the following tables, the descriptive statistics of participants' choice of key elements are presented separately for each of the transport sectors.

Table 3.2 Important elements for the passenger transport sector

Cluster	Element	Total (%)	Affiliation (%)		
			Policy-makers	Industry	Academia
Megatrends	Environmental challenges – climate change	86.49	18.92	18.92	48.65
Megatrends	Urbanization and megacities	72.97	18.92	18.92	35.14
Megatrends	Ageing society	59.46	13.51	10.81	35.14
Megatrends	Energy demand and sources	56.76	10.81	5.41	40.54
Political imperatives	Innovative research system	56.76	16.22	10.81	29.73
Megatrends	Changing lifestyles	54.05	13.51	16.22	24.32
Technological advances	Infrastructure	54.05	16.22	18.92	18.92
Political imperatives	Vehicle efficiency	51.35	10.81	5.41	35.14
Technological advances	Automation	48.65	10.81	10.81	27.03
Political imperatives	Increasing connectivity, intermodal access, and fit-for-purpose network standards	45.95	13.51	10.81	21.62
Political imperatives	Closer public and private cooperation	45.95	13.51	16.22	16.22
Political imperatives	Supporting modal shift	43.24	8.11	10.81	24.32
Technological advances	Electrified vehicles/vessels	43.24	10.81	8.11	24.32
Technological advances	Alternative fuels	40.54	8.11	8.11	24.32
Political imperatives	Reducing climate related externalities	37.84	2.70	5.41	29.73
Political imperatives	Raising investment in infrastructure development	37.84	16.22	5.41	16.22
Political imperatives	Digitization strategy/regulations/markets	37.84	8.11	13.51	16.22
Technological advances	Digitalization	37.84	13.51	10.81	13.51
Megatrends	Bigger world economy	35.14	10.81	5.41	18.92
Political imperatives	Revising fuel and power taxation and regulation by governments	35.14	8.11	5.41	21.62
Megatrends	Key resources scarcity - shortages and consumption	32.43	5.41	5.41	21.62
Political imperatives	Electricity, transport and heat sector combination	32.43	10.81	8.11	13.51

Technological advances	Communication, navigation & control systems	32.43	5.41	5.41	21.62
Political imperatives	Improving/Extending Urban Mass Public Transport Systems	29.73	5.41	8.11	16.22
Technological advances	Battery systems	29.73	2.70	2.70	24.32
Technological advances	New materials	27.03	5.41	5.41	16.22
Political imperatives	Improving energy supply	24.32	2.70	2.70	18.92
Megatrends	The shift of economic power	21.62	5.41	8.11	8.11
Political imperatives	Supporting industries and science regarding fuel technologies	21.62	5.41	5.41	10.81
Technological advances	Vehicle design	21.62	5.41	2.70	13.51
Technological advances	Computer Aided Engineering	13.51	5.41	0.00	8.11
Technological advances	Inspection & testing	13.51	5.41	8.11	0.00
Technological advances	Engine Design	13.51	2.70	2.70	8.11
Technological advances	Manufacturing processes	13.51	2.70	2.70	8.11
Technological advances	Integrated emissions control	8.11	2.70	0.00	5.41

Table 3.3 Key elements for the freight transport sector

Cluster	Element	Total (%)	Affiliation (%)		
			Policy-makers	Industry	Academia
Megatrends	Environmental challenges – climate change	66.67	6.67	16.67	43.33
Megatrends	Urbanization and megacities	60.00	10.00	13.33	36.67
Political imperatives	Vehicle efficiency	53.33	10.00	6.67	36.67
Megatrends	Bigger world economy	50.00	10.00	10.00	30.00
Megatrends	Energy demand and sources	50.00	3.33	10.00	36.67
Megatrends	Ageing society	46.67	3.33	10.00	33.33
Political imperatives	Innovative research system	46.67	6.67	13.33	26.67

Technological advances	Infrastructure	46.67	13.33	16.67	16.67
Technological advances	Automation	46.67	10.00	6.67	30.00
Megatrends	Changing lifestyles	43.33	3.33	13.33	26.67
Political imperatives	Raising investment in infrastructure development	43.33	6.67	10.00	26.67
Political imperatives	Digitisation strategy/regulations/markets	43.33	3.33	13.33	26.67
Political imperatives	Closer public and private cooperation	36.67	6.67	13.33	16.67
Technological advances	Communication, navigation & control systems	36.67	3.33	10.00	23.33
Technological advances	Battery systems	36.67	0.00	10.00	26.67
Megatrends	Globalization 2.0	33.33	3.33	16.67	13.33
Political imperatives	Reducing climate related externalities	33.33	0.00	10.00	23.33
Technological advances	Alternative fuels	33.33	3.33	13.33	16.67
Megatrends	Security issues	30.00	6.67	10.00	13.33
Political imperatives	Improving energy supply	30.00	3.33	6.67	20.00
Technological advances	Digitalization	30.00	3.33	6.67	20.00
Megatrends	Key resources scarcity - shortages and consumption	26.67	0.00	6.67	20.00
Political imperatives	Supporting industries and science regarding fuel technologies	26.67	0.00	6.67	20.00
Technological advances	Electrified vehicles/vessels	26.67	10.00	0.00	16.67
Technological advances	New materials	23.33	0.00	6.67	16.67
Megatrends	Shift of economic power	20.00	3.33	10.00	6.67
Political imperatives	Revising fuel and power taxation and regulation by governments	20.00	3.33	3.33	13.33
Political imperatives	Electricity, transport and heat sector combination	20.00	3.33	6.67	10.00
Political imperatives	Improved risk management	16.67	6.67	6.67	3.33
Political imperatives	Innovative scenario development	16.67	0.00	6.67	10.00
Technological advances	Manufacturing processes	16.67	3.33	6.67	6.67

Technological advances	Vehicle design	16.67	3.33	3.33	10.00
Technological advances	Computer-Aided Engineering	16.67	6.67	3.33	6.67
Technological advances	Inspection & Testing	13.33	6.67	6.67	0.00
Technological advances	Integrated emissions control	6.67	0.00	3.33	3.33
Technological advances	Engine Design	3.33	0.00	0.00	3.33

Further, the initial set of elements has been created according to their frequencies distribution. Principal components analysis as a variable-reduction technique was used to reduce a broader set of elements into a smaller one, which accounts for most of the variance in the original set of elements. The proportion of each variable's variance that can be explained by the retained elements was taken into account. In the sector of passenger transport 13 components explain a total of 80.891% variance, so 13 is the optimal number of elements that we can keep. Also, according to the scree plot, the decision was made to adopt the intersection on the 13th factor (Figure. 3.3). Those elements in the steep curve before the first point that starts the flat line trend are going to be retained.

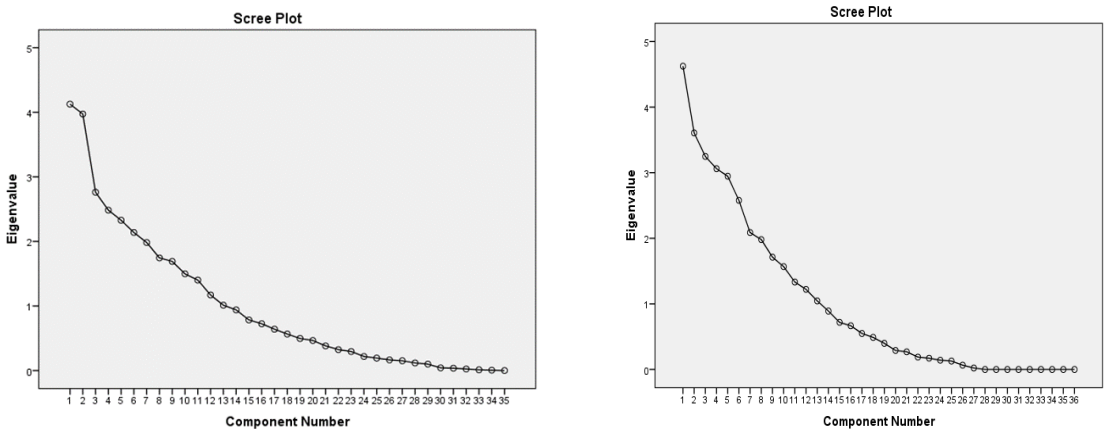


Figure 3.3 Scree plot for passenger and freight transport

There are similar results for the freight transport sector where 13 components explain a total of 86.14% variance, so 13 is the optimal number of elements that we can keep. Also, according to the obtained screen plot, the decision was made at the point where the slope of the curve is clearly leveling off.

Further, trying to determine whether observed sample frequencies differ significantly from expected frequencies and to compare proportions of a categorical outcome according to different independent groups, we consider the chi-squared goodness of fit test.

Standardized residuals were used to determine what categories, i.e., cells, were significant contributors to rejecting the null hypothesis. Greater absolute values of the residual lead to a conclusion that there is a considerable influence on a significant chi-square test statistic. Those

elements which show higher values for residuals may be taken as indicating those cells which make a particularly strong contribution to the relationship between the elements.

So, the positive standardized residuals indicate that more participants have chosen a particular element than expected. The negative standardized residuals indicate that there were less participants who have chosen particular element than expected.

Concerning all of the criteria mentioned above the sets of key elements which are most likely to impact the future research needs and priorities for both transport sectors were identified according to the priorities assigned by participants (Table 3.4).

Table 3.4 Key elements that impact the future research needs and priorities for both transport sectors

No	Passenger transport Sector		Freight transport sector	
	Cluster	Element	Cluster	Element
1	Megatrends	Environmental challenges – climate change	Megatrends	Environmental challenges – climate change
2	Megatrends	Urbanization and megacities	Megatrends	Urbanization and megacities
3	Megatrends	Ageing society	Political imperatives	Vehicle efficiency
4	Megatrends	Energy demand and sources	Megatrends	Bigger world economy
5	Political imperatives	Innovative research system	Megatrends	Energy demand and sources
6	Megatrends	Changing lifestyles	Megatrends	Ageing society
7	Technological advances	Infrastructure	Political imperatives	Innovative research system
8	Political imperatives	Vehicle efficiency	Technological advances	Infrastructure
9	Technological advances	Automation	Technological advances	Automation
10	Political imperatives	Increasing connectivity, intermodal access and fit-for-purpose network standards	Megatrends	Changing lifestyles
11	Political imperatives	Closer public and private cooperation	Political imperatives	Raising investment in infrastructure development
12	Political imperatives	Supporting modal shift	Political imperatives	Digitisation strategy/regulations/markets
13	Technological advances	Electrified vehicles/vessels	Political imperatives	Closer public and private cooperation

In order to investigate if there are differences in the selection of key elements concerning participants' affiliation, a series of Kruskal-Wallis tests were performed. Based on the results of the Kruskal-Wallis H test it has shown that there are no statistically significant differences among responses regarding affiliation, neither within the passenger transport sector (except in case of two key elements - *Energy demand and sources* and *Vehicle efficiency*), nor for the freight transport sector.

Further, the analysis includes relationships among those key elements, which were selected in the previous step. The aim is to determine types of relationship (no relationship, one way, opposite or feedback), obtained by participants' responses, and their statistical significance, as well. Depending on the transport sector, the determined types of relationship will be further used in ANP networks for passenger and freight transport concept of the future.

Considering the equal number of identified key elements (13) in both transport sectors, there is also an equal number of possible relationships among them (78 per transport sector), which were offered to participants for assessment. The list of possible relationships is shown in the tables 3.5 and 3.6.

The statistical analysis reveals a lack of significant associations in participants' responses, i.e., all of the four offered alternatives (no relationship, one way, opposite and feedback) were equally preferred within both transport sectors, implying the coherence in experts' assessments.

The determination of the relationship type as the result of choice among the four of the offered alternatives could be described in the following example:

The experts' opinion regarding the type of relationship for passenger transport between the elements *Ageing society* (which refers to ageing the world's population and increasing the life expectancy) on the one hand, and *Electrified vehicles/vessels* (related to the electrification of vehicles and ships, including electrification of auxiliary systems and drives, electric cars, buses, airplanes and passenger ships, etc.), on the other, is explored (yellow mark row in a table 3.5).

As a response, 66.67% of the experts expressed the opinion that there was no relationship between these two elements, while 11.11% of the experts suggested that ageing the world's population show influence on the electrification of the vehicles/vessels. On the other hand, none of the experts declared that the process of vehicles/vessels electrification could have an impact on the ageing of the world's population. However, 22.22% of the experts stated the existence of a mutual relationship between the processes the ageing of the world's population and the vehicles/vessels electrification.

Based on the above, the expert opinion that there is no relationship between these two elements could be adopted as dominant.

Table 3.5 Selection of relationship between key elements for passenger transport (%)

Relationship	No	One Way	Opposite	Feedback
Ageing society and Environmental challenges – climate change?	39.13	13.04	26.09	21.74
Ageing society and Urbanization and megacities?	25.00	18.75	6.25	50.00
Ageing society and Changing lifestyles?	6.67	40.00	0.00	53.33

Ageing society and Energy demand and sources?	42.86	7.14	14.29	35.71
Ageing society and Closer public and private cooperation?	61.54	15.38	15.38	7.69
Ageing society and Vehicle efficiency?	66.67	25.00	0.00	8.33
Ageing society and Innovative research system?	41.67	25.00	16.67	16.67
Ageing society and Automation?	0.00	25.00	41.67	33.33
Ageing society and Infrastructure?	8.33	33.33	8.33	50.00
Ageing society and Increasing connectivity, intermodal access and fit-for-purpose network standards?	38.36	26.27	0.00	35.36
Ageing society and Supporting modal shift?	40.00	30.00	0.00	30.00
Ageing society and Electrified vehicles/vessels?	66.67	11.11	0.00	22.22
Energy demand and sources and Environmental challenges – climate change?	0.00	28.00	8.00	64.00
Energy demand and sources and Urbanization and megacities?	20.00	0.00	53.33	26.67
Energy demand and sources and Innovative research system?	11.11	27.78	27.78	33.33
Energy demand and sources and Vehicle efficiency?	0.00	38.46	7.69	53.85
Energy demand and sources and Infrastructure?	8.33	25.00	8.33	58.33
Energy demand and sources and Supporting modal shift?	10.00	30.00	10.00	50.00
Energy demand and sources and Closer public and private cooperation?	40.00	20.00	10.00	30.00
Energy demand and sources and Automation?	30.00	10.00	20.00	40.00
Energy demand and sources and Increasing connectivity, intermodal access and fit-for-purpose network standards?	37.50	0.00	25.00	37.50
Energy demand and sources and Electrified vehicles/vessels?	0.00	66.67	0.00	33.33
Environmental challenges – climate change and Vehicle efficiency?	5.56	27.78	16.67	50.00
Environmental challenges – climate change and Closer public and private cooperation?	29.41	17.65	0.00	52.94
Environmental challenges – climate change and Urbanization and megacities?	3.85	15.38	50.00	30.77
Environmental challenges – climate change and Automation?	18.75	6.25	12.50	62.50
Environmental challenges – climate change and Innovative research system?	4.35	26.09	8.70	60.87
Environmental challenges – climate change and Infrastructure?	5.26	21.05	42.11	31.58
Environmental challenges – climate change and Supporting modal shift?	5.67	42.00	12.33	40.00
Environmental challenges – climate change and Electrified vehicles/vessels?	7.69	30.77	7.69	53.85
Environmental challenges – climate change and Increasing connectivity, intermodal access and fit-for-purpose network standards?	7.14	14.29	21.43	57.14
Urbanization and megacities and Innovative research system?	32.58	30.58	10.53	26.32
Urbanization and megacities and Infrastructure?	0.00	28.57	0.00	71.43
Urbanization and megacities and Vehicle efficiency?	16.67	38.89	22.22	22.22
Urbanization and megacities and Supporting modal shift?	0.00	50.00	16.67	33.33
Urbanization and megacities and Increasing connectivity, intermodal access and fit-for-purpose network standards?	16.67	33.33	0.00	50.00
Urbanization and megacities and Automation?	0.00	0.00	25.00	75.00
Urbanization and megacities and Closer public and private cooperation?	36.36	18.18	18.18	27.27
Urbanization and megacities and Electrified vehicles/vessels?	0.00	63.64	0.00	36.36
Changing lifestyles and Energy demand and sources?	0.00	0.00	15.38	84.62
Changing lifestyles and Environmental challenges – climate change?	0.00	15.79	21.05	63.16
Changing lifestyles and Urbanization and megacities?	0.00	0.00	21.05	78.95
Changing lifestyles and Innovative research system?	14.29	35.71	0.00	50.00
Changing lifestyles and Infrastructure?	8.33	25.00	25.00	41.67

Changing lifestyles and Vehicle efficiency?	36.36	9.09	9.09	45.45
Changing lifestyles and Closer public and private cooperation?	50.00	20.00	0.00	30.00
Changing lifestyles and Automation?	0.00	0.00	20.00	80.00
Changing lifestyles and Supporting modal shift?	0.00	11.11	11.11	77.78
Changing lifestyles and Increasing connectivity, intermodal access and fit-for-purpose network standards?	0.00	0.00	11.11	88.89
Changing lifestyles and Electrified vehicles/vessels?	11.11	22.22	11.11	55.56
Supporting modal shift and Innovative research system?	15.38	7.69	46.15	30.77
Supporting modal shift and Automation?	44.44	11.11	11.11	33.33
Supporting modal shift and Increasing connectivity, intermodal access and fit-for-purpose network standards?	0.00	25.00	0.00	75.00
Supporting modal shift and Vehicle efficiency?	50.00	25.00	0.00	25.00
Supporting modal shift and Electrified vehicles/vessels?	50.00	12.50	0.00	37.50
Supporting modal shift and Infrastructure?	0.00	0.00	20.00	80.00
Supporting modal shift and Closer public and private cooperation?	0.00	52.00	0.00	48.00
Innovative research system and Automation?	0.00	20.00	10.00	70.00
Innovative research system and Electrified vehicles/vessels?	0.00	36.36	0.00	63.64
Innovative research system and Infrastructure?	0.00	25.00	16.67	58.33
Vehicle efficiency and Electrified vehicles/vessels?	12.50	12.50	0.00	75.00
Vehicle efficiency and Automation?	0.00	12.50	37.50	50.00
Vehicle efficiency and Innovative research system?	0.00	9.09	54.55	36.36
Vehicle efficiency and Infrastructure?	11.11	22.22	0.00	66.67
Vehicle efficiency and Closer public and private cooperation?	20.00	20.00	0.00	60.00
Increasing connectivity, intermodal access and fit-for-purpose network standards and Innovative research system?	10.00	10.00	30.00	50.00
Increasing connectivity, intermodal access and fit-for-purpose network standards and Automation?	0.00	18.18	18.18	63.64
Increasing connectivity, intermodal access and fit-for-purpose network standards and Infrastructure?	9.09	9.09	36.36	45.45
Increasing connectivity, intermodal access and fit-for-purpose network standards and Vehicle efficiency?	37.50	25.00	12.50	25.00
Increasing connectivity, intermodal access and fit-for-purpose network standards and Closer public and private cooperation?	12.50	12.50	12.50	62.50
Increasing connectivity, intermodal access and fit-for-purpose network standards and Electrified vehicles/vessels?	75.00	0.00	12.50	12.50
Closer public and private cooperation and Automation?	18.18	18.18	18.18	45.45
Closer public and private cooperation and Infrastructure?	18.18	29.27	25.27	27.27
Closer public and private cooperation and Innovative research system?	0.00	33.33	0.00	66.67
Closer public and private cooperation and Electrified vehicles/vessels?	0.00	50.00	25.00	25.00
Electrified vehicles/vessels and Automation?	83.33	0.00	0.00	16.67
Electrified vehicles/vessels and Infrastructure?	0.00	0.00	20.00	80.00
Automation and Infrastructure?	11.11	35.33	22.22	31.33

Table 3.6 Selection of relationship between key elements for freight transport (%)

Relationship	No	One Way	Opposite	Feedback
Environmental challenges – climate change and Urbanization and megacities?	3.85	15.38	50.00	30.77
Environmental challenges – climate change and Innovative research system?	4.35	26.09	8.70	60.87

Environmental challenges – climate change and Infrastructure?	5.26	21.05	42.11	31.58
Environmental challenges – climate change and Vehicle efficiency?	5.56	27.78	16.67	50.00
Environmental challenges – climate change and Closer public and private cooperation?	29.41	17.65	0.00	52.94
Environmental challenges – climate change and Raising investment in infrastructure development?	20.00	33.33	20.00	26.67
Environmental challenges – climate change and Digitisation strategy/regulations/markets?	35.71	21.43	21.43	21.43
Environmental challenges – climate change and Automation?	20.00	10.00	30.00	40.00
Energy demand and sources and Environmental challenges – climate change?	0.00	28.00	8.00	64.00
Energy demand and sources and Innovative research system?	11.11	27.78	27.78	33.33
Energy demand and sources and Urbanization and megacities?	20.00	0.00	53.33	26.67
Energy demand and sources and Vehicle efficiency?	0.00	38.46	7.69	53.85
Energy demand and sources and Raising investment in infrastructure development?	15.38	23.08	7.69	53.85
Energy demand and sources and Infrastructure?	8.33	25.00	8.33	58.33
Energy demand and sources and Closer public and private cooperation?	40.00	20.00	10.00	30.00
Energy demand and sources and Digitisation strategy/regulations/markets?	55.56	0.00	11.11	33.33
Energy demand and sources and Automation?	16.67	0.00	33.33	50.00
Ageing society and Environmental challenges – climate change?	39.13	13.04	26.09	21.74
Ageing society and Urbanization and megacities?	25.00	18.75	6.25	50.00
Ageing society and Changing lifestyles?	6.67	40.00	0.00	53.33
Ageing society and Energy demand and sources?	42.86	7.14	14.29	35.71
Ageing society and Closer public and private cooperation?	61.54	15.38	15.38	7.69
Ageing society and Vehicle efficiency?	66.67	25.00	0.00	8.33
Ageing society and Digitisation strategy/regulations/markets?	25.00	33.33	16.67	25.00
Ageing society and Innovative research system?	41.67	25.00	16.67	16.67
Ageing society and Infrastructure?	8.33	33.33	8.33	50.00
Ageing society and Bigger world economy?	30.00	20.00	30.00	20.00
Ageing society and Raising investment in infrastructure development?	45.00	35.00	10.00	10.00
Ageing society and Automation?	20.00	40.00	20.00	20.00
Changing lifestyles and Raising investment in infrastructure development?	28.57	28.57	0.00	42.86
Changing lifestyles and Environmental challenges – climate change?	0.00	15.79	21.05	63.16
Changing lifestyles and Urbanization and megacities?	0.00	0.00	21.05	78.95
Changing lifestyles and Innovative research system?	14.29	35.71	0.00	50.00
Changing lifestyles and Energy demand and sources?	0.00	0.00	15.38	84.62
Changing lifestyles and Infrastructure?	8.33	25.00	25.00	41.67

Changing lifestyles and Vehicle efficiency?	36.36	9.09	9.09	45.45
Changing lifestyles and Digitisation strategy/regulations/markets?	9.09	18.18	0.00	72.73
Changing lifestyles and Closer public and private cooperation?	50.00	20.00	0.00	30.00
Changing lifestyles and Automation?	0.00	0.00	25.00	75.00
Urbanization and megacities and Innovative research system?	35.58	31.58	10.53	22.32
Urbanization and megacities and Vehicle efficiency?	16.67	38.89	22.22	22.22
Urbanization and megacities and Infrastructure?	0.00	28.57	0.00	71.43
Urbanization and megacities and Digitisation strategy/regulations/markets?	8.33	33.33	8.33	50.00
Urbanization and megacities and Closer public and private cooperation?	36.36	18.18	18.18	27.27
Urbanization and megacities and Raising investment in infrastructure development?	20.00	20.00	0.00	60.00
Urbanization and megacities and Automation?	0.00	42.00	20.00	38.00
Bigger world economy and Infrastructure?	9.09	45.45	9.09	36.36
Bigger world economy and Environmental challenges – climate change?	0.00	60.00	13.33	26.67
Bigger world economy and Energy demand and sources?	0.00	42.86	7.14	50.00
Bigger world economy and Innovative research system?	7.14	44.86	5.14	42.86
Bigger world economy and Urbanization and megacities?	0.00	50.00	20.00	30.00
Bigger world economy and Vehicle efficiency?	10.00	42.00	39.00	9.00
Bigger world economy and Raising investment in infrastructure development?	0.00	44.44	22.22	33.33
Bigger world economy and Changing lifestyles?	0.00	53.00	0.00	47.00
Bigger world economy and Digitisation strategy/regulations/markets?	0.00	25.00	12.50	62.50
Bigger world economy and Automation?	12.50	50.00	12.50	25.00
Bigger world economy and Closer public and private cooperation?	0.00	33.33	0.00	66.67
Vehicle efficiency and Infrastructure?	11.11	22.22	0.00	66.67
Vehicle efficiency and Automation?	11.11	22.22	35.33	31.33
Innovative research system and Infrastructure?	0.00	25.00	16.67	58.33
Vehicle efficiency and Innovative research system?	0.00	9.09	54.55	36.36
Vehicle efficiency and Raising investment in infrastructure development?	40.00	0.00	10.00	50.00
Vehicle efficiency and Digitisation strategy/regulations/markets?	57.14	0.00	0.00	42.86
Vehicle efficiency and Closer public and private cooperation?	20.00	20.00	0.00	60.00
Closer public and private cooperation and Raising investment in infrastructure development?	11.11	22.22	22.22	44.44
Closer public and private cooperation and Innovative research system?	0.00	33.33	0.00	66.67
Closer public and private cooperation and Infrastructure?	18.18	32.27	25.27	24.27
Closer public and private cooperation and Digitisation strategy/regulations/markets?	0.00	14.29	14.29	71.43
Closer public and private cooperation and Automation?	0.00	40.00	0.00	60.00

Raising investment in infrastructure development and Digitisation strategy/regulations/markets?	20.00	20.00	40.00	20.00
Raising investment in infrastructure development and Automation?	0.00	42.86	28.57	28.57
Raising investment in infrastructure development and Infrastructure?	0.00	27.27	18.18	54.55
Raising investment in infrastructure development and Innovative research system?	12.50	37.50	50.00	0.00
Digitisation strategy/regulations/markets and Automation?	0.00	16.67	16.67	66.67
Digitisation strategy/regulations/markets and Infrastructure?	28.57	0.00	28.57	42.86
Digitisation strategy/regulations/markets and Innovative research system?	7.69	0.00	7.69	84.62
Innovative research system and Automation?	0.00	25.00	25.00	50.00
Infrastructure and Automation?	0.00	0.00	0.00	100.00

4 The ANP methodology

This chapter provides a description of the used methodology and the scale for the estimation of megatrends, political imperatives, and technical advances' relative importance, as well as transport concepts of the future (further in the text they called 'elements'). This methodology is used to analyze the impact of elements in a complex environment. The complex environment is a problem with a large number of influencing factors and a large number of available actions, and the relationship between elements or the decision-making process with a different group of actors. The problem can be solved by applying the ANP which reflects the decision makers' expertise.

4.1 Introduction

The ANP method, as the outcome of the applied ANP methodology, is a mathematical tool capable of creating complex relations between various elements to improve recommendations. It is used in studies across a wide range of fields such as energy and the environment, business, economics, production, transport, etc. (Mardani et al., 2013). The ANP is one of the Multi-Criteria Decision Making (MCDM) methods introduced by Thomas L. Saaty in 1993 and is used to derive judgment priorities or validation of elements impact for decision-makers. The method is structured as a network composed of criteria and alternatives (all called elements) grouped into clusters, where internal and external comparisons are made between clusters and between all the related elements, analytically determining the decision-making process (Saaty, 2009, 2013). This provides a more accurate model of complex settings. The mathematical proofs of the influence of the model structure are given in detail in Huang et al. (2005) and Saaty (2009).

In other words, the problem decomposition provides itself to an analysis based on the relationship between and in defined clusters. (Saaty, 1980). Managerial judgments are stated regarding the pair-wise comparisons of elements in the cluster based on their influences on the elements in another cluster as well as between elements in the same cluster. Each of the pair-wise comparisons signifies an approximation of the proportion of the weights of the two elements being compared. Since ANP exploits a proportionate scale for personal decisions, the relative weights reflect the relative importance of the norms in attaining the objective of the network. The influence of the elements in the network of other elements in that network can be represented in a Super matrix.

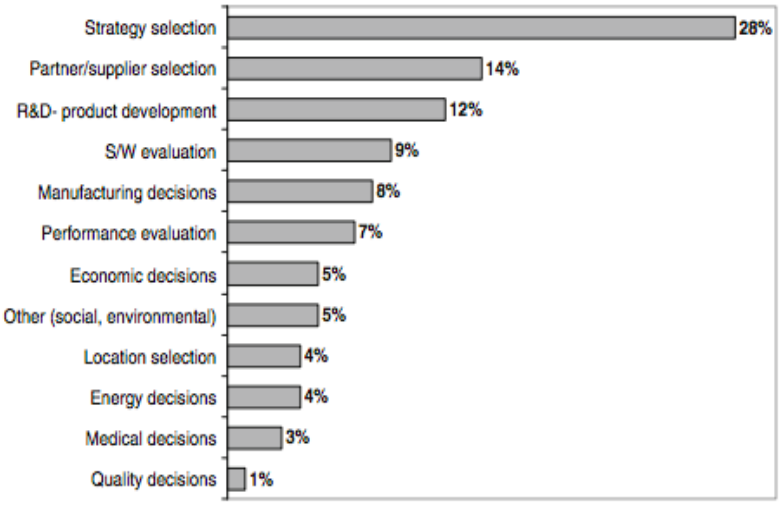
The advantage of this method is that we can more easily judge the difference between elements and understand influence between them. In contrary, it is difficult for a human to evaluate the dissimilarities in the complex systems. Even though we can divide the complex system into many subsystems which can be quickly assessed, the weights of the subsystems also are a hard problem because of existing interdependence and feedback relationships.

Due to the fact that the ANP **can consider the interrelationships** among elements in a problem set as well as a **human way of thinking in the process of elements evaluation** –pair-wise estimation of importance, the use of the ANP method for selecting has increased substantially in recent years both in the areas of transportation but also foresight.

The papers are in brief reviewed here. The ANP can be a very useful tool in decision-making sciences and strategic directions (Saaty, T., 1996, 2005; Saaty, T., Vargas, L., 2012; Saaty, T.,L., 2009).

Sipahi and Timor (2010) have presented a comprehensive literature review and application fields for applying ANP, including the field of transport for the years 2005 to 2009. The study revealed that the ANP applications of the method have been mainly in manufacturing, the environmental management and agriculture field, power and energy industry, transportation industry, construction industry, and healthcare.

Voulgaridou et al, 2009, conducted a review of the ANP usage. She concluded that the ANP has been more frequently used for foresight and scenario analysis in taking strategic decisions. The diagram below demonstrates the areas that the ANP has been applied the most:



Source: adopted from Voulgaridou et al., 2009

With regards to transportation, Tsai and Su (2005) completed a research on political risk assessment process on designing ports. In particular, he developed a case study of business environment scenarios of five East Asian ports taking into consideration the political influences of Hong Kong, Singapore, Busan, Kaohsiung, and Shangha. This system approach consists of political measures analysis and assessment processes using the three methods of Delphi, AHP, and Ward's clustering.

Chang et al. (2009) applied the ANP method in combination with fuzzy Delphi, and zero-one goal programming to evaluate regeneration scenarios for the railway industry. The ANP model consisted of a network of clusters, alternatives, factors, and criteria to be considered for making recommendations for the most suitable scenario/strategy.

Ulutas (2009) utilized the Data Envelopment Analysis (DEA) in combination with the ANP model to evaluate the performance of airports in Turkey. DEA is a known method to determine the efficient and inefficient units in concern. The ANP was used to define the most important factors that impact on performance; therefore, the characteristics of the major airports that impact the operations were selected through the application of the ANP. Ulutas (2005) constructed an ANP selection model for choosing energy policy in Turkey as well,.

Sevkli et al. (2012) derived conclusions on strategic management decisions in the Turkish airline industry. The study used Strengths, Weaknesses, Opportunities, and Threats (SWOT) to evaluate alternative strategies and ANP in order to model potential dependencies among the SWOT factors. The results demonstrate that the methodology introduced (SWOT & ANP) is an efficient methodology that provides invaluable insights for other complex decision-making processes.

Meade and Sarkis (1998) adopted the ANP for selecting a strategy for managing logistical chains while Wu and Lee (2006) integrated the ANP for selection knowledge management strategies. Maede and Presley (2002) applied ANP for the selection of developmental and research projects

Thus, the ANP represents an excellent holistic approach to solving the problem which needs a strategic approach. With the application of the ANP, experts are directed to systematically thinking (there is a consistency check in the evaluation of elements), which yields to valid results. The result represents the quantification of the elements influence, i.e., it is possible to follow the impact of changes on the transport concepts of the future ranking. Based on ANP outcome, decision-makers should be able to gain which megatrend mostly influence on transport concept of the future as well as what transport concept of the future will develop further.

4.2 Model definition- building the model

The ANP model building (Figure 4.1) comprises the following steps:

1. Identifying the components and network elements and their relationships.

2. The purpose of this step is to determine which element is more influential and to what extent among the elements of a cluster. This is done by paired comparisons and calculating the eigenvector associated with the main eigenvalue. As a result of this step, the unweighted Super matrix is obtained.

3. This is done using pair-wise comparison matrices between clusters. A pair-wise comparison matrix between clusters associated with a network group is a matrix whose rows and columns are formed by all network clusters that have some influence on a given cluster.

4. The weighting of the unweighted super matrix blocks using the priorities of each cluster, so that the resulting super matrix, weighted Super matrix, is column-stochastic.

5. Getting the limit Super matrix. The limit Super matrix is obtained by raising the weighted Super matrix to successive powers until their inputs converge. In this matrix, the elements of each column represent the final weightings of the different elements considered.

The network design is usually the first and the most important step of the method. It forces the decision maker and his/her team to conduct a thorough analysis of the problem (Saaty and Shih, 2009). How deep to go in the decomposition of the problem? Psychologists have observed that it is difficult to simultaneously evaluate the influence of more than 7 elements (Saaty & Ozdemir, 2003) by the human mind. Therefore, it is recommended to build clusters of elements that do not contain more than 7 elements. Further research has shown that usable and good solutions can be obtained by using the software that mimics the way of thinking and

it enables that the number of an element cannot be strict, especially for the cluster alternatives (Saaty and Ozdemir, 2003).

The representatives evaluate the relationships between the elements of the defined model using their professional experience to perform pair-wise comparisons and following the operational procedure of the ANP approach.

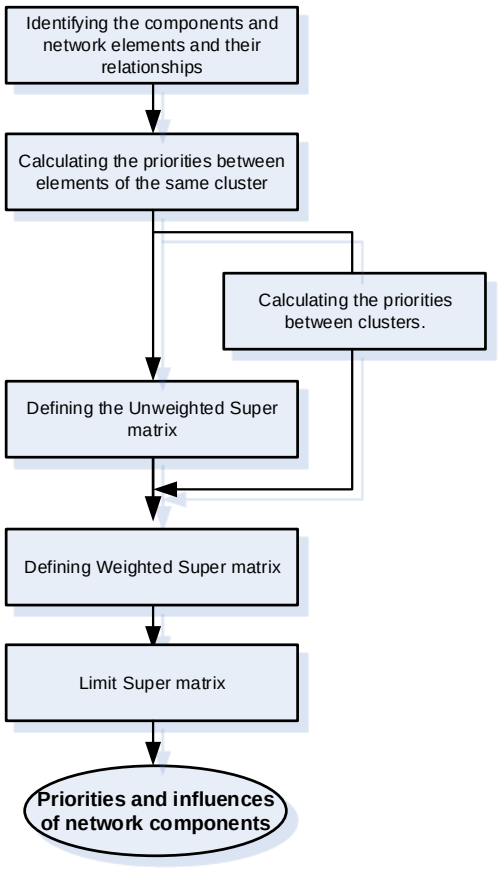


Figure 4.1 ANP model building

The psychologist Arthur Blumenthal writes in his book The Process of Cognition, Prentice-hill Inc. Englewood Cliffs, New Jersey, 1977, that there are two types of judgment:" *Comparative judgment which is the identification of some relation between two stimuli both present to the observer, and absolute judgment which involves the relation between a single stimulus and some information held in short-term memory about some former comparison stimuli or about some previously experienced measurement scale using which the observer rates the single stimulus*". Comparative or relative judgment is made on pairs of elements to ensure accuracy. In paired comparisons, the smaller or lesser elements is used as the unit, and the larger or greater elements is estimated as the multiple of that unit with respect to the common property or criterion for which the comparison is made. In this sense, measurement with many pair-wise comparisons is made more scientifically than by assigning numbers more or less arbitrarily trough guessing.

The quality of results of the ANP method is strongly related to the consistency of judgments that respondents demonstrate during the series of pair-wise comparisons. It is measured by calculating the consistency index and the consistency ratio (CR). Since CR is less than 0.10,

the result is exact enough, and there is no need for any corrections in the comparisons or repeated calculation. The algorithm and details about the calculation of the consistency can be found in Saaty (1996).

Conceptually the ANP network structure for passenger and freight transport is given in figure 4.2. The network consists of four clusters and their connections in greater detail. The main cluster is the cluster where the elements are the transport concept of the futures. It is connected with other three clusters such as clusters of megatrends, political imperatives, and technological advances. Loops as in megatrends, political imperatives, and technological advances feedback into cluster itself. Arrows feed into and leave every cluster to indicate the flow of influence between the clusters.

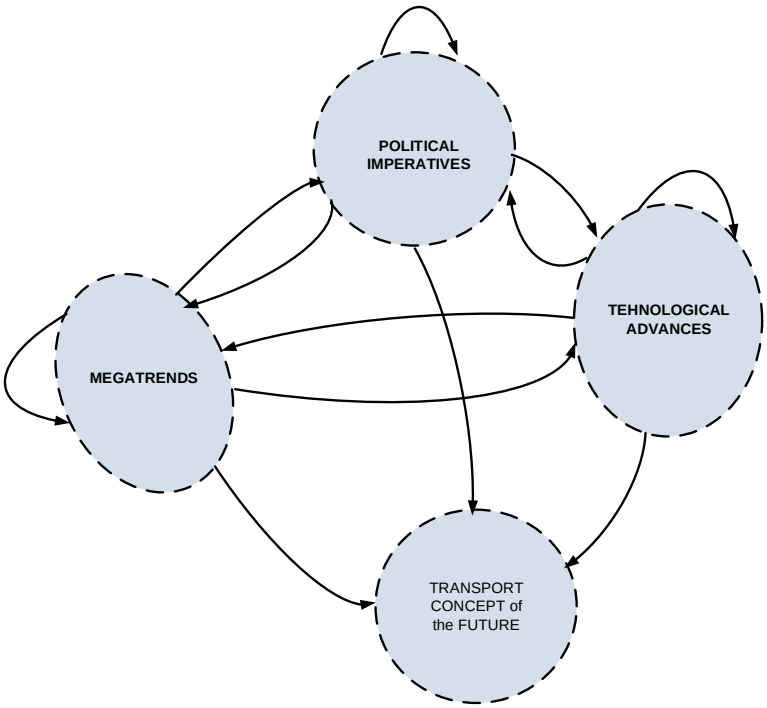


Figure 4.2 ANP model in general

4.2.1 Scale for relations evaluation

A basic, Saaty's fundamental priority scale is used for determining relative weights of network elements. His objective was to create/build new scales (cardinal scales) within homogeneous clusters. The validity and applicability of this scale have been proved in several theoretical papers and publications as well as in the implementation of many real problems in the field of transportation (Jharkharia and Shankar, 2007; Longo et al., 2009; Banai, 2010; Brozova and Ruzicka, 2010).

When we use judgment to estimate dominance in making comparisons, instead of using two numbers w_i and w_j from a scale, we assign a single number drawn from the fundamental 1–9 scale of absolute numbers shown in Table 4.1. The derived scale interpreting the significance of the ratio between two elements (w_i/w_j). It will reveal what the w_i and w_j are. This is a central fact about the relative measurement approach and the need for a fundamental scale.

Table 4.1 Fundamental Scale of Absolute Number

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgment slightly favour one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favour one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance proved in practice
8	Very, very strong	
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
1.1–1.9	When activities are very close a decimal is added to 1 to show their difference as appropriate	A better alternative way to assigning the small decimals is to compare two close activities with other widely contrasting ones, favouring the larger one a little over, the smaller one when using the 1–9 values
Reciprocals of above	If activity i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	A logical assumption

(Saaty, 2003)

Validations of the 1-9 scale showed the ability of our brain to make an estimation. It is assumed that an element with weight zero is eliminated from comparison because zero can be applied to the whole universe of factors not included in the discussion. Reciprocals of all scaled ratios that are ≥ 1 are entered in the transpose positions.

A useful observation has emerged from research in psychology that relates to the use of the fundamental scale. In his book, Stanislas Dehaene (Oxford University Press, p.73, 1997) writes "*Introspection suggests that we can mentally represent the meaning of numbers 1 through 9 with actual acuity. Indeed these symbols seem equivalent to us. They all seem equally easy to work with, and we feel that we can add or compare any two digits in a small and fixed amount of time like a computer. In summary, the invention of numerical symbols should have fed us from the fuzziness of the quantitative representation of numbers".*

4.2.2 ANP network for passenger and freight transport

The ANP network structuring starts with identifying the knowledge of an existing group of respondents about the environment for the megatrends validation and assessment of its impact on the transport concept of the future. The environment represents the network that consists of three clusters, megatrends, political imperatives and technological advances,

relations between elements and finally with key transport concepts of the future grouped in the cluster as well.

The results of the questionnaire analysis, as explained in Chapter 3, showed the key megatrends, political imperatives, and technological advances and the relationship between them.

Based on the methodology steps defined in Deliverable 2.2 the seven top-cited passenger transport concepts for the future were identified and considered to be the dominant ones (Table 4.2). The same principles were also applied for identification of dominant freight transport – applicable concepts of the future (Table 4.2). It is identified eight transport concepts. The transport concepts are ranked according to their frequency of occurrence in the reviewed literature.

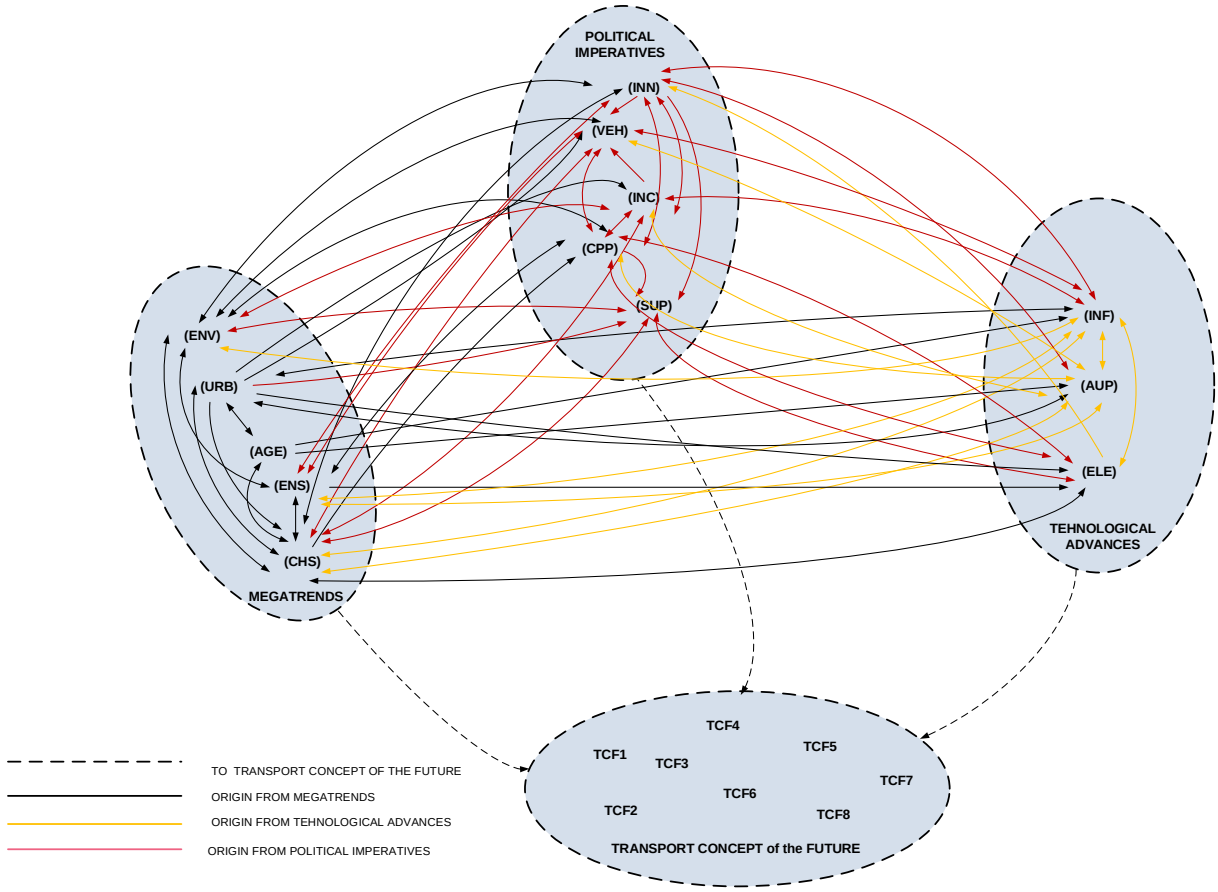
Table 4.2 Dominant passenger and freight transport – the applicable concept of the future

Passenger transport concept of the future	Freight transport concept of the future
Automation – Passenger Transport (autonomous cars, aircraft, trains, vessels)	Shared Mobility, On-Demand Mobility, MaaS, FaaS, LaaS
Shared Mobility, On-Demand Mobility, MaaS	Seamless Transport Chains – Multimodality, Intermodality
Electrification – Passenger Transport (electric cars, trains, aircrafts, vessels)	Automation – Freight Transport (autonomous trucks, trains, vessels)
Seamless Transport Chains – Multimodality, Intermodality	Electrification – Freight Transport (electric trucks, trains, aircraft, vessels)
Personal Air Transportation, "Flying Cars," “Flying Taxis”	Delivery Drones
Smart Use of Travel Time	Superfast Ground and Underground Transportation, Cargo Tubes, Underground Freight Pipelines
High-Speed Rail for Passenger Transport	Freight Consolidation Hubs, Freight Distribution Centres
Superfast Ground and Underground Transportation, Hyperloops	

Forty-eight sets of judgments matrices were generated after the analyzing the response of the participants regarding the selection of key elements and relationships between them.

Two ANP networks were identified. The first one is the ANP network used to evaluate transport concepts for the future in passenger transport. The other is an ANP network where transport concepts of the future are in freight transport. The number of elements in the networks differs.

The ANP network for passenger transport consists of 13 key elements that represent the environment: five megatrends, five political imperatives, three technological advances and eight transport concepts of the future (Figure 4.3). When it comes to the ANP network for freight transport, there are 6 megatrends, 5 political imperatives and two technological advances (Figure 4.4).



Megatrends:

1. Environmental challenges – climate change (ENV)
2. Urbanization and megacities (URB)
3. Ageing society (AGE)
4. Energy demand and sources (ENS)
5. Changing lifestyle (CHS)

Political Imperatives:

1. Innovative research system (INN)
2. Vehicle efficiency (VEH)
3. Increasing connectivity, intermodal access and fit-for-purpose network standards (INC)
4. Closer public and private cooperation (CPP)
5. Supporting modal shift (SUP)

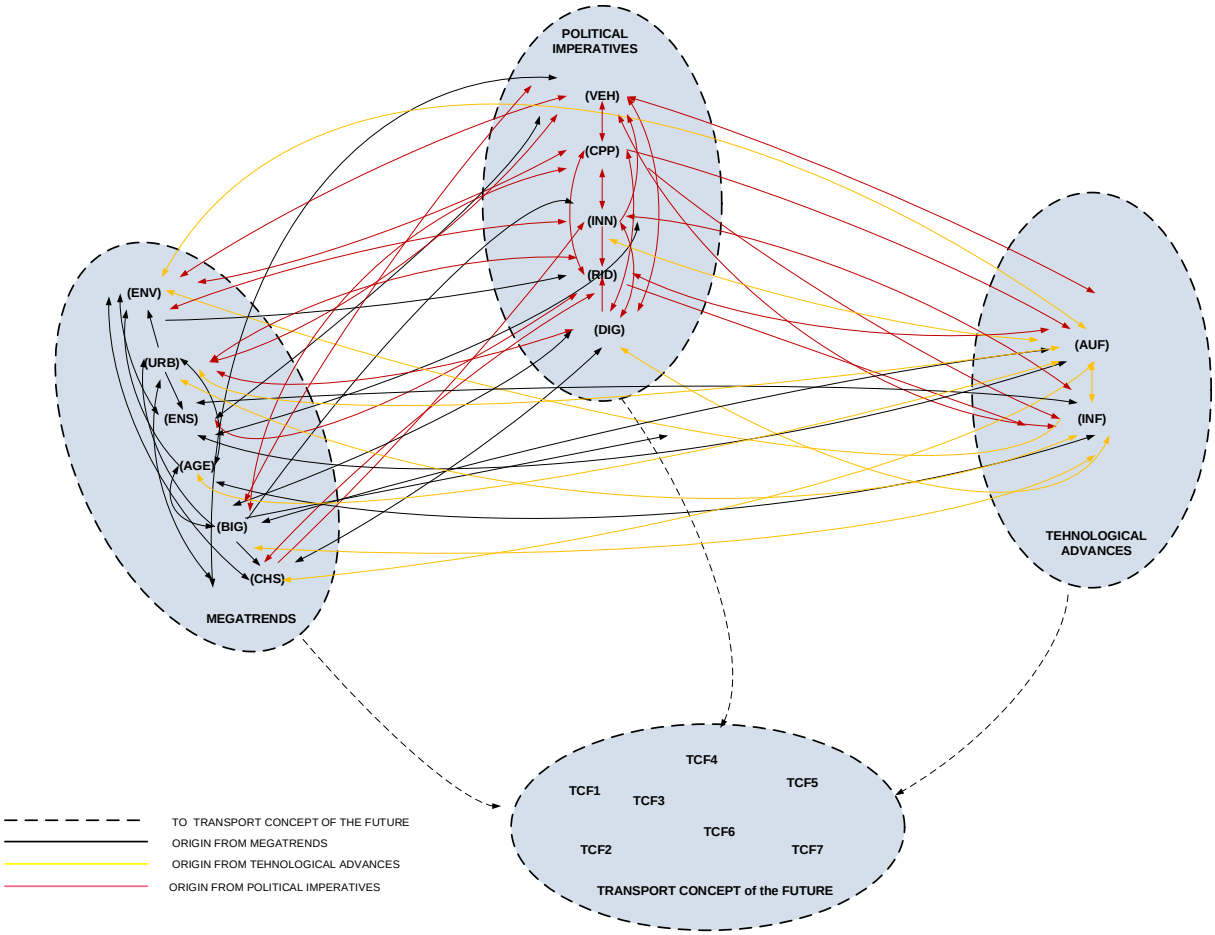
Technological advances:

1. Infrastructure (INF)
2. Automation-passenger (AUP)
3. Electrified vehicles/vessels (ELE)

Transport concepts of the future:

1. Automation-passenger transport (TCF1)
2. Shared mobility, on-demand mobility, MaaS (TCF2)
3. Electrification-passenger transport (TCF3)
4. Seamless transport chains-multimodality, intermodality (TCF4)
5. Personal air transportation, “flying cars”, “flying taxis” (TCF5)
6. Smart use of travel time (TCF6)
7. High-speed rail (TCF7)
8. Superfast ground and underground transportation -hyperloops (TCF8)

Figure 4.3 ANP network for passenger transport



Megatrends:

1. Environmental challenges – climate change (ENV)
2. Urbanization and megacities (URB)
3. Energy demand and sources (ENS)
4. Ageing society (AGE)
5. Bigger world economy (BIG)
6. Changing lifestyle (CHS)

Political Imperatives:

1. Vehicle efficiency (VEH)
2. Closer public and private cooperation (CPP)
3. Innovative research system (INN)
4. Raising investment in infrastructure development (RID)
5. Digitalization strategy/regulations/markets (DIG)

Technological advances:

1. Automation-freight (AUF)
2. Infrastructure (INF)

Transport concepts of the future:

1. Shared mobility, on-demand mobility, MaaS, FaaS, LaaS (TCF1)
2. Seamless transport chains-multimodality, intermodality (TCF2)
3. Automation-freight transport (TCF3)
4. Electrification-freight transport (TCF4)
5. Delivery drons (TCF5)
6. Superfast ground and underground transportation (cargo tubes, underground freight pipelines) (TCF6)
7. Freight consolidation hubs, freight distribution centers (TCF7)

Figure 4.4 ANP network for freight transport

4.3 Model Specification – ANP engine

The application of ANP requires estimation of relationships between all the elements in clusters and between the clusters.

Implementation of the ANP method in INTEND is supported by the ANP Graphical user interface (GUI) application. The results of implementation will be presented and discussed in chapter 5. During the processes of definition and production of ANP GUI application the following actions: identification of the inconsistent elements and determination of global priority vectors. From the point of view of the INTEND project, this means that consistency in assessing the impact of megatrends, political imperatives and technological advances on transport concepts of the future is ensured. Within the ANP GUI application, the ANP sensitivity analysis is added as one menu item tool. The results from the sensitivity analysis are presented in chapter 6.

The ANP structures a decision problem into an ANP network with decision criteria (elements) organized into relevant clusters which are weighted and compared against alternatives to decide which alternatives should be selected. Elements in each cluster have a zero or non-zero influence on some or all elements of any cluster including cluster of alternatives.

Overall there are two levels of influences between elements and alternatives. The first level is the influence between the elements of the ANP network (elements and alternatives) with regard to other elements, and the second level is the influence between elements of the ANP network with regard to clusters of elements and alternatives in the ANP network.

In the beginning of ANP Model specification, influences are noted only as zero or non-zero. Non-zero influences between elements have three possible directions: one-way direction, opposite direction and interaction. One-way direction is noted as (0,1), opposite direction is noted as (1,0), while interaction and non-zero influence are noted as (1,1) and (0,0) respectively. All possible notations of the influences between elements A and B in the first step are presented in the Figure 4.5.

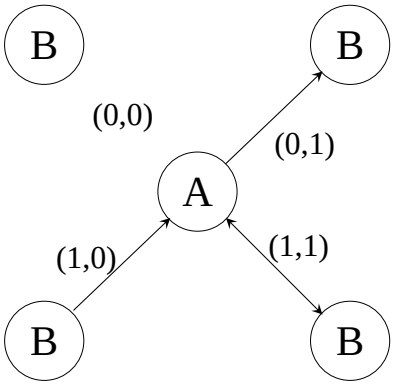


Figure 4.5 Graph presentation of One-way direction, opposite direction, interaction and zero influence

At the stage of ANP Model specification where the importance of elements and the ranking of alternatives are judged through the numerical values of influences, the notations from the Figure 4-5 are not convenient for the use. Thus, Pair- wise Comparison Matrices (PCMs) are used for the assignment of numerical values to non-zero influences.

PCMs related to the first level of influences will be called PCMs on element level, while the other PCMs related to the second level of influences will be called PCMs on a cluster level.

Paired comparisons or preference relations are statements made by the group of experts[1] that involve their views and reflections. In PCMs, paired comparisons correspond to numerical values of the preferences, importance, and likelihood concerning a certain property that the elements being compared have in common (Adams,2011).

The main features of the PCMs are measurement scale, consistency index, judgments issues and priority derivation method. Paired comparisons in the PCMs are filled in by the expert judgments using a measurement scale by Saaty (1999). Judgments include the process of comparing elements in PCMs leading to misjudgments expressed as various levels of inconsistencies in PCMs. The level of inconsistency is measured by the consistency ratio (CR) by the numerical values of entries in PCMs. The value of CR is set to 0.1. If the value of CR is greater than 0.1, PCM is considered inconsistent, and inconsistent paired comparisons are identified.

The identification of the inconsistent elements is done with the script written in Python (Python script), while visualization of the inconsistent elements is performed through HTML script. MySQL database stores all the data from PCMs and serves as a starting point for the calculation (measurement) of CRs. CRs are calculated by the Python script.

The entire process of calculation of acceptable CRs is done in two steps. In the first step, experts fill the entries of PCMs. In the second step HTML script imports the calculated values of CRs from Python script, visualizes all of the elements of PCMs on the PC Monitor and marks the entries with inconsistent elements if the CRs are unacceptable. In the same time values in marked entries are replaced by HTML script with the new values calculated by the Python script. New values in the entries suggest the shortest path for the calculation of acceptable CRs. If experts accept the new values the process of calculation of acceptable CRs is done. If experts do not accept the suggested values step 2 is repeated.

The process of calculation of CRs and correction of inconsistent elements is done by Python script and MySQL database. Special attention is directed to the revelation of PCM entries responsible for inconsistencies.

Python script accesses the MySQL database with a query on a database. MySQL database stores PCMs and their elements in a number format with values determined in the first step or calculated in the second step. Python script derives all element values of PCMs and calculates CRs, locates the inconsistent ones and calculates new values if the CRs are unacceptable. In the end, new values (if there is some) are written down and stored in the MySQL databases.

PCMs represent subjective judgments of experts. It means that experts assign values of the paired comparisons. Values are judged by experts in the logic of preference way (which is called *transitive property*) in order to get acceptable CRs (Adams, 2011).

The code in Python script is written on the base of two algorithms described in (Ergu et all, 2011) and (Pradeep et all, 2016). Algorithms are responsible for the calculation of CRs,

[1] Academia, Industry and policy makers

location of inconsistent elements, revision of inconsistent ones and calculation of new CRs (until the inconsistency is reduced to an acceptable level).

Following the processes of filling the PCMs and determination of PCMs with acceptable CRs, priority weights are derived from PCMs. In this deliverable, priority weights represent the influences between elements and are similar to eigenvectors[2] of the linear transformations of PCMs.

Thus, PCMs become mathematical matrices used by the ANP methodology for deriving numerical values of non-zero influences between elements and alternatives.

Priority vectors derived from PCMs on an element level (local priorities) are grouped and arranged in one super matrix called the unweighted super matrix. Unweighted super matrix is multiplied by priority vectors derived from the PCMs on cluster level to get a weighted super matrix. Weighted super matrix rows correspond to the importance of each row (element or alternative) in it.

Weighted super matrix is raised to a sufficiently large power until it converges into the stable limited super matrix. If the power is indexed with n, then the limited super matrix is reached when the multiplication of a weighted super matrix by itself n times, is equal to the multiplication of a weighted super matrix by itself *n+1* times. Limited super matrixes are recognizable if all entries in one row have the same values independently of the column. Also, the summations per columns are always equal to 1 and vector priorities (global priorities) can be easily computed for the elements of each cluster and alternatives.

Calculation of limited super matrix is done by the script written in Python. First, one desktop graphical user interface (GUI) application on Windows is made in the wxPython toolkit. GUI application with typical menu items is linked with a mentioned script to be able to calculate limited super matrix. Solutions, obtained from GUI application will be displayed and discussed in chapter 5.

Limited super matrix produces limited priorities by capturing all of the direct and indirect influences of each limited super matrix element on every other limited super matrix element including the alternatives. The final (synthesized) priorities of elements and alternatives are found in corresponding columns in the limited super matrix. A computational method for reaching limited super matrixes from the weighted super matrixes is compiled from the solutions suggested by Rokou et all (2012) and Saaty (1999).

5 Results –Megatrend validation

The judgment with regard to elements in megatrends, political imperatives, and technological advances clusters, as well as the comparisons of the relative impact of all elements in the network was conducted by the ANP questionnaire. The overall results are presented in this chapter below and Annex 1.

[2] In linear algebra, an eigenvector or characteristic vector of a linear transformation is a non-zero vector that changes by only a scalar factor when that linear transformation is applied to it.

The megatrends validation for all respondents and by experts group has been carried out through the discussion of the results in two ways:

- An analysis of the priorities of all elements within the transport concept of the future cluster
- By analyzing the diversity and similarity of the priorities of the elements within the cluster megatrends, political imperatives, and technological advances.

5.1 Results of the passenger transport ANP network analysis

The final priorities for the passenger transport concept of the future and the priorities of megatrends, political imperatives and technological advances in the limit super matrix, obtained by evaluation of all respondents, are presented in Table 5.1. In other words, outcomes are the perception of the priorities for each passenger transport concept of the future and impact of the megatrends, political imperatives and technological advances by all respondents.

Table 5.1, a simplified presentation of limited super-matrix, consists of four groups of outcomes. The first group of outcomes/results are the priorities of transport concepts of the future for passenger transport (TCFPs). Then follows a set of priorities for megatrends, political imperatives and for technological advances. For each of these groups is given, a rank in relation to the best-ranked element (Ideal), the normalized priority as a share of the element in relation to all elements in the group (Normalized by cluster), and the Score (priorities from Limited Matrix).

It can be noticed that the elements with the highest priority are:

1. *High-speed rail* in the group of TCFP with 15.99% of overall priorities
2. *Changing lifestyle* megatrend with 35 % influence on the TCFP ranking
3. *Closer public and private cooperation, as* political imperatives, with 23.42% influence
4. *Electrified vehicles/vessels*, as technological advances, with 41.51% influence

Detailed result for TCFPs ranking is shown in Figure 5.1. This is the perception of all respondents on the priorities of TCFPs. We can see that the highest priority value of TCFP has *High-speed rail*. Looking ahead, the second, third and fourth TCFP is very close to the first one, and these are *Personal air transportation*, *Automation,* and *Electrification*. The other four TCPFs can be grouped into two groups, namely the fifth and the sixth TCFP respectively the seventh and eighth TCFPs. According to the differences between the priorities value of the first four TCFPs, all respondents estimate that all of them can be taken into consideration for future research.

Table 5.1 The elements with their priorities and ranking for passenger transport by all respondents

Overall	Priority for Passenger transportation			
Elements	Ranking	Ideals	Normalized By Cluster	Score
TCFP				
Automation	3	0.8682	0.1388	0.0459
Electrification	4	0.8543	0.1366	0.0451
High speed rail	1	1.0000	0.1599	0.0528
Personal air transportation	2	0.8744	0.1398	0.0462
Seamless transport chains	6	0.7306	0.1168	0.0386
Shared mobility	8	0.5553	0.0888	0.0293
Smart use of travel time	7	0.6313	0.1009	0.0334
Superfast ground	5	0.7416	0.1186	0.0392
Megatrends				
Ageing society	5	0.2063	0.0722	0.0188
Changing lifestyles	1	1.0000	0.3500	0.0911
Energy demand and sources	3	0.5326	0.1864	0.0485
Enviromental challanges - climate change	2	0.8622	0.3018	0.0786
Urbanization and megacities	4	0.2561	0.0896	0.0233
Political imperatives				
Closer public and private cooperation	1	1.0000	0.2342	0.0454
fit-for-purpose network standards	2	0.9952	0.2331	0.0452
Innovative research system	5	0.5780	0.1354	0.0263
Supporting modal shift	4	0.7856	0.1840	0.0357
Vehicle efficiency	3	0.9106	0.2133	0.0414
Tehnological advances				
Automation- passenger	3	0.5857	0.2432	0.0523
Electrified vehicles/vessels	1	1.0000	0.4151	0.0893
Infrastructure	2	0.8231	0.3417	0.0735

*the yellow mark is an element with the highest importance

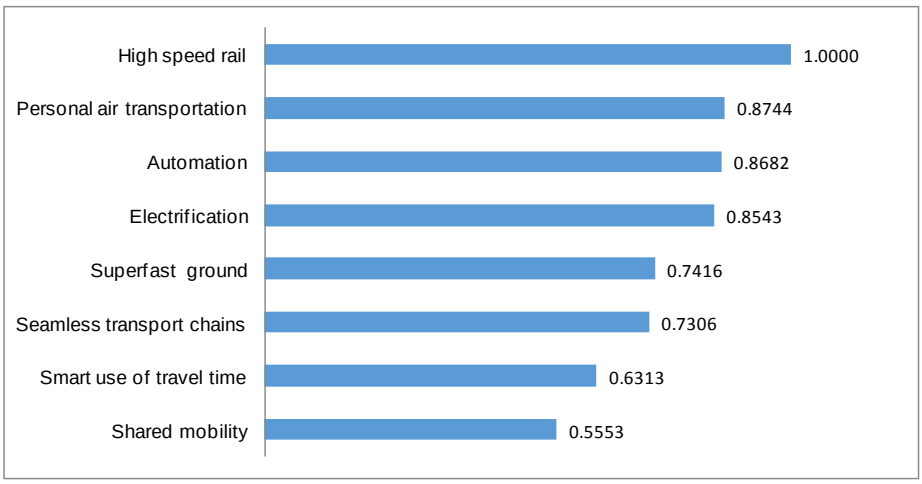


Figure 5.1 TCFP ideal value

When it comes to elements influences within the cluster megatrends, political imperatives and technological advances (Figure 5.3), all respondents estimate that the most important elements are: *Changing lifestyle*, *Closer public and private cooperation* and *Electrified vehicles/vessels*.

Significantly stands out the influence of the megatrends *Changing lifestyle* and *Environmental Challenges* compared to other megatrends. Impacts of these megatrends for the TCFPs are 35% and 30.1%. In contrast to them, the impact of megatrends *Ageing society* and *Urbanization and megacities* are smaller and similar values of priorities.

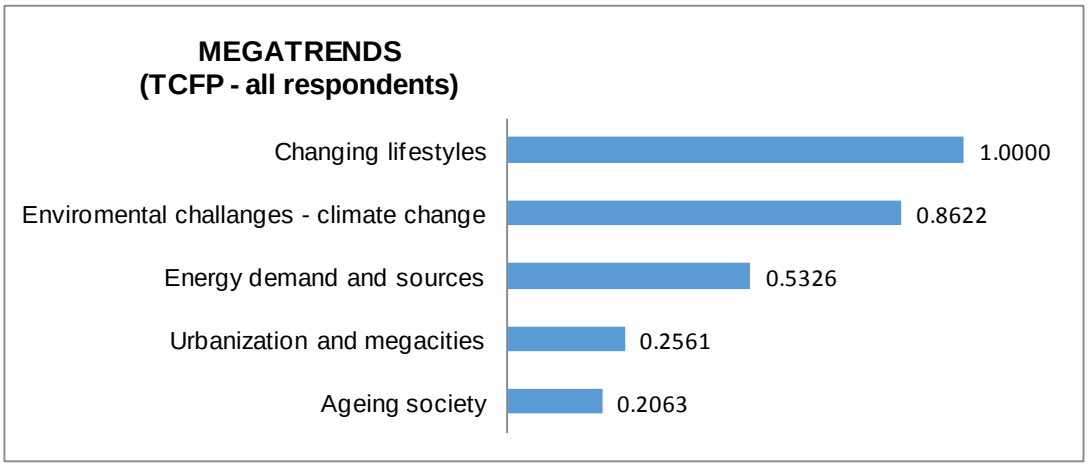


Figure 5.2 Megatrend ideal value – passenger transport

The merits of the political imperatives priorities (Figure 5.3) indicate that the first two political imperatives are very close to each other. It has been seen that there are the same distances between transportation advances according to the values of the priorities.

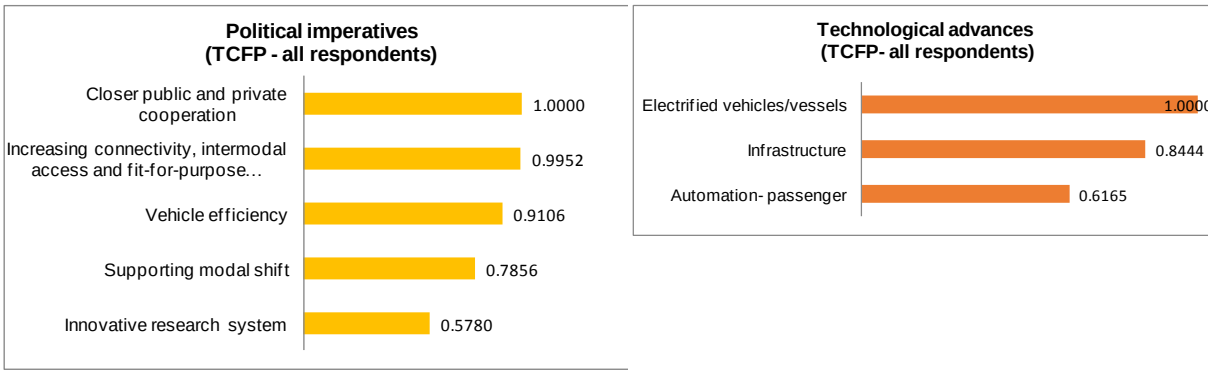


Figure 5.3 Political imperatives and technological advances ideal value – passenger transport

5.1.1 Results of the passenger transport ANP network analysis by groups

As mentioned before, the validation of the megatrends impact on the TCFPs was conducted by three groups of respondents, from the academia, policy making, and industry. The outcome is presented in table 5.2. The question arises as to whether validation varies by individual

groups, or are there significant differences in perception/thinking between academia, policymakers, and industry?

The assessment of the responders' group significantly differs, when

- the ranking of elements within TCFP, megatrends, political imperatives and technical advances groups differs at least two places/ranks.
- the obtain priority of the elements in the TCFPs, megatrends, political imperatives and technological advances groups (normalized value of priority per cluster) differ significantly.

When it comes to TCFPs ranking, the only significant difference is shown in the *Superfast ground* TCFP ranking. Respondents from academia ranked *Superfast Ground* considerably higher than respondents from policy makers and industry. Such a ranking as a result of evaluating of respondents from academia, it can be interpreted that Superfast ground as an alternative to a conventional transport system, and as a technological solution, is a transport concept that needs to be further developed in the coming periods.

Regarding the ranking of megatrends, political imperatives, and technological advances, there is no significant difference in the estimation between the groups. It can even be noticed that sometimes all three groups of respondents evaluate the same some megatrends, such as the *Changing lifestyle* and *Environmental challenges - climate change.* These two megatrends according to the priorities of all groups of respondents take an important first or second place so that they can be considered as the leading megatrends that influence the determination for future research needs.

Although the representatives of different groups have evaluated the effects of megatrends, political imperatives and technological advances in the same way or similar, their evaluation was checked once again by observing the normalized values of priorities. It was noted that the normalized value of the impact follows the ranking of the elements or the calculated value of the priorities does not differ significantly so that the priorities and ranking are the results of the concise and comprehensive validation of all groups responders.

The final order of the TCFPs by responders groups also shows no significant difference. In other words, in addition to the fact that they estimate the same the importance of megatrends, political imperatives and technological advances, respondents from different groups according to the same criteria are almost the same as TCPFs.

Table 5.2 TCFPs ranking and normalized priorities by all respondents and by groups

PASSENGER TRANSPORT	ranking				Normalized by cluster			
	overall	Academia	Policy makers	industry	overall	Academia	Policy makers	industry
TCFP								
Automation	3	3	1	1	0.1388	0.13879	0.2004	0.1770
Electrification	4	4	4	4	0.1366	0.13656	0.1461	0.1160
Seamless transport chains	6	6	5	5	0.1168	0.11679	0.1061	0.1034
Shared mobility	8	8	6	6	0.0888	0.08876	0.0952	0.0943
Superfast ground	5	5	8	7	0.1186	0.11855	0.0675	0.0909
Smart use of travel time	7	7	7	8	0.1009	0.10091	0.0784	0.0793
High speed rail	1	1	3	2	0.1599	0.15985	0.1469	0.1733
Personal air transportation	2	2	2	3	0.1398	0.13978	0.1595	0.1657
Megatrends								
Ageing society	5	5	4	4	0.0722	0.0722	0.1256	0.0612
Changing lifestyles	1	1	1	1	0.3500	0.3500	0.3190	0.3587
Energy demand and sources	3	3	3	3	0.1864	0.1864	0.2135	0.2123
Enviromental challanges - climate change	2	2	2	2	0.3018	0.3018	0.2379	0.3152
Urbnization and megacities	4	4	5	5	0.0896	0.0896	0.1040	0.0527
Political imperatives								
Increasing connectivity, intermodal access ar	2	2	1	2	0.2331	0.2331	0.2795	0.2380
Supporting modal shift	4	4	4	5	0.1840	0.1840	0.1447	0.1385
Closer public and private cooperation	1	1	2	1	0.2342	0.2342	0.2563	0.2887
Innovative research system	5	5	3	3	0.1354	0.1354	0.1906	0.1956
Vehicle efficiency	3	3	5	4	0.2133	0.2133	0.1289	0.1392
Technological advances								
Automation- passenger transport	3	3	3	3	0.2432	0.2432	0.2348	0.2751
Infrastructure	2	2	2	2	0.3417	0.3417	0.3539	0.3206
Electrified vehicles/vessels	1	1	1	1	0.4151	0.4151	0.4113	0.4043

5.2 Results of the freight transport ANP network analysis

The resulting final priorities (Table 5.3) for freight transport are obtained by estimation elements and relationships in ANP network for freight transport by evaluation of all respondents (the similar procedure as for passenger transport). It is worth emphasizing that ANP network for freight transport is different from ANP network for passenger transport (chapter 4.2.2).

The elements with the highest priority are:

1. *Automation* as TCFF with 20.87% normalized priority
2. *Changing lifestyle* megatrend with 28.4% influence on TCFF ranking
3. *Digitalization strategy/regulations/markets, as* political imperatives, with 24% influence
4. *Automation in freight transport, as* technological advances with, 60.6% influence

Focusing on the priorities of TCFFs (Figure 5.4) we can see that the *Automation is* dominant. TCFF *Delivery drones* and *Shared mobility* ranked second and third, are with a significant difference in priority value compared to *Automation*. All other TCPFs can be clustered into two groups, and the last group consists of *Seamless transport chains* and *Super ground and underground* that representing business platforms.

Table 5.3 The elements with their priorities and ranking for freight transport by all respondents

Overall	Priority for Freight transportation			
Elements	Ranking	Ideals	Normalized By Cluster	Score
TCFF				
Automation	1	1.0000	0.2087	0.0744
Delivery drones	2	0.7635	0.1593	0.0568
Electrification	5	0.6468	0.1350	0.0481
Freight consolidation hubs	4	0.6592	0.1376	0.0490
Seamless transport chains	6	0.5669	0.1183	0.0422
Shared mobility	3	0.7186	0.1500	0.0535
Superfast ground and underground	7	0.4370	0.0912	0.0325
Megatrends				
Agying society	6	0.3325	0.0943	0.0298
Bigger world economy	5	0.4063	0.1153	0.0364
Changing lifestyle	1	1.0000	0.2837	0.0896
Energy demand and sources	4	0.4997	0.1418	0.0448
Environmental challenges -climate change	3	0.6428	0.1824	0.0576
Urbanization and megacities	2	0.6437	0.1826	0.0576
Political imperatives				
Closer public and private cooperation	5	0.7160	0.1714	0.0323
Digitalization strategy/regulations/markets	1	1.0000	0.2393	0.0451
Innovative research systems	3	0.8010	0.1917	0.0361
Raising investment in infrastructure development	2	0.9394	0.2248	0.0423
Vehicle efficiency	4	0.7219	0.1728	0.0325
Tehnological advances				
Automation-freight	1	1.0000	0.6062	0.0846
Infrastructure	2	0.6496	0.3938	0.0549

*the yellow mark is an element with the highest importance

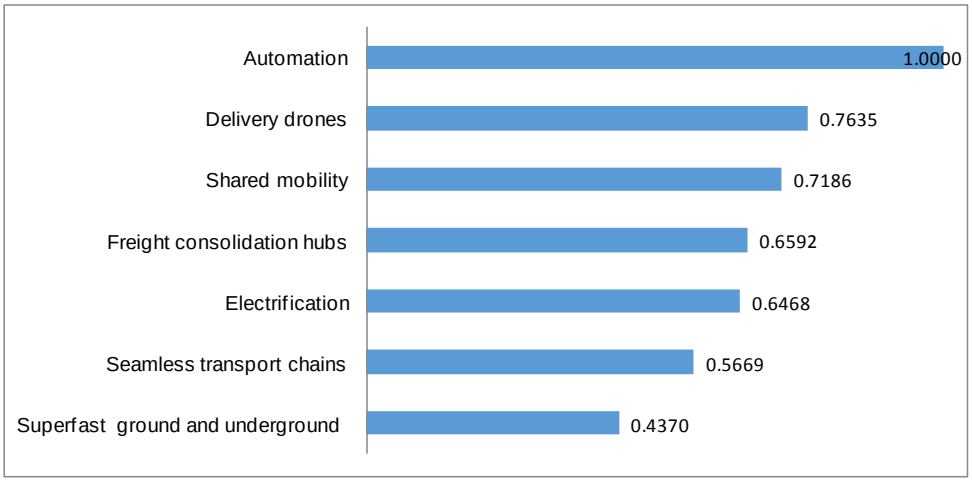


Figure 5.4 TCFF ideal

When it comes to elements influences within the group's megatrends, political imperatives and technological advances (Figures 5.5, and 5.6), all respondents estimate that the most important elements per groups are: *Changing lifestyle*, *Digitalization strategy/regulations /markets and Automation in freight transport.*

Significantly stands out the influence of the megatrends *Changing lifestyle*. The importance of this megatrend suggests that the change in the lifestyle generates new and in the transport of goods different demands for transportation, or different supply and demand. In contrast to them, the impact of megatrends *Bigger world economy* and *Ageing society* are with small impact.

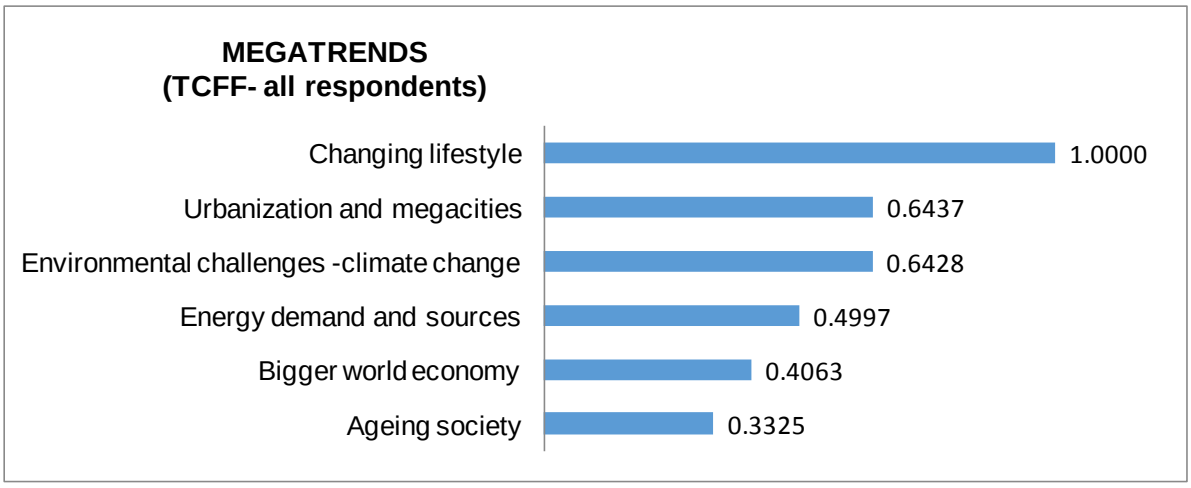


Figure 5.5 Megatrends ideal – freight transport

The merits of the political imperatives priorities (Figure 5.6) indicate that the first two political imperatives are very close to each other. It has been noted that there is the considerable difference between transportation advances according to the values of the priorities.

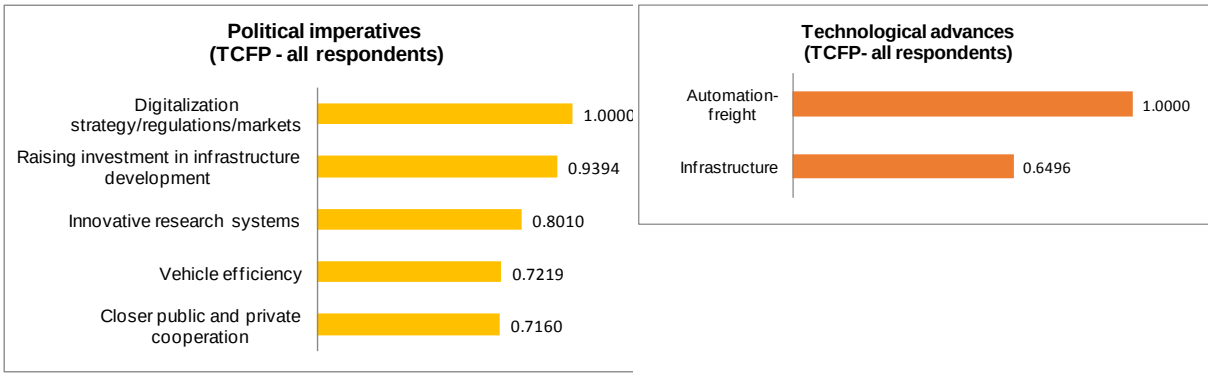


Figure 5.6 Political imperatives and technological advances ideal – freight transport

5.2.1 Results of the freight transport ANP network analysis by groups

The answer to the question of whether there are significant differences in the assessments among the groups of respondents was given using the same principles of analysis applied in the assessment validation by groups of respondents for TCFP.

In table 5.4 can be noted that all three groups of respondents compactly evaluated all three groups of outcomes (megatrends, political imperatives, and technology advances) and TCFFs accordingly. Although the representatives of different groups have evaluated the effects of megatrends, political imperatives and technological advances in the same way or similar, their evaluation was checked once again by observing the normalized values of priorities. It was noted that the normalized value of the impact follows the ranking of the elements or the calculated value of the priorities does not differ significantly so that the priorities and ranking are the results of the concise and comprehensive validation of all groups respondents.

The only significant difference is in ranking the transport concept of *Shared mobility*. *Shared mobility* encompasses several service models and basically are a concept that is mostly presented in passenger transportation. When it comes to freight transport, it is a business model that focuses on the supply side of goods to customers, which is accessed through a single "window." Representatives of policy-makers and industry ranked this concept lower than academics, which could be interpreted by the fact that new technologies and procedures for collected freight transport are only in the implementation phase.

The final order of the TCFPs by responders groups also shows no significant difference. In other words, in addition to the fact that they value the importance of megatrends, political imperatives and technological advances, respondents from different groups according to the same criteria are almost the same as TCPFs.

Table 5.4 TCFFs ranking and normalized priorities by all respondents and by groups

	ranking				Normalized by cluster			
FREIGHT TRANSPORTATION	overall	Academia	Policy makers	industry	overall	Academia	Policy makers	industry
TCFF								
Automation	1	1	1	2	0.2087	0.1581	0.2172	0.1962
Electrification	5	5	3	3	0.1350	0.1432	0.1296	0.1592
Seamless transport chains	6	6	5	5	0.1183	0.1370	0.1244	0.0974
Shared mobility	3	4	7	6	0.1500	0.1449	0.1203	0.0951
Superfast ground and underground transportation	7	7	6	7	0.0912	0.1137	0.1205	0.0771
Delivery drones	2	2	2	1	0.1593	0.1552	0.1248	0.2508
Freight consolidation hubs	4	3	2	4	0.1376	0.1480	0.1633	0.1242
Megatrends								
Bigger world economy	5	4	5	6	0.1153	0.1198	0.1079	0.1129
Ageing society	6	6	6	5	0.0943	0.0717	0.0669	0.1265
Changing lifestyle	1	1	2	1	0.2837	0.3221	0.2279	0.3073
Energy demand and sources	4	5	4	4	0.1418	0.1131	0.1618	0.1340
Environmental challenges -climate change	2	2	3	2	0.1824	0.2329	0.1687	0.1603
Urbanization and megacities	3	3	1	3	0.1826	0.1405	0.2668	0.1590
Political imperatives								
Digitalization strategy/regulations/markets	1	2	2	1	0.2393	0.1865	0.2121	0.2723
Raising investment in infrastructure development	2	1	1	2	0.2248	0.2747	0.2951	0.1923
Closer public and private cooperation	5	3	5	5	0.1714	0.1848	0.1514	0.1661
Innovative research systems	3	4	4	3	0.1917	0.1784	0.1657	0.1869
Vehicle efficiency	4	5	3	4	0.1728	0.1756	0.1757	0.1824
Technological advances								
Automation-freight transport	1	1	1	1	0.6062	0.6205	0.5525	0.6056
Infrastructure	2	2	2	2	0.3938	0.3795	0.4475	0.3944

6 Sensitivity analysis - Megatrends impact assessment

Chapter 5 specifies the priorities of transport concepts of the future while the impacts of megatrends are validated. This verification is relevant and implemented with a large number of responses from the academia, industry and policy-makers area. How much stable is the result of megatrend validation? How sensitive are the transport concepts of the future priorities to the changes of the megatrends importance?

The sensitivity analysis is conducted to understand how the priorities of the transport concepts of the future are robust and responding to the changes in megatrends, political imperatives and technological advances influence on the whole of the ANP network. In other words, the aim of the sensitivity analysis in ANP methodology is to predict how the different influences among the criteria[3] of the ANP model, affect on the priority of alternatives[4]. The row sensitivity method has been used because this method enabled us to preserve the ANP structure.

6.1 Results of the sensitivity analysis for ANP networks

The FTTE research team has developed a software solution that allows sensitivity analysis to all components in the ANP network. In other words sensitivity analysis was applied to explore how possible different influences (weightings) among elements in ANP passenger and freight model affect TCFs scores.

In this chapter are illustrated sensitivity and stability of the ANP model outcomes, the result of the estimation of all respondents, for passenger and freight transport with respect to megatrends.

Sensitivity analysis is used to show the impact of changing the importance of **one megatrend** to the priority of transport concepts - the direct impact of megatrend (line charts). The FTTE software solution registers the points of the TCF ranking change with the change of the megatrends priorities (dots in cross-check of two lines). The change of the impact of all megatrends is shown on the spyder graphs that defines the stability of the first-ranked TCF solution. The space of the stability of the results (outcomes) is marked with transparent light green, and it indicates the stability of the best ranking TCF.

The scientific base for sensitivity analysis is:

1) Numerical size of the change of each megatrend is controlled by the parameter value (p). Parameter value varies from 0 to 1. The scale factor for the parameter value is set to 0.01.
2) The starting point for the changes begins with the limited super matrix. The parameter value is set to 0.5 (p_0=0.5) at the starting point, and it corresponds to the limited super matrix and weighted super matrix calculated from PCMs. It means that priority vectors calculated from the PCMs determine initial ratios of local priorities between elements. From p_0 changes can go lower to the value of 0 or upper to the value of 1. If parameter values go below 0.5 it will point out that importance of element, for which sensitivity

[3] Criteria in developed ANP models are megatrends, political imperatives and technological advances
[4] Alternatives are transport concepts of the future

analysis is being done, drop down, ie its priority decreases. If the parameter value goes over 0.5, the priority of element rises accordingly. Boundary values of 0 and 1 for the parameter value mean that element priorities tend to 0 and 1 respectively (Saaty, 2001). In this deliverable, only parameter values that are higher than 0.5 are considered.

The example of the sensitivity of TCFFs with respect to *Environmental Challenges – climate change* for the passenger and freight transportation is given in Figure 6.1 and 6.2. The sensitivity of TCFFs with respect to other megatrends is provided in Annex 2.

The Figures 6.1 and 6.2 illustrate graphically modifications of normalized scores of TCFF (synthesized priorities) with the change of priority of *Environmental challenges – climate cha*nge megatrend. Normalized TCFFs scores are displayed with the solid lines as a function of the parameter value.

By changing the local priorities, global priorities change too. Thus, solid lines in the Figure represent limited matrices for any parameter value between 0 and 1. In practice, every solid line is an indicator of changes in synthesized priorities with the change of local priorities for each element that goes up ($p \rightarrow 0$) or go down ($p \rightarrow 1$). It is called “node sensitivity” (Adams, 2014).

As can be seen in Figure 6.1. changes of megatrend *Environmental changes - climate change* importance is most reflected in the change of the *Personal air transportation* concept and *Smart use of travel time.* In the first case, we can say that the impact of the megatrend is direct and positive so that it quickly leads to a change in the *Personal air transportation* rank and it becomes the best ranked TCFP. In the case of TCFP *Smart use of travel time*, the impact of the megatrend is such that it loses its position and falls to the last position from the sixth place.

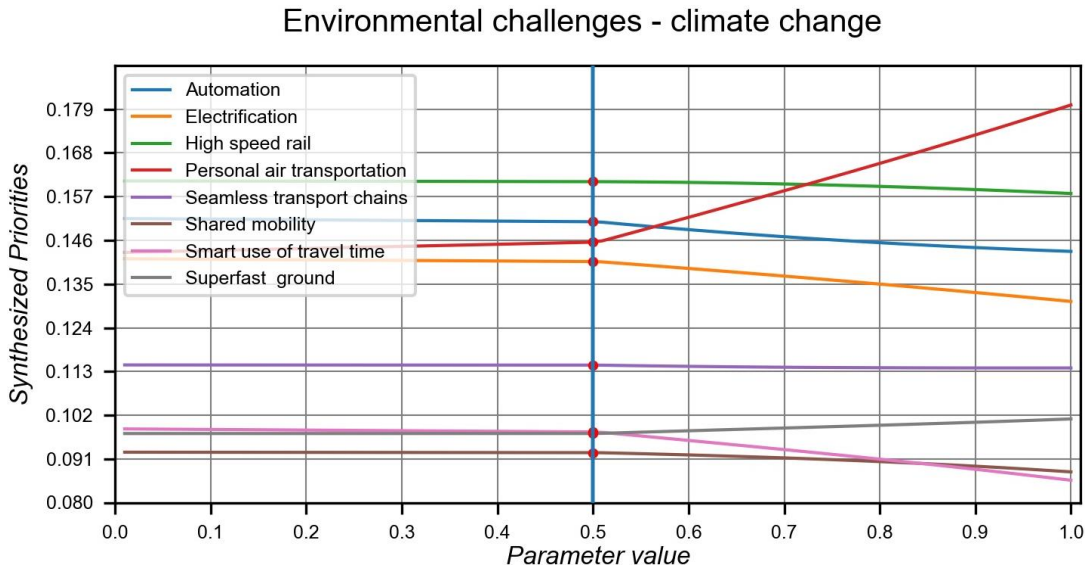


Figure 6.1 Modifications of TCFPs scores with respect to *Environmental challenges – climate change* megatrend priority changing for passenger transport

As can be noted from Figure 6.2, the initial rank of TCFFs obtained after the evaluation of all respondents is changed with the increase of the *Environmental challenges – climate change* megatrend impact. There are eight changes in the ranking of TCFFs. The rise of megatrend impact has mostly affected TCFFs *Shared mobility* and *Electrification*. *Share mobility* in the final

ranking moves from the third place to the last position, and Electrification from the fifth place moves to the first position. Therefore, it can be expected that with the increase of the *Environmental challenges - climate change* megatrend impact *Electrification*, a concept that characterizes the use of clean energy sources and environmental protection, will continue to penetrate each market at a different pace. Hence, at the same time, the stability of the position of the first-ranked *Automation* is only endangered when megatrend *Environmental challenges - climate change* are valued in a society with a value 0.8615.

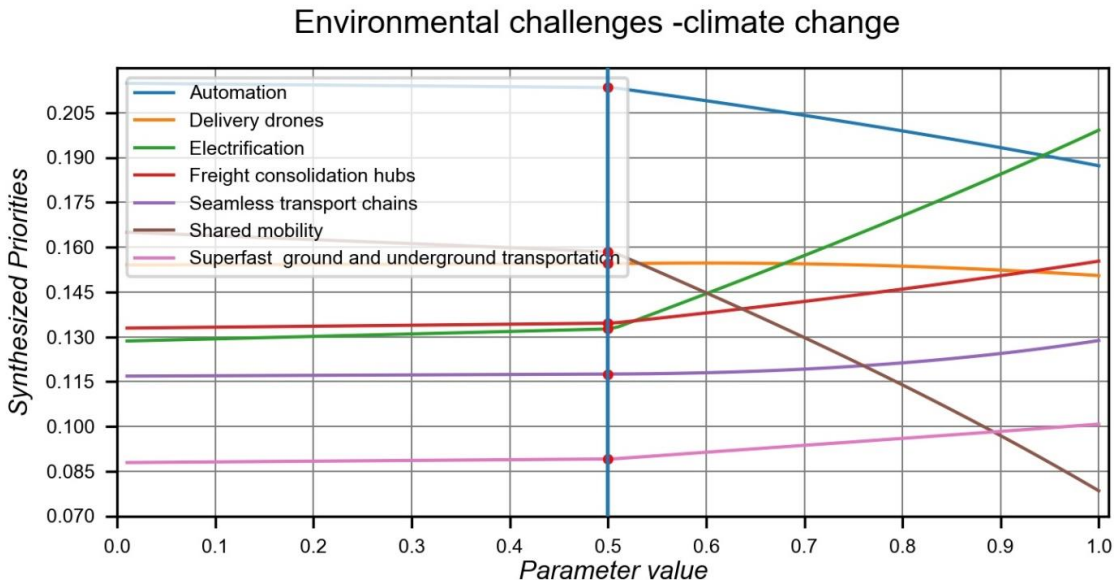


Figure 6.2 Modifications of TCFFs scores with respect to *Environmental challenges – climate change* megatrend priority changing for freight transport

The impact of **all megatrends** is illustrated on the spider graphs that defines the stability of the best ranked TCF score. From the outcomes data set is used megatrends limited value and upper value is obtained by using a developed software for passenger and freight transport (Table 6.1 and Table 6.2).

Spider chart is used for seeing how much the change of importance of a given megatrend cause a change in the first ranking TCF. Each megatrend is provided with the axis, and the same scale is between all axis. Each megatrend limited and upper value is shown along with its own axis. Megatrends limited value are connected together and form one polygon (red color), and connected upper values form another polygon (light green color).

In the Figure 6.3. red color polygon illustrates the impacts of the megatrends on the TCFPs ranking. The light green color polygon represents the upper values of the megatrends at the moment when the best-ranking TCFP change its rank. For the outcomes for the passenger transport, megatrends Ageing *society* and *Environmental challenges-climate change* impact on the ranking of the *High-speed train*. The small change of the priority value for the *Changing lifestyle*, *Energy demand and sources* and *Urbanization and megacities* do not lead to the changes of the best-ranking TCFP. The space outside the cross-section of the two polygons represents the instability of the outcomes.

Table 6.1 Limited and upper values of Megatrends priority for the first-ranked TCFP

PASSANGER TRANSPORT	Priority							
	Overall		Policy makers		Academia		Industry	
Megatrends	Limited	Upper	Limited	Upper	Limited	Upper	Limited	Upper
Ageing society	0.0198	0.5511	0.0289	0.0289	0.0183	0.2804	0.0109	0.2354
Changing lifestyle	0.0841	0.0841	0.0793	0.0793	0.0907	0.4926	0.0631	0.1247
Energy demand and sources	0.0452	0.0452	0.0522	0.0522	0.0477	0.4245	0.0383	0.5919
Environmental challenges -climate change	0.0684	0.4505	0.0576	0.6719	0.0773	0.0773	0.0531	0.0981
Urbanization and megacities	0.0222	0.0222	0.0276	0.6309	0.0246	0.2636	0.0110	0.0110
The first-ranked TCF	High speed train		Automation		High speed train		Automation	

Table 6.2 Limited and upper values of Megatrends priority for the first-ranked TCFF

FREIGHT TRANSPORT	Priority							
	Overall		Policy makers		Academia		Industry	
Megatrends	Limited	Upper	Limited	Upper	Limited	Upper	Limited	Upper
Ageing society	0.0298	0.0264	0.0249	0.0326	0.0168	0.6267	0.0417	0.6884
Bigger world economy	0.0364	0.0403	0.0401	0.4870	0.0281	0.0567	0.0373	0.0423
Changing lifestyle	0.0896	0.5255	0.0847	0.2342	0.0755	0.3455	0.1014	0.8067
Energy demand and sources	0.0448	0.8043	0.0602	0.2946	0.0265	0.0538	0.0442	0.4052
Environmental challenges -climate change	0.0576	0.8615	0.0628	0.5595	0.0546	0.2437	0.0529	0.7469
Urbanization and megacities	0.0576	0.0565	0.0992	0.1705	0.0329	0.0612	0.0525	0.1590
The first-ranked TCF	Automation		Automation		Automation		Delivery dron	

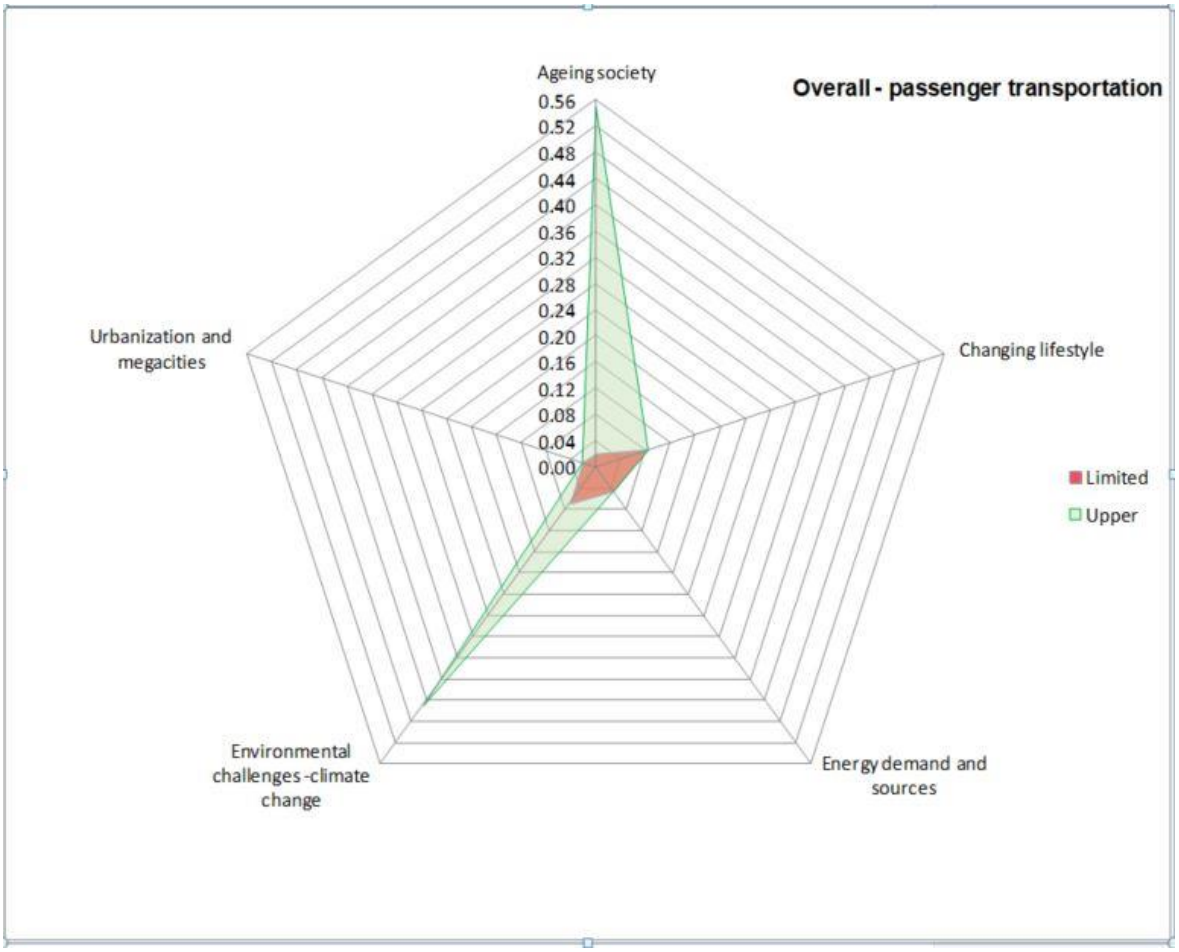


Figure 6.3 The impact of the megatrends on the best-ranking TCFP (High-speed train)

In Figure 6.4 is presented the impact of the megatrends on the TCFFs ranking. Red color polygon illustrates the impacts of the megatrends on the TCFFs ranking. The light green color polygon represents the upper values of the megatrends at the moment when the best-ranking TCFF change its rank. Outcomes for the freight transport, megatrends priorities for *Changing lifestyle*, *Energy demands and sources* and *Environmental challenges-climate change* impact on the ranking of the *Automation transport concept of the future*. In the long-term Automation will have a revolutionary impact on travel behavior that is confirmed with a high ranking influence on Changing lifestyle and the robustness of the solution. The small change of the priority value for the *Ageing society*, *Bigger world economy,* and *Urbanization and megacities* do not lead to the changes of the best-ranking TCFP. The space outside the cross-section of the two polygons represents the instability of the outcomes.

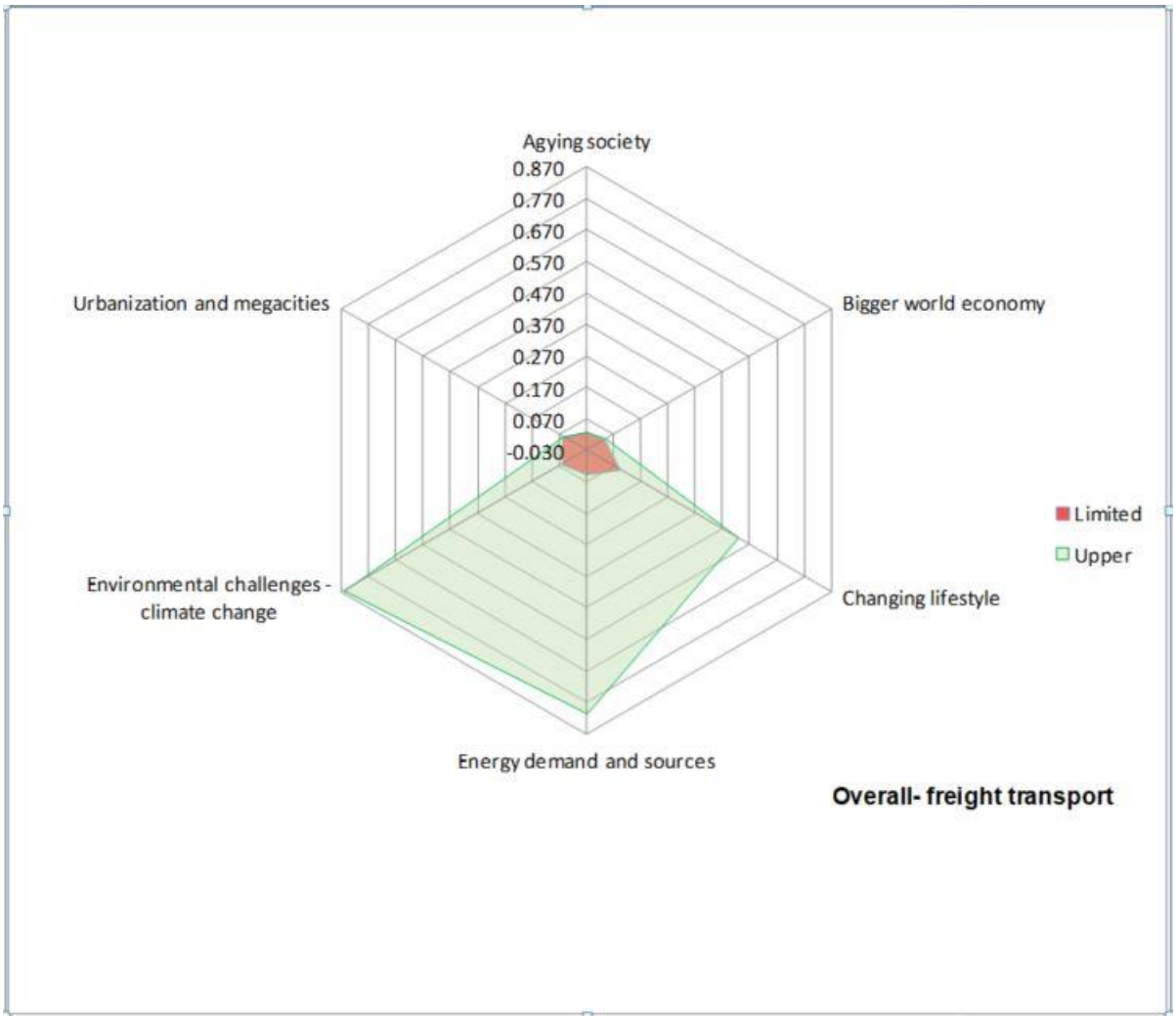


Figure 6.4 The impact of the megatrends on the best-ranking TCFF (Automation)

7 Conclusion

The research in this Deliverable was aimed to point out the key TCFs and what are the most influential megatrends and how they impact on the TCFs. The ANP (Analytic Network Process) methodology was applied. The basis of this methodology is that the results are obtained through the perception of experts belonging to different interest groups. The ANP method prevents the inconsistency of the experts during the validation process.

The perception of experts towards transport concepts of the future and megatrends validation and impact assessment is recorded based on the data collected via the INTEND survey session.

The INTEND survey session, in which ninety representatives from three different groups (academia, policy making, and industry) participated, helped to structure the ANP model, and to perform the pairwise assessment of elements while pointing out the megatrends, political imperatives, and technological advances impact on the priority of key transport concepts of the future. The pairwise comparison combined with an impartial attitude of the respondents from the different group implies that an estimation of megatrends impact on a TCFs is the equal treated or similar without any difference.

The results of the megatrends validation and their effect in the passenger transport have shown that for all interest groups the key megatrends are *Changing lifestyle* and *Environmental challenges - climate changes*, and then *Energy demand and sources*, *Urbanization and megacities* and finally *Ageing society*.

For freight transport research has shown that the most influential megatrends for all interest groups are also *Changing lifestyle* and *Environmental challenges - climate changes.* The following megatrends have a slightly less impact: *Urbanization and megacities, Energy demand and sources*, Bigg world economy and finally *Ageing society*.

The research emphasized that the key TCFPs in passenger transport for all interest groups will be: *High-speed rail*, *Personal air transportation*, *Automation*, *Electrification*, *Super fast ground*, *Seamless transport chain*s, *Smart use of travel time* and *Shared mobility*. By analyzing TCFPs validation values, it can be noticed that the dominant TCFPs are: *High-speed trains* and *Automation.*

When it comes to freight transport, the key TCFFs in freight transport for all interest groups are *Automation*, Delivery drones, *Shared mobility, Freight consolidation hubs, Electrification*, *Seamless transport chains and Superfast ground and underground transportation*. By analyzing TCFFs validation values, it can be noticed that the dominant TCFFs are: *Automation and Delivery drones.*

Looking at the similarities and differences between the results obtained for passenger and freight transport, it can be noticed that TCF *Automation* that is not only first ranked but also such as evaluated to make a significant difference over other TCF. This raises the question of what are the reasons for such a perception of the interest groups (academia, industry, and policy-makers)? The answer might lie with the fact that key megatrends for freight transport *Changing lifestyle* and *Environmental changes – climate change* and *Urbanization and megacities* are closely linked to *Digitalization strategy/regulations /markets* as key political imperatives and Automation freight transport as the first technological advances. All of these

elements are in close interconnection so that it is not possible to clearly determine what the cause is and what is the consequence and to what extent this relationship is. Actually (really) relations Automation-Changing lifestyle-Urbanization-Digitalisation-Automatization freight transport represent one loop or circle in which one another stimulates, causes, and in multiplication cooperate.

Similar to passenger transport. If we look at influential megatrends, political imperatives and technological advances in general, once again it is confirmed that the environment in which decisions are made about transport concepts of the future and priorities are to be followed by changes in lifestyle. So the political imperatives and technological advances affect the lifestyle change. Changing Lifestyle as a megatrend represent the acceptance of the key/new advances and imperatives. Today's transport concepts are the result of the improvement of existing transport concepts. In order to accept the transport concept of the future, we have to shorten the path from the innovations to the fact that they are noticed in our lives.

Also, in most cases, representatives of policy-makers and industry, evaluate Superfast ground as the latest transport concept of the future for passenger transport, consider that, when deciding on the priorities for future research, it is still far at this moment to be a future.

The sensitivity analysis illustrated that the most influential megatrends for passenger transport and for freight transport as well are: *Energy demand and sources* and *Urbanization and megacities*. Bearing in mind stability of the ANP model outcomes *Energy demand and sources megatrend* is the megatrend with the biggest influence on best ranking TCFs priorities.

This deliverable has, nevertheless, created a sufficient and comprehensive validation and impact assessment of megatrends which will be a valuable source for further analyses under D4.3.

A last but not at least the INTEND will develop an online platform, INTEND Synopsis tool, where the result of megatrends validation and impact assessment by the implementation of the ANP networks will be graphically presented. This will provide visualization of the ANP and sensitivity analysis results.

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9 ANNEX 1 - ANP results by different interest groups evaluation

In this annex is given outcomes from the different groups estimation of the ANP model for passenger and freight transport.

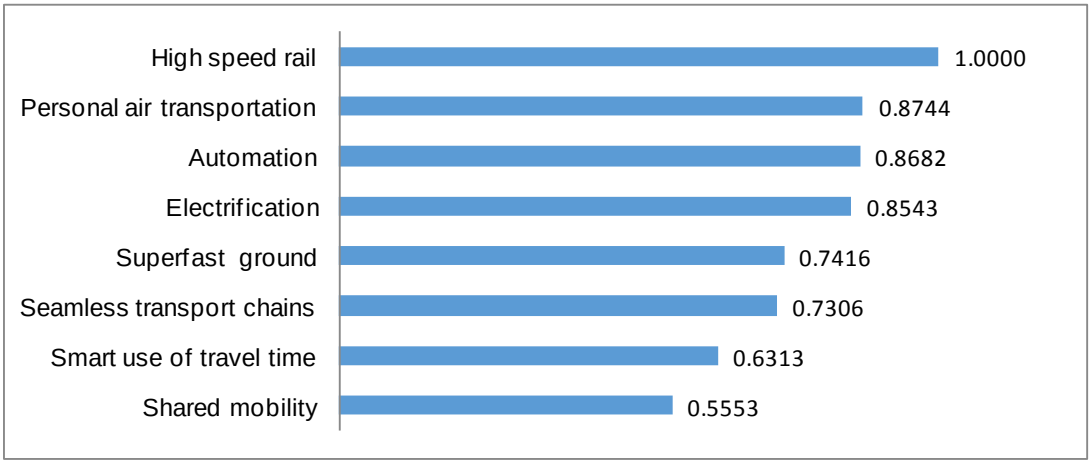
PASSENGER TRANSPORT

ACADEMIA

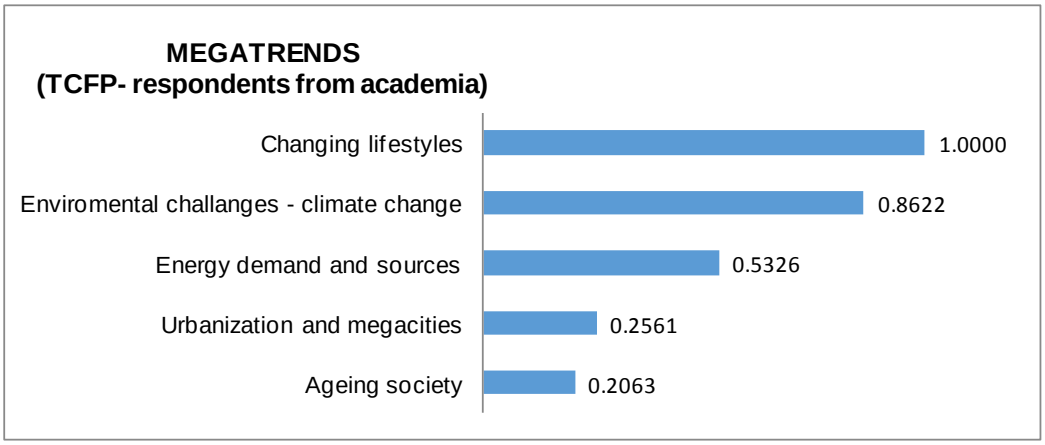
The elements with their priorities and ranking for passenger transport by respondent from academia

Academia group	Priority for Passenger transportation			
Elements	Ranking	Ideals	Normalized By Cluster	Score
Automation	3	0.8682	0.1388	0.0459
Electrification	4	0.8543	0.1366	0.0451
High speed rail	1	1.0000	0.1599	0.0528
Personal air transportation	2	0.8744	0.1398	0.0462
Seamless transport chains	6	0.7306	0.1168	0.0386
Shared mobility	8	0.5553	0.0888	0.0293
Smart use of travel time	7	0.6313	0.1009	0.0334
Superfast ground	5	0.7416	0.1186	0.0392
Ageing society	5	0.2063	0.0722	0.0188
Changing lifestyles	1	1.0000	0.3500	0.0911
Energy demand and sources	3	0.5326	0.1864	0.0485
Environmental challenges - climate change	2	0.8622	0.3018	0.0786
Urbanization and megacities	4	0.2561	0.0896	0.0233
Closer public and private cooperation	1	1.0000	0.2342	0.0454
Increasing connectivity, intermodal access and fit-for-purpose network standards	2	0.9952	0.2331	0.0452
Innovative research system	5	0.5780	0.1354	0.0263
Supporting modal shift	4	0.7856	0.1840	0.0357
Vehicle efficiency	3	0.9106	0.2133	0.0414
Automation- passenger	3	0.5857	0.2432	0.0523
Electrified vehicles/vessels	1	1.0000	0.4151	0.0893
Infrastructure	2	0.8231	0.3417	0.0735

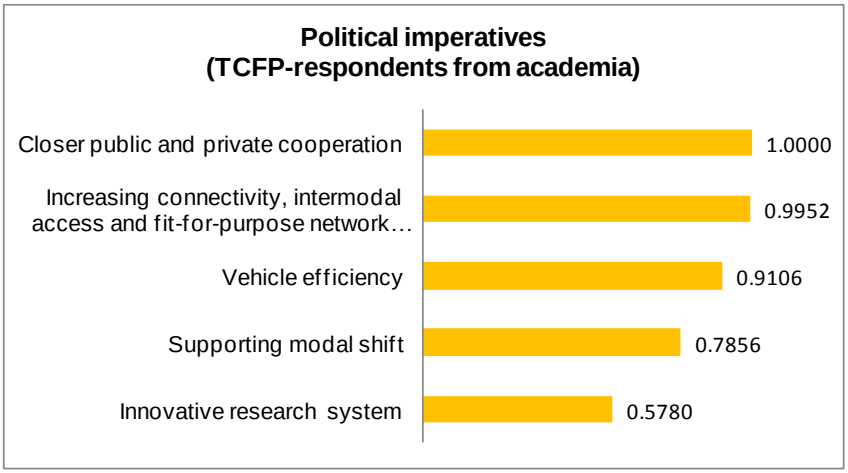
TCFP priorities by respondents from academia

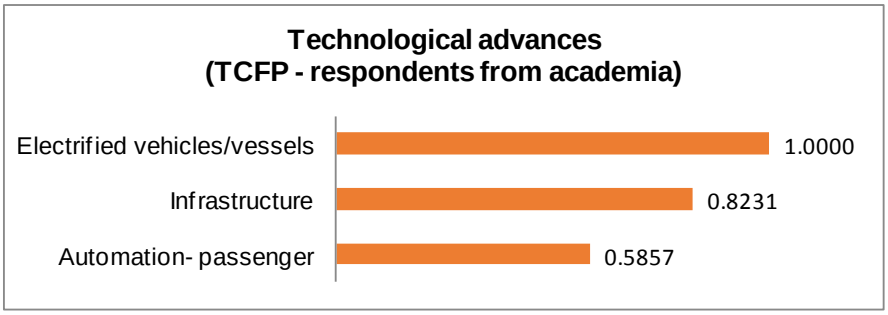


Megatrend priorities by respondents from academia



Political imperatives and technological advances priorities by respondents from academia



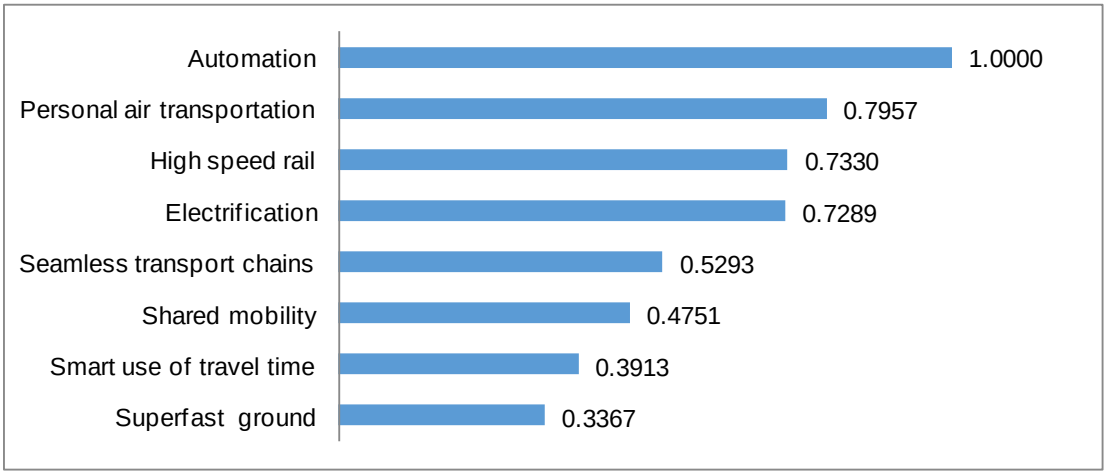


POLICY-MAKERS

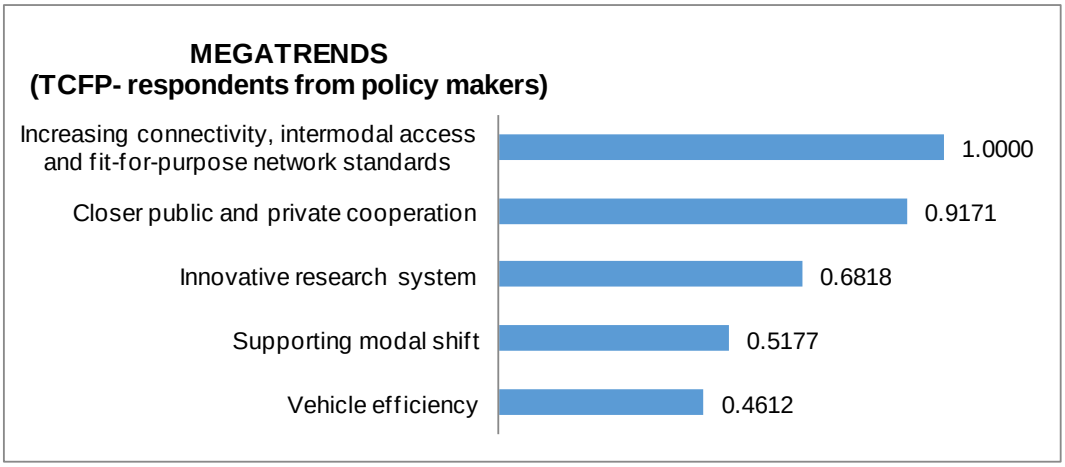
The elements with their priorities and ranking for passenger transport by respondent from policy-makers

Policy makers group	Priority for Passenger transportation			
Elements	Ranking	Ideals	Normalized By Cluster	Score
Automation	1	1.0000	0.2004	0.0772
Electrification	4	0.7289	0.1461	0.0563
High speed rail	3	0.7330	0.1469	0.0566
Personal air transportation	2	0.7957	0.1595	0.0615
Seamless transport chains	5	0.5293	0.1061	0.0409
Shared mobility	6	0.4751	0.0952	0.0367
Smart use of travel time	7	0.3913	0.0784	0.0302
Superfast ground	8	0.3367	0.0675	0.0260
Ageing society	4	0.3936	0.1256	0.0314
Changing lifestyles	1	1.0000	0.3190	0.0799
Energy demand and sources	3	0.6693	0.2135	0.0534
Environmental challenges - climate change	2	0.7457	0.2379	0.0595
Urbanization and megacities	5	0.3259	0.1040	0.0260
Closer public and private cooperation	2	0.9171	0.2563	0.0302
Increasing connectivity, intermodal access and fit-for-purpose network standards	1	1.0000	0.2795	0.0330
Innovative research system	3	0.6818	0.1906	0.0225
Supporting modal shift	4	0.5177	0.1447	0.0171
Vehicle efficiency	5	0.4612	0.1289	0.0152
Automation- passenger transport	3	0.5708	0.2348	0.0578
Electrified vehicles/vessels	1	1.0000	0.4113	0.1013
Infrastructure	2	0.8604	0.3539	0.0872

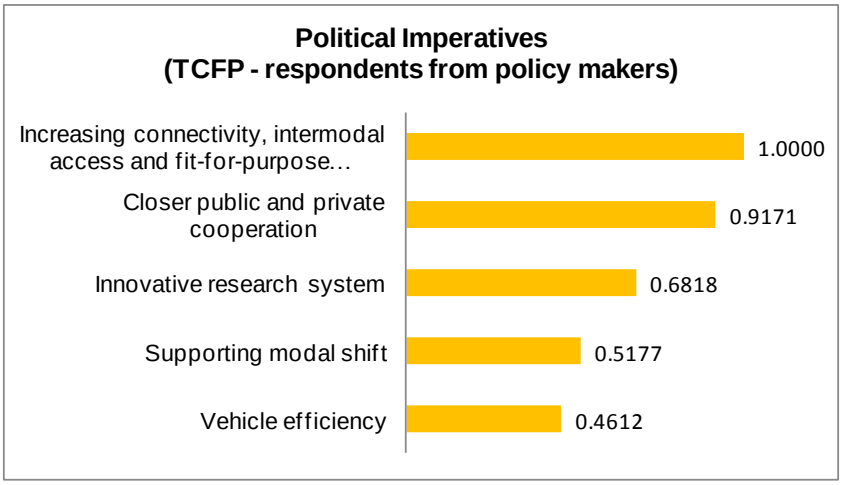
***TCFP priorities by respondents from* policy-makers**

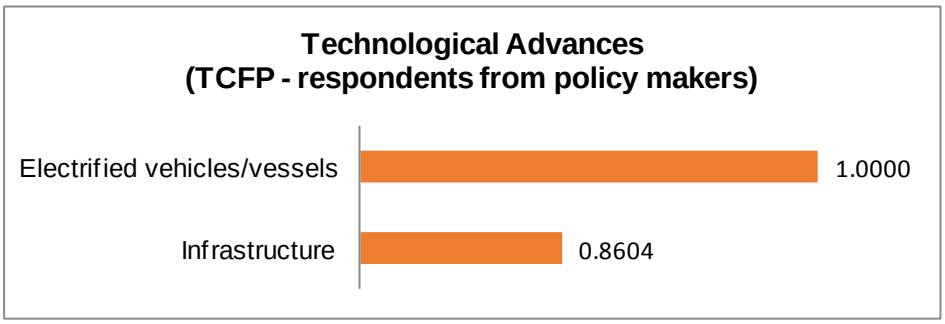


Megatrends priorities by respondents from policy-makers



Political imperatives and technological advances priorities by respondents from policy-makers



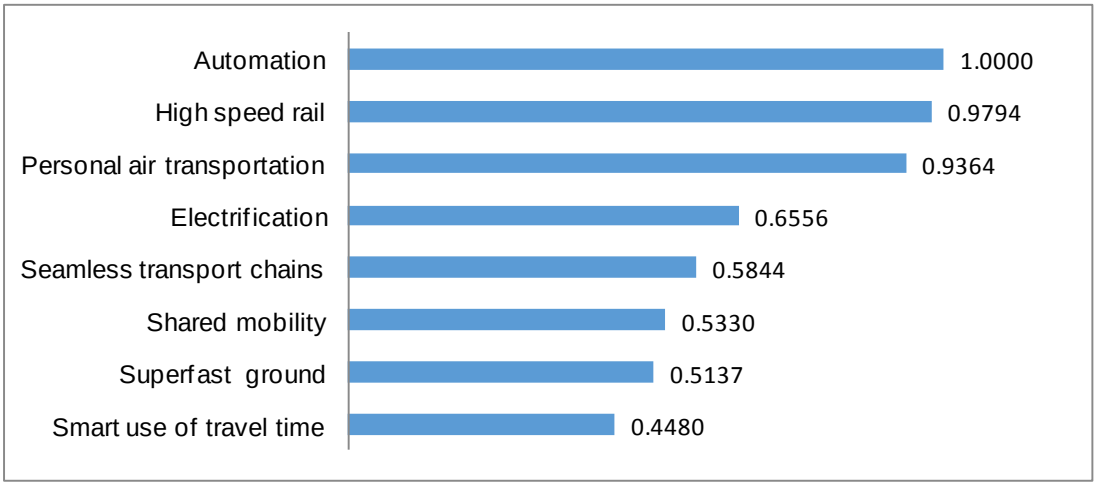


INDUSTRY

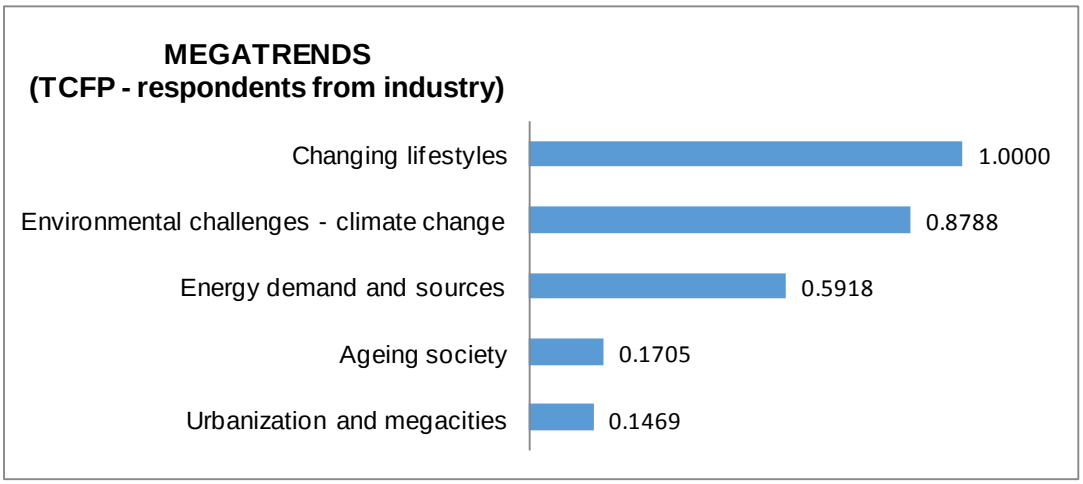
The elements with their priorities and ranking for passenger transport by respondent from industry

Industry group	Priority for Passenger transportation			
Elements	Ranking	Ideals	Normalized By Cluster	Score
Automation	1	1.0000	0.1770	0.0617
Electrification	4	0.6556	0.1160	0.0404
High speed rail	2	0.9794	0.1733	0.0604
Personal air transportation	3	0.9364	0.1657	0.0577
Seamless transport chains	5	0.5844	0.1034	0.0360
Shared mobility	6	0.5330	0.0943	0.0329
Smart use of travel time	8	0.4480	0.0793	0.0276
Superfast ground	7	0.5137	0.0909	0.0317
Ageing society	4	0.1705	0.0612	0.0111
Changing lifestyles	1	1.0000	0.3587	0.0654
Energy demand and sources	3	0.5918	0.2123	0.0387
Environmental challenges - climate change	2	0.8788	0.3152	0.0574
Urbanization and megacities	5	0.1469	0.0527	0.0096
Closer public and private cooperation	1	1.0000	0.2887	0.0695
Increasing connectivity, intermodal access and fit-for-purpose network standards	2	0.8243	0.2380	0.0573
Innovative research system	3	0.6775	0.1956	0.0471
Supporting modal shift	5	0.4798	0.1385	0.0334
Vehicle efficiency	4	0.4820	0.1392	0.0335
Automation- passenger transport	3	0.6805	0.2751	0.0629
Electrified vehicles/vessels	1	1.0000	0.4043	0.0925
Infrastructure	2	0.7930	0.3206	0.0733

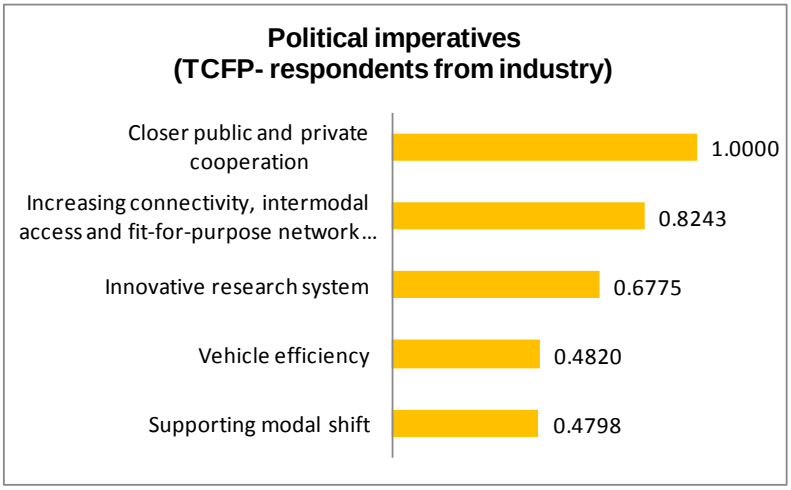
TCFP priorities by respondents from industry

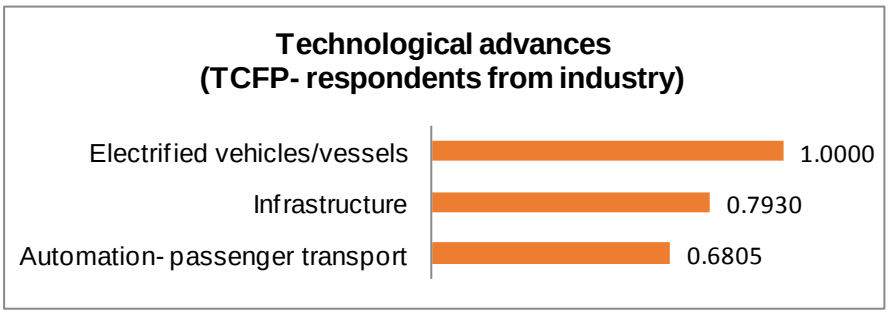


Megatrends priorities by respondents from industry



Political imperatives and technological advances priorities by respondents from industry





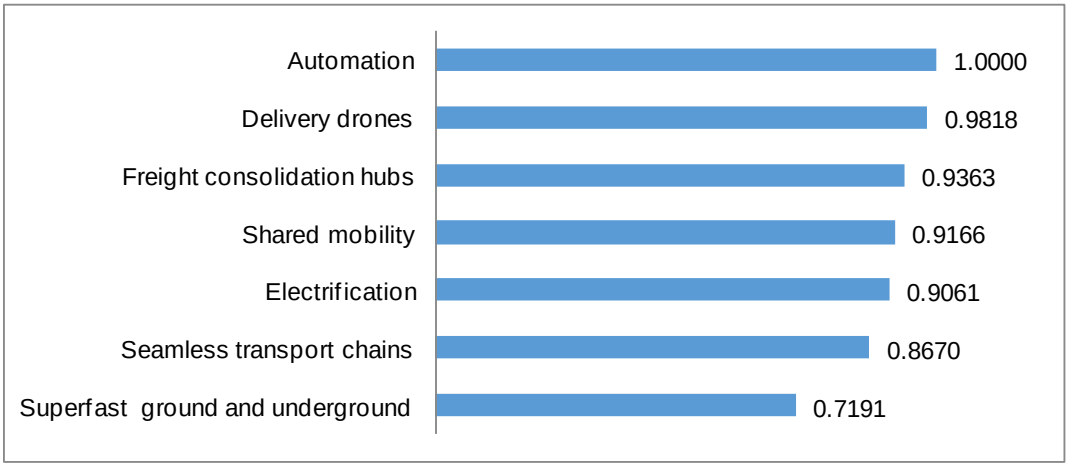
FREIGHT TRANSPORT

ACADEMIA

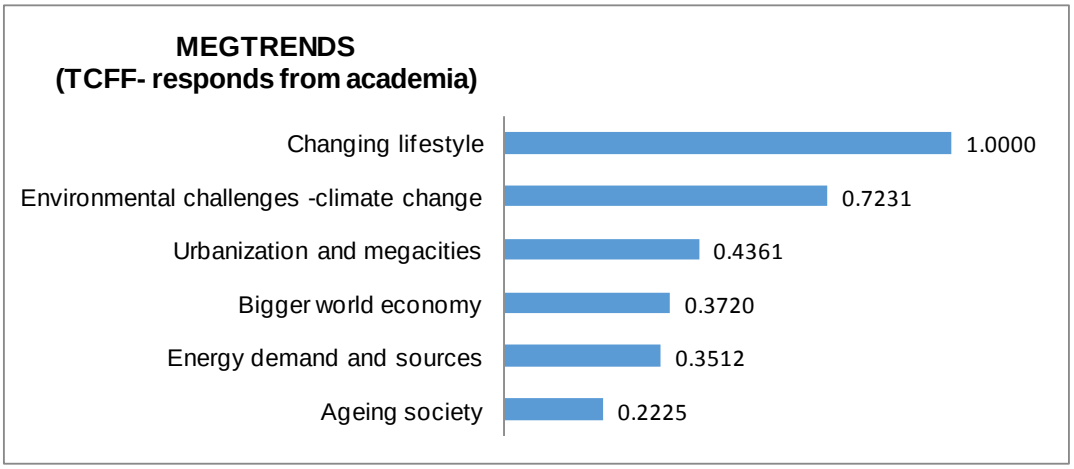
The elements with their priorities and ranking for freight transport by respondents from academia

Academia group	Priority for Freight transportation			
Elements	Ranking	Ideals	Normalized By Cluster	Score
Automation	1	1.0000	0.1581	0.0600
Delivery drones	2	0.9818	0.1552	0.0589
Electrification	5	0.9061	0.1432	0.0544
Freight consolidation hubs	3	0.9363	0.1480	0.0562
Seamless transport chains	6	0.8670	0.1370	0.0520
Shared mobility	4	0.9166	0.1449	0.0550
Superfast ground and underground	7	0.7191	0.1137	0.0431
Ageing society	6	0.2225	0.0717	0.0168
Bigger world economy	4	0.3720	0.1198	0.0281
Changing lifestyle	1	1.0000	0.3221	0.0755
Energy demand and sources	5	0.3512	0.1131	0.0265
Environmental challenges -climate change	2	0.7231	0.2329	0.0546
Urbanization and megacities	3	0.4361	0.1405	0.0329
Closer public and private cooperation	3	0.6725	0.1848	0.0501
Digitalization strategy/regulations/markets	2	0.6789	0.1865	0.0505
Innovative research systems	4	0.6492	0.1784	0.0483
Raising investment in infrastructure development	1	1.0000	0.2747	0.0744
Vehicle efficiency	5	0.6393	0.1756	0.0476
Automation-freight transportation	1	1.0000	0.6205	0.0714
Infrastructure	2	0.6117	0.3795	0.0437

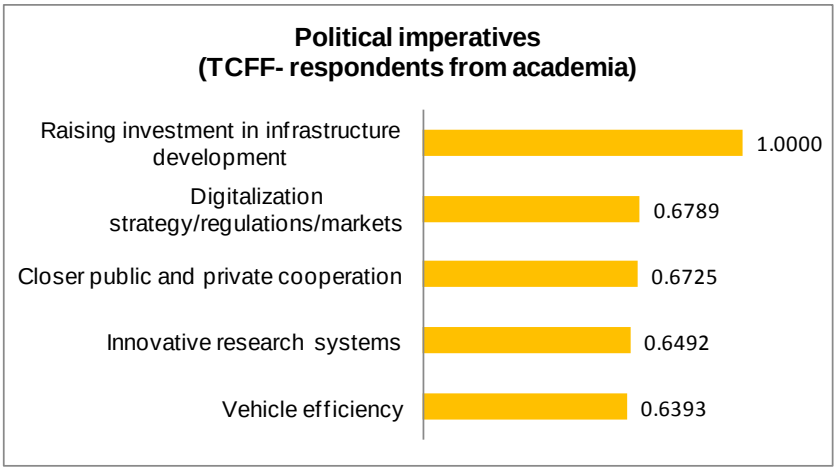
TCFF priorities by respondents from academia

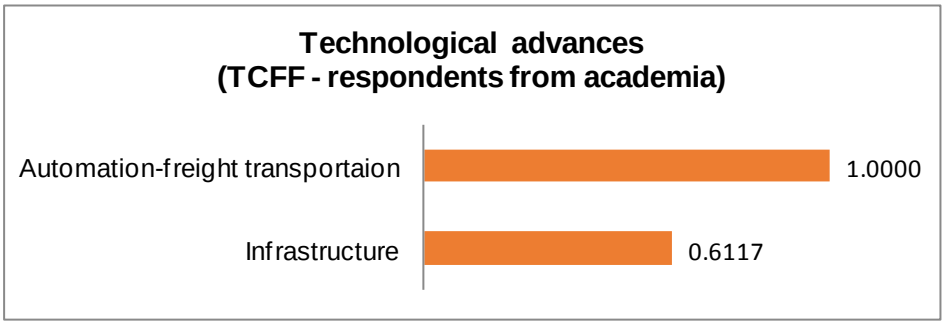


Megatrends priorities by respondents from academia



Political imperatives and technological advances priorities by respondents from academia



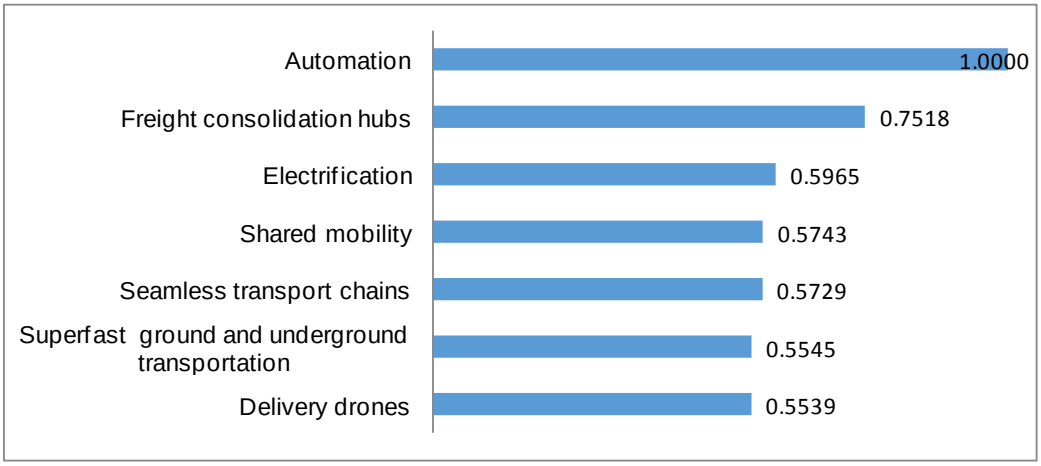


POLICY-MAKERS

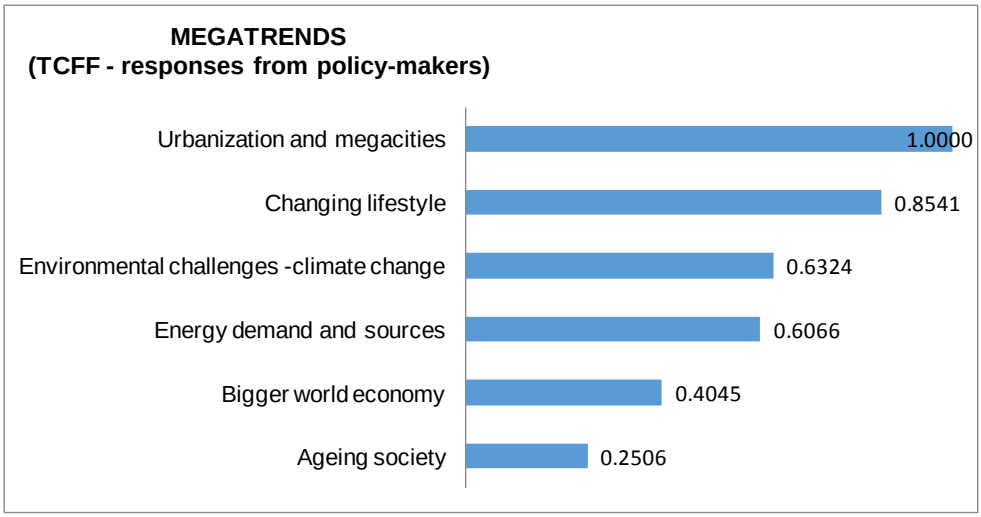
The elements with their priorities and ranking for freight transport by respondents from s

Policy-makers group	Priority for Freight transportation			
Elements	Ranking	Ideals	Normalized By Cluster	Score
Automation	1	1.0000	0.2172	0.0456
Delivery drones	7	0.5539	0.1203	0.0253
Electrification	3	0.5965	0.1296	0.0272
Freight consolidation hubs	2	0.7518	0.1633	0.0343
Seamless transport chains	5	0.5729	0.1244	0.0261
Shared mobility	4	0.5743	0.1248	0.0262
Superfast ground and underground transportation	6	0.5545	0.1205	0.0253
Ageing society	6	0.2506	0.0669	0.0249
Bigger world economy	5	0.4045	0.1079	0.0401
Changing lifestyle	2	0.8541	0.2279	0.0847
Energy demand and sources	4	0.6066	0.1618	0.0602
Environmental challenges -climate change	3	0.6324	0.1687	0.0628
Urbanization and megacities	1	1.0000	0.2668	0.0992
Closer public and private cooperation	5	0.5131	0.1514	0.0247
Digitalization strategy/regulations/markets	2	0.7189	0.2121	0.0347
Innovative research systems	4	0.5615	0.1657	0.0271
Raising investment in infrastructure development	1	1.0000	0.2951	0.0482
Vehicle efficiency	3	0.5956	0.1757	0.0287
Automation-freight	1	1.0000	0.5525	0.1408
Infrastructure	2	0.8101	0.4475	0.1141

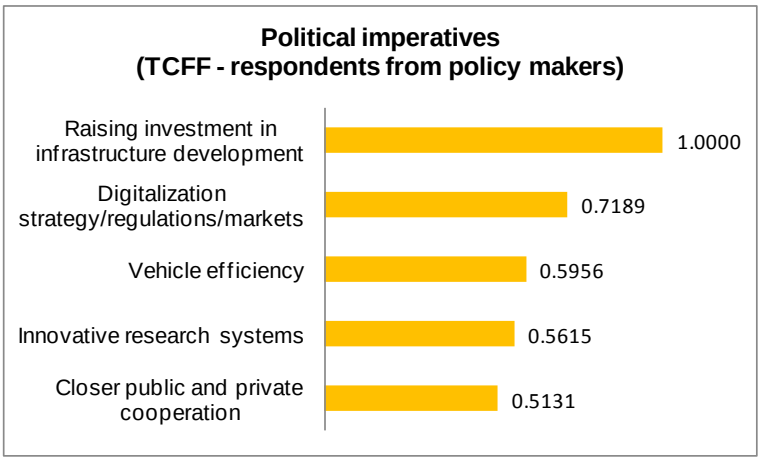
TCFF priorities by respondents from policy-makers

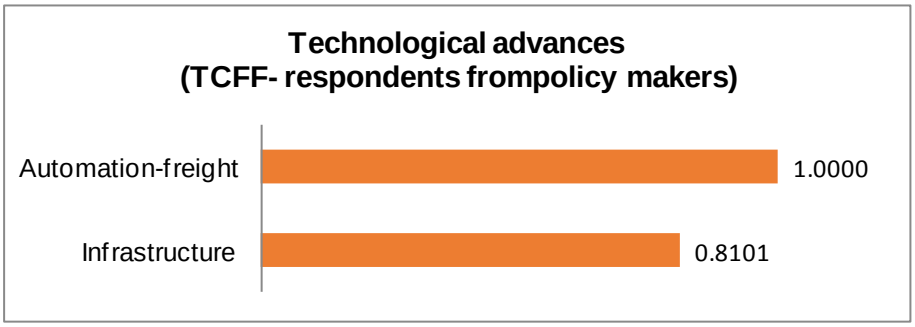


Megatrends priorities by respondents from policy-makers



Political imperatives and technological advances priorities by respondents from policy-makers



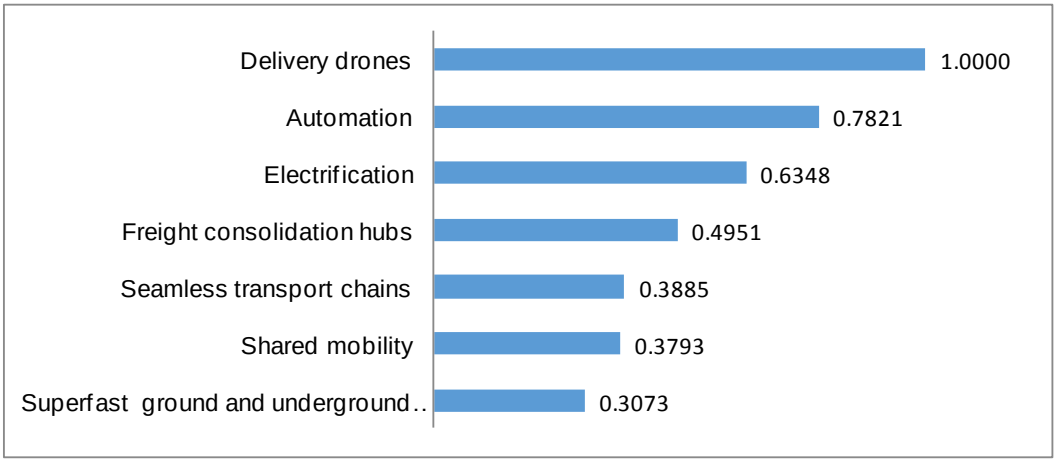


INDUSTRY

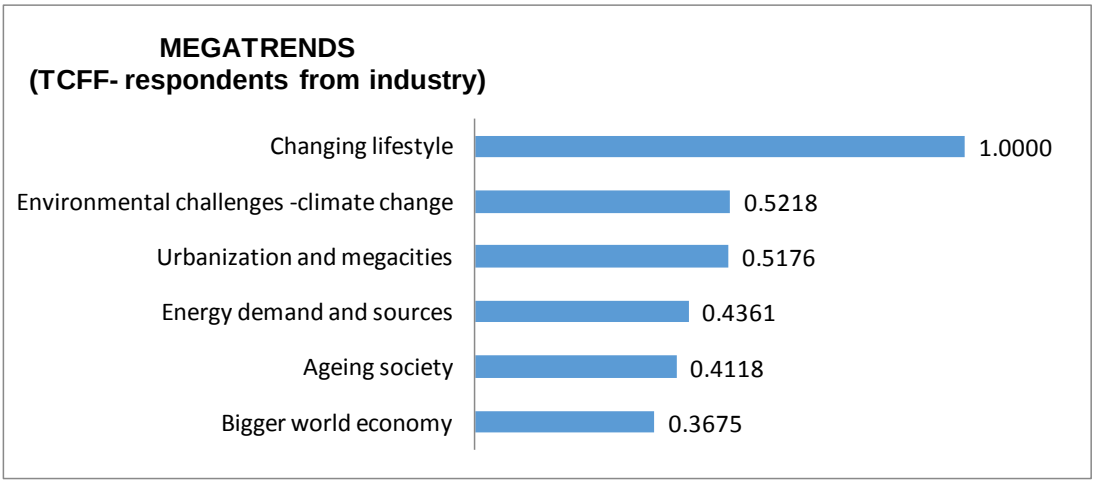
The elements with their priorities and ranking for freight transport by respondents from industry

Industry group	Priority for Freight transportation			
Elements	Ranking	Ideals	Normalized By Cluster	Score
Automation	2	0.7821	0.1962	0.0808
Delivery drones	1	1.0000	0.2508	0.1033
Electrification	3	0.6348	0.1592	0.0655
Freight consolidation hubs	4	0.4951	0.1242	0.0511
Seamless transport chains	5	0.3885	0.0974	0.0401
Shared mobility	6	0.3793	0.0951	0.0392
Superfast ground and underground transportation	7	0.3073	0.0771	0.0317
Ageing society	5	0.4118	0.1265	0.0417
Bigger world economy	6	0.3675	0.1129	0.0373
Changing lifestyle	1	1.0000	0.3073	0.1014
Energy demand and sources	4	0.4361	0.1340	0.0442
Environmental challenges -climate change	2	0.5218	0.1603	0.0529
Urbanization and megacities	3	0.5176	0.1590	0.0525
Closer public and private cooperation	5	0.6101	0.1661	0.0250
Digitalization strategy/regulations/markets	1	1.0000	0.2723	0.0410
Innovative research systems	3	0.6866	0.1869	0.0281
Raising investment in infrastructure development	2	0.7063	0.1923	0.0289
Vehicle efficiency	4	0.6700	0.1824	0.0275
Automation-freight transportation	1	1.0000	0.6056	0.0653
Infrastructure	2	0.6513	0.3944	0.0426

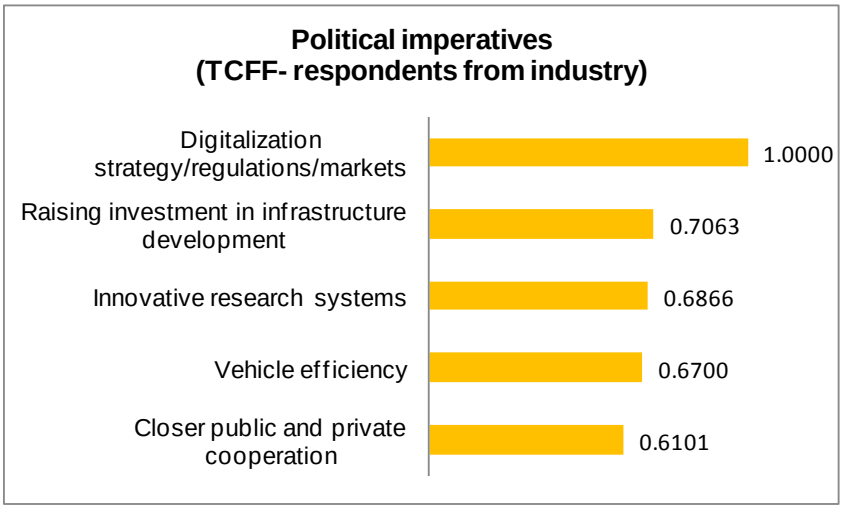
TCFF priorities by respondents from industry

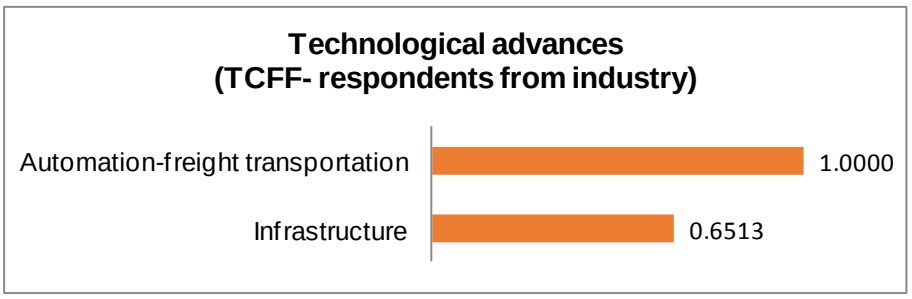


Megatrends priorities by respondents from industry



Political imperatives and technological advances priorities by respondents from industry





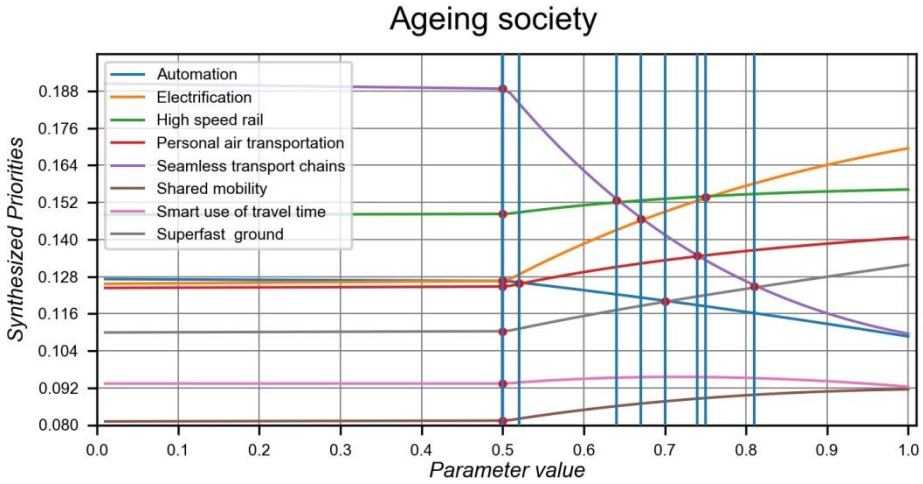
10 ANNEX 2 – Sensitivity and stability analysis

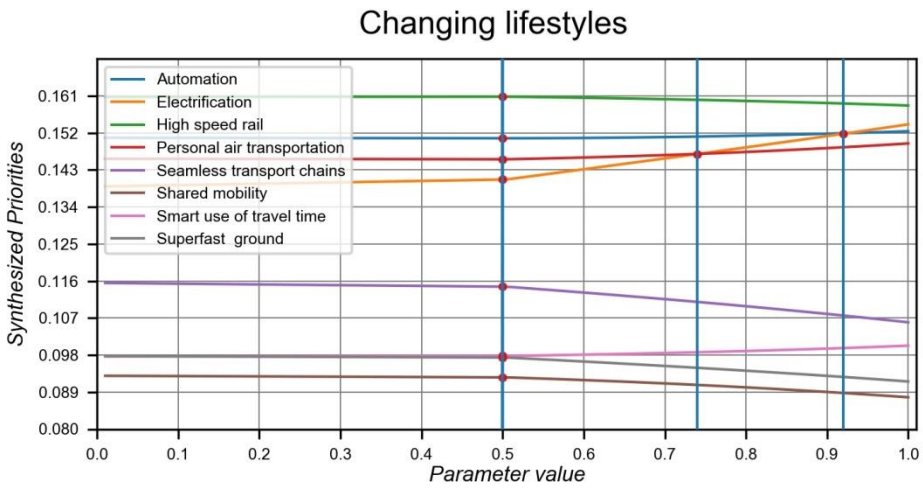
Node sensitivites analysis for all megatrends, political imperatives and technological advances for different groups and for overall are given bellow

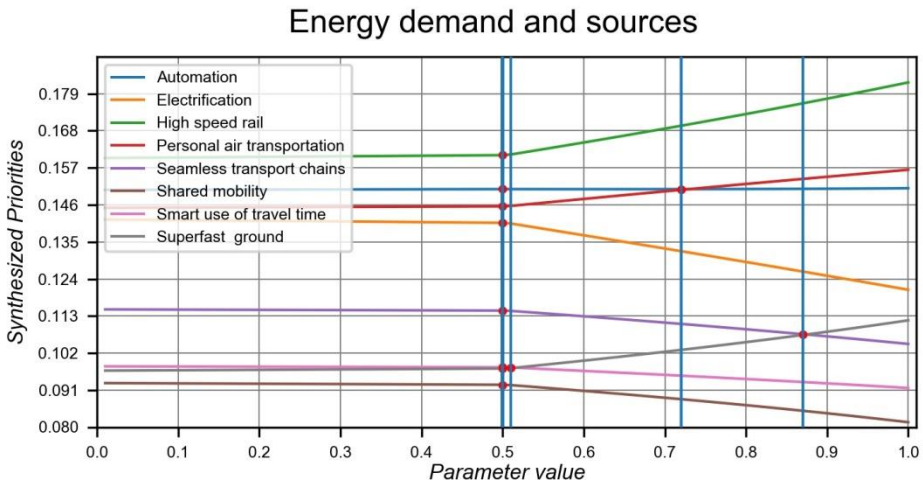
PASSENGER TRANSPORTATION

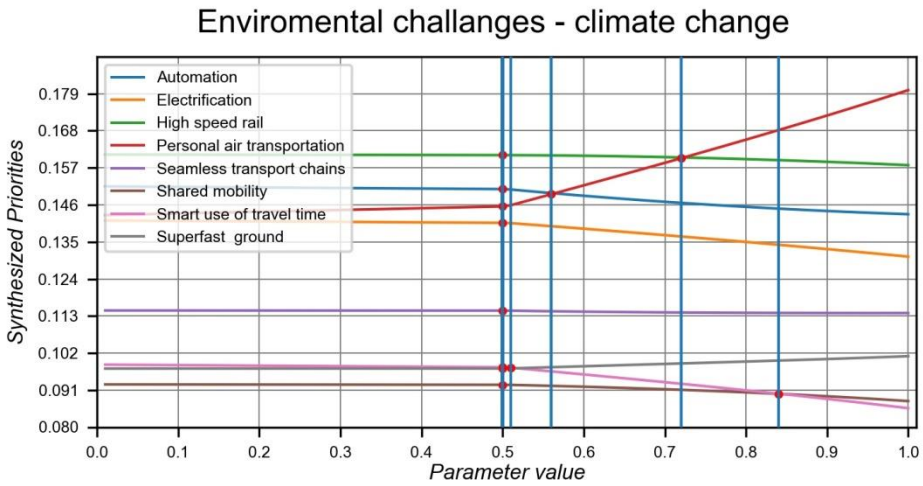
1. OVERALL

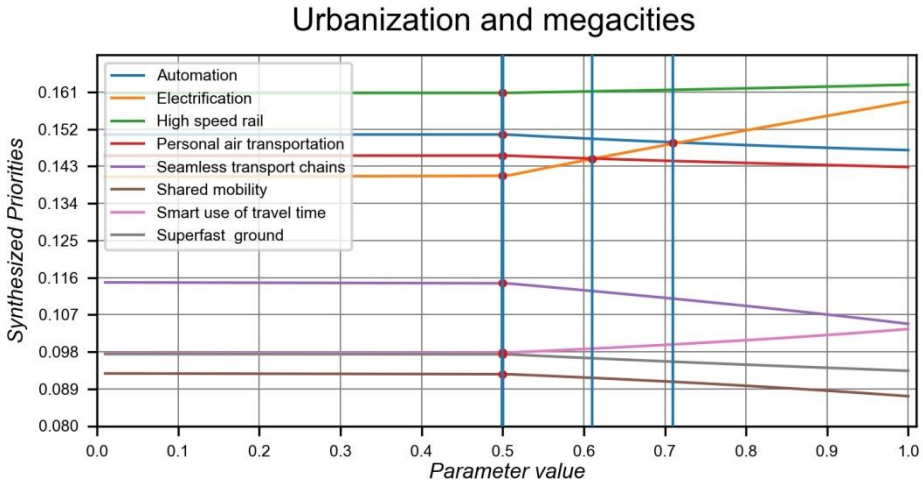
MEGATRENDS





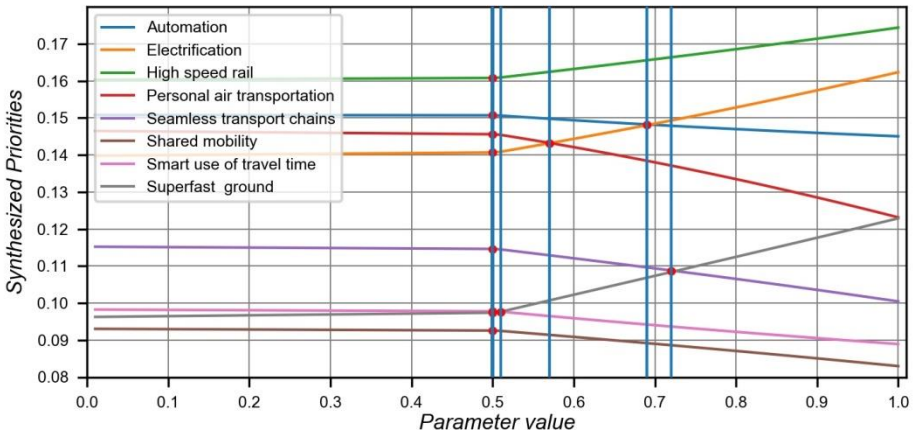

Energy demand and sources
Automation
Electrification
High speed rail
Personal air transportation
Seamless transport chains
Shared mobility
Smart use of travel time
Superfast ground
Synthesized Priorities
Parameter value


Enviromental challanges - climate change
Automation
Electrification
High speed rail
Personal air transportation
Seamless transport chains
Shared mobility
Smart use of travel time
Superfast ground
Synthesized Priorities
Parameter value

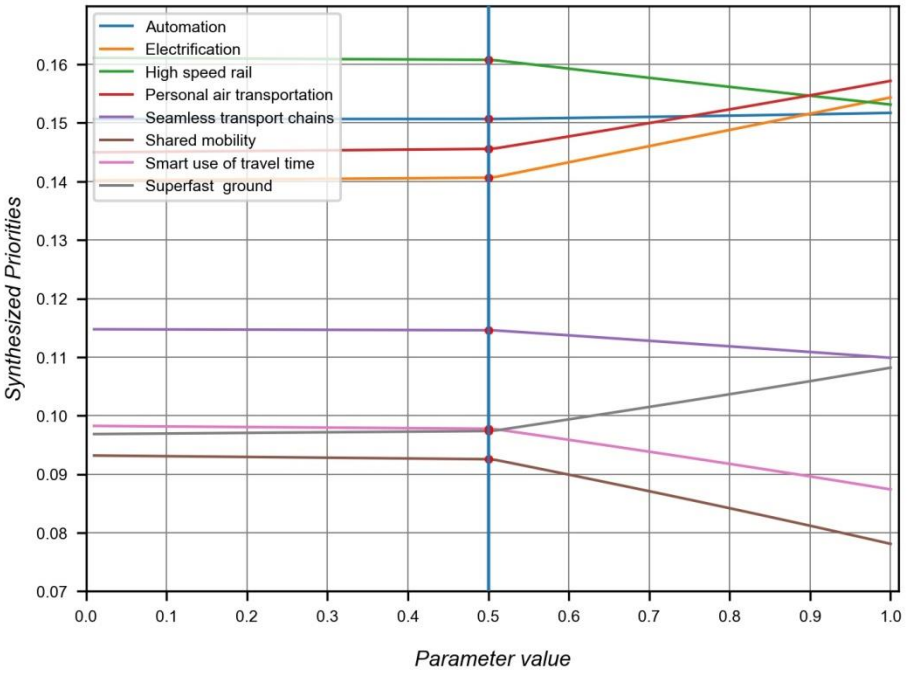

Urbanization and megacities
Automation
Electrification
High speed rail
Personal air transportation
Seamless transport chains
Shared mobility
Smart use of travel time
Superfast ground
Synthesized Priorities
Parameter value

POLITICAL IMPERATIVES

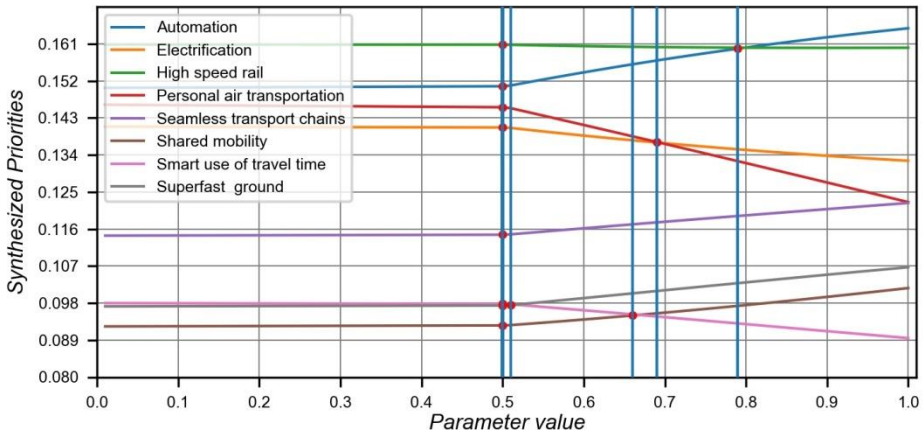
Closer public and private cooperation

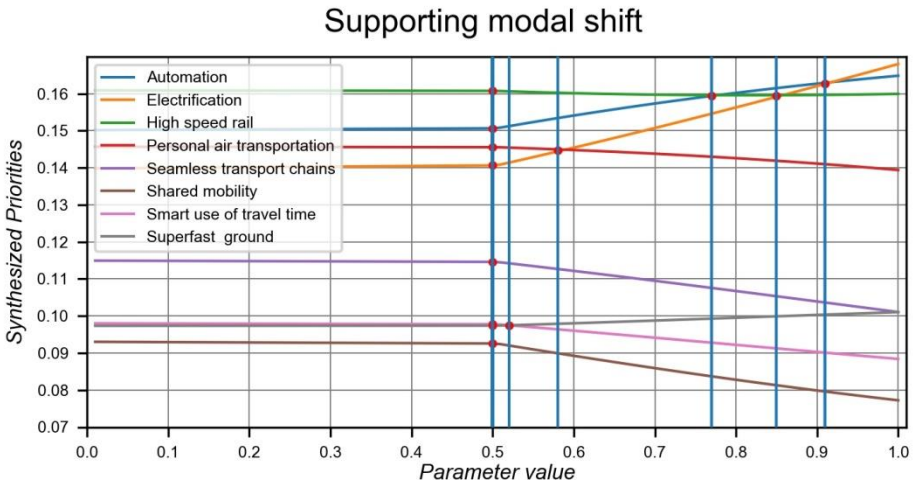


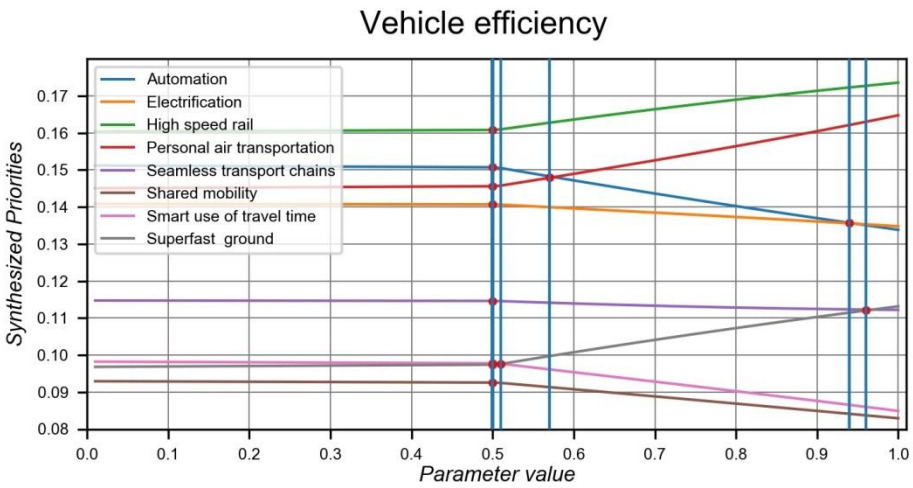
Increasing connectivity, intermodal access and fit-for-purpose network standards



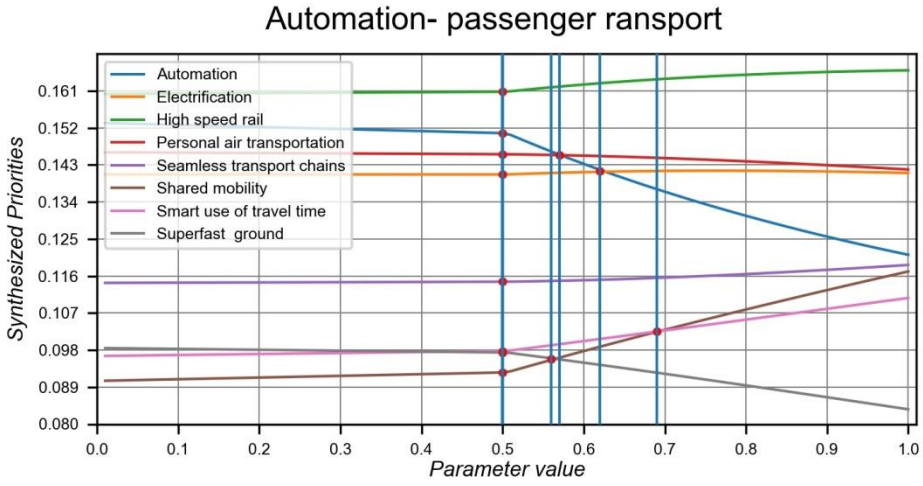
Innovative research system

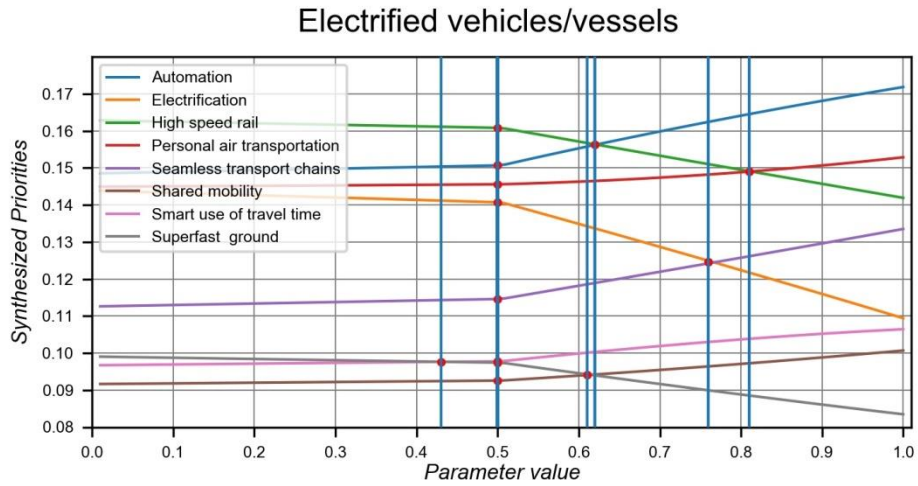


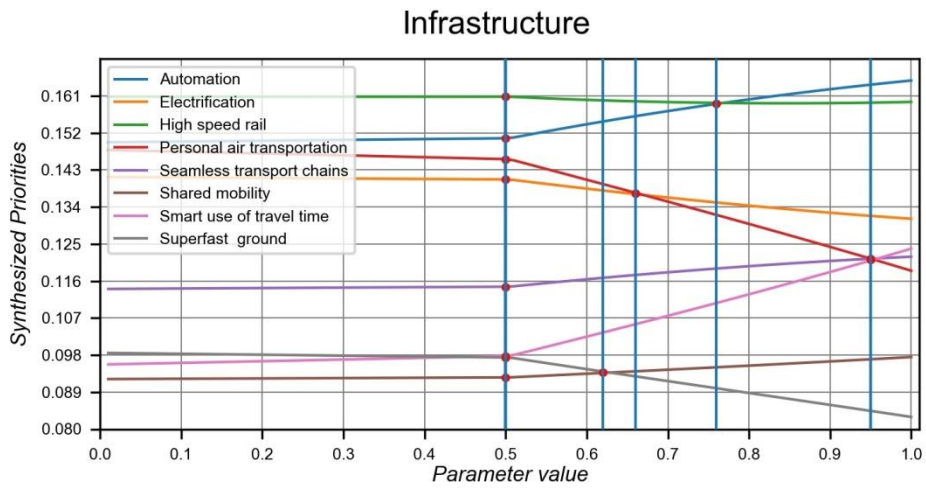




TEHNOLOGICAL ADVANCES

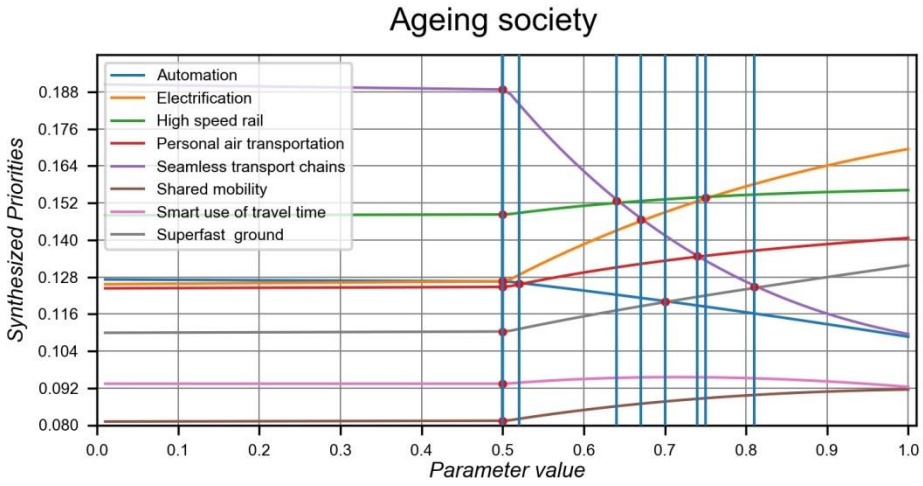


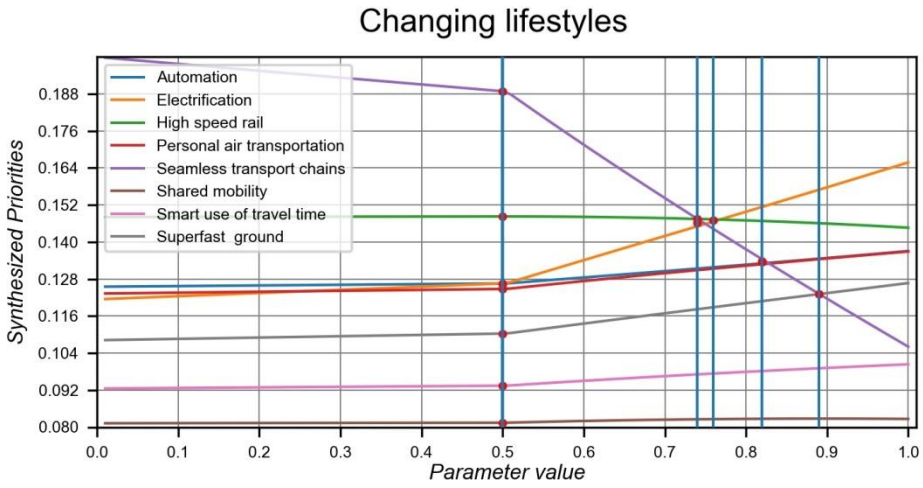

Electrified vehicles/vessels
Automation
Electrification
High speed rail
Personal air transportation
Seamless transport chains
Shared mobility
Smart use of travel time
Superfast ground
Synthesized Priorities
Parameter value

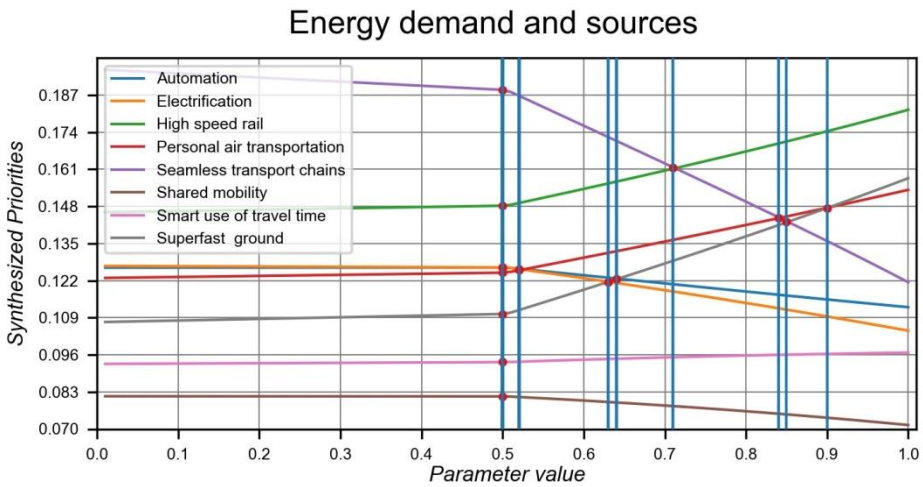

Infrastructure
Automation
Electrification
High speed rail
Personal air transportation
Seamless transport chains
Shared mobility
Smart use of travel time
Superfast ground
Synthesized Priorities
Parameter value

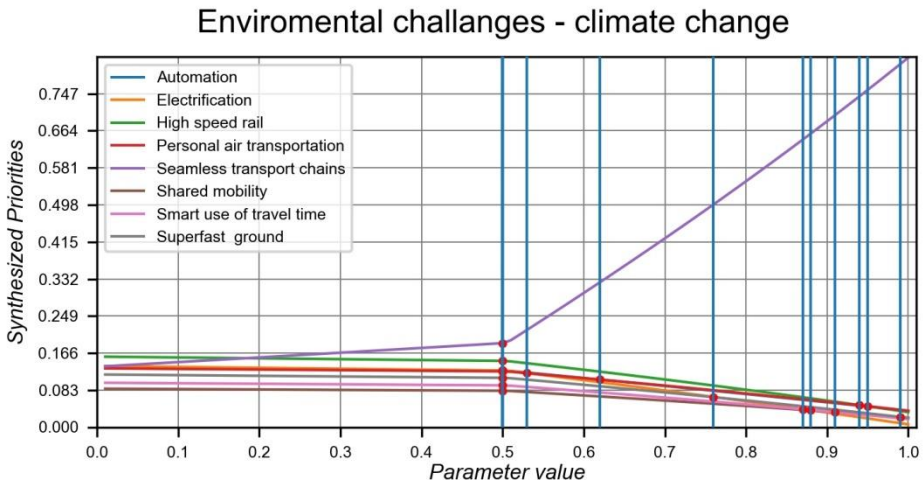
2. ACADEMIA

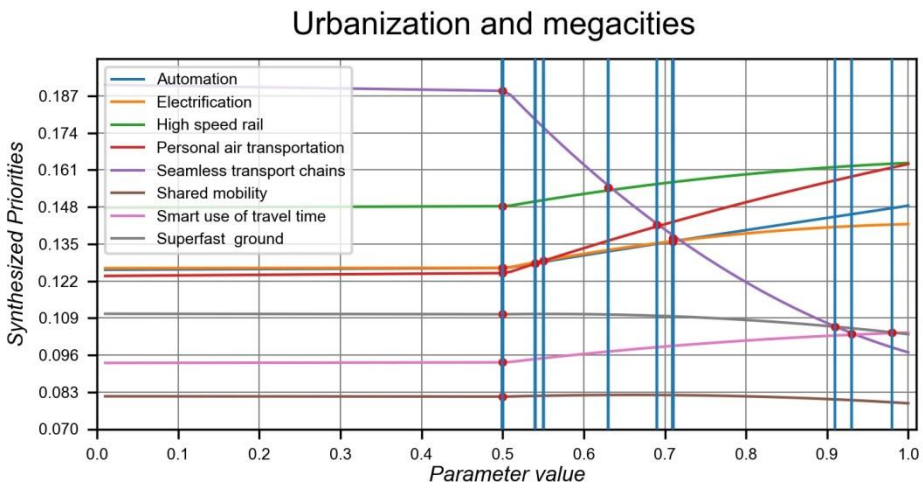
MEGATRENDS



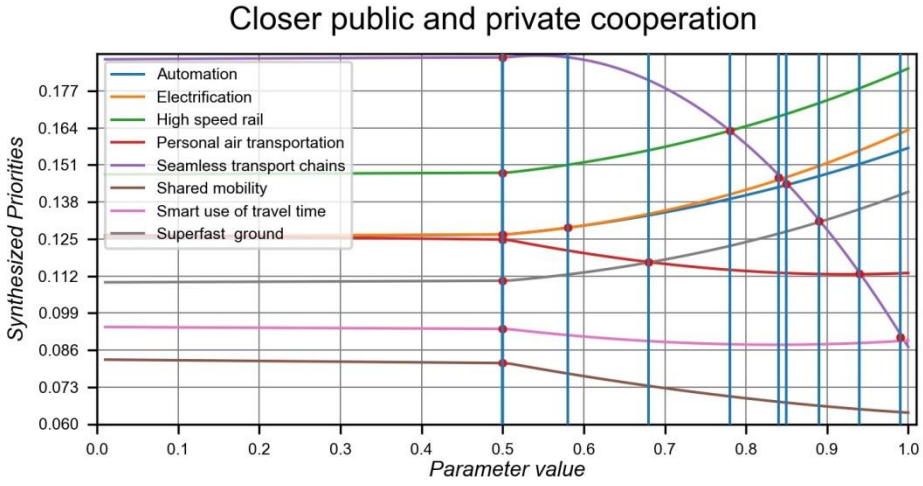




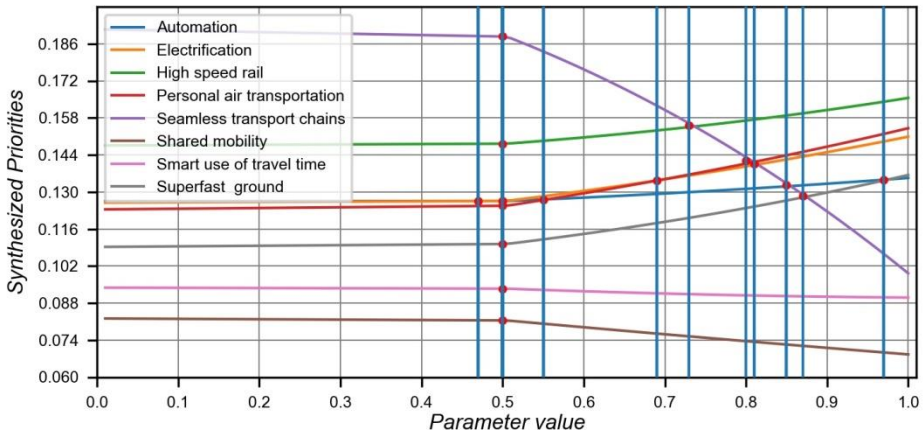




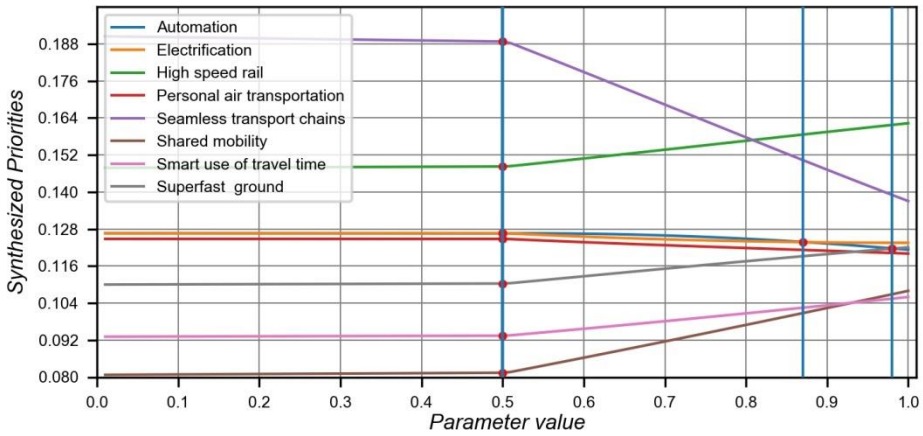
POLITICAL IMPERATIVES



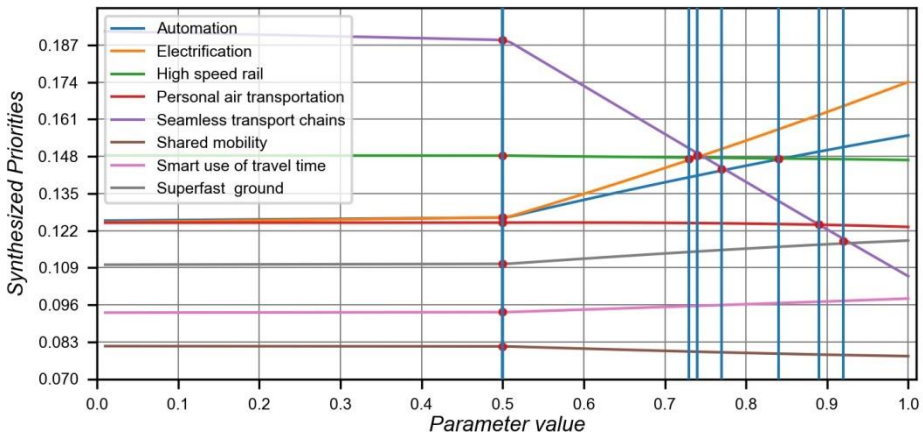
Increasing connectivity, intermodal access and fit-for-purpose network standards

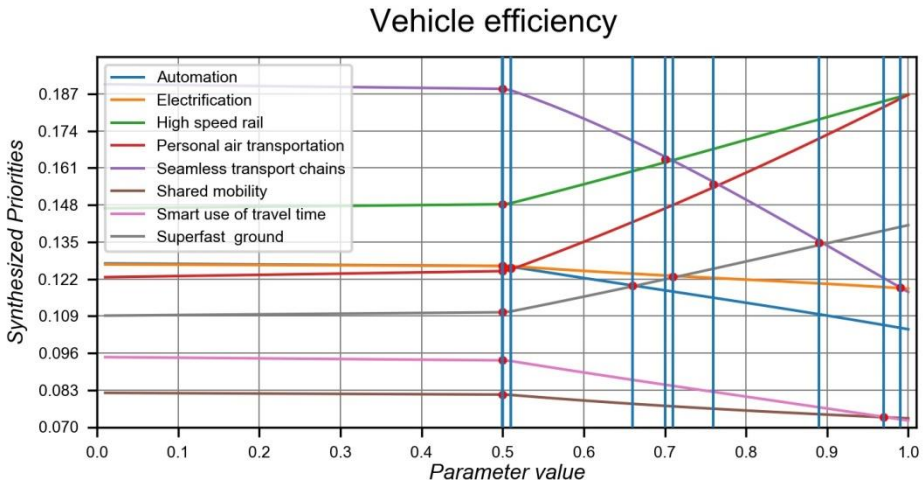


Innovative research system

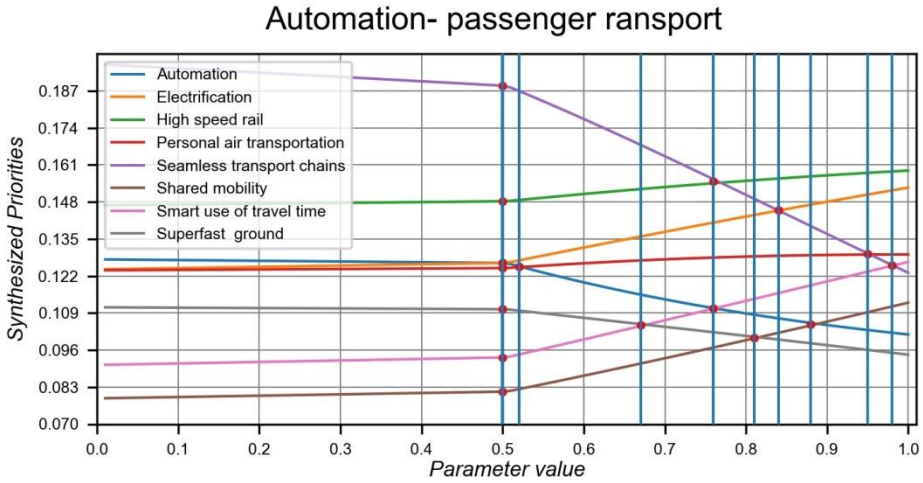


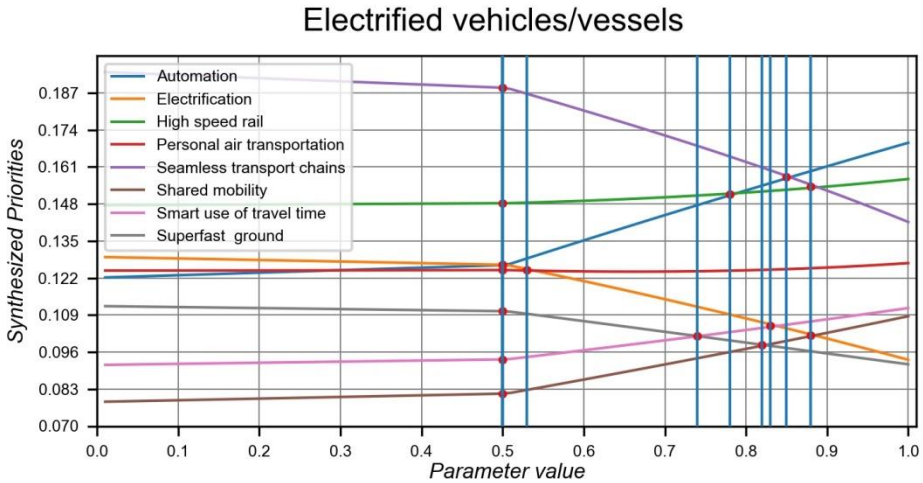
Supporting modal shift

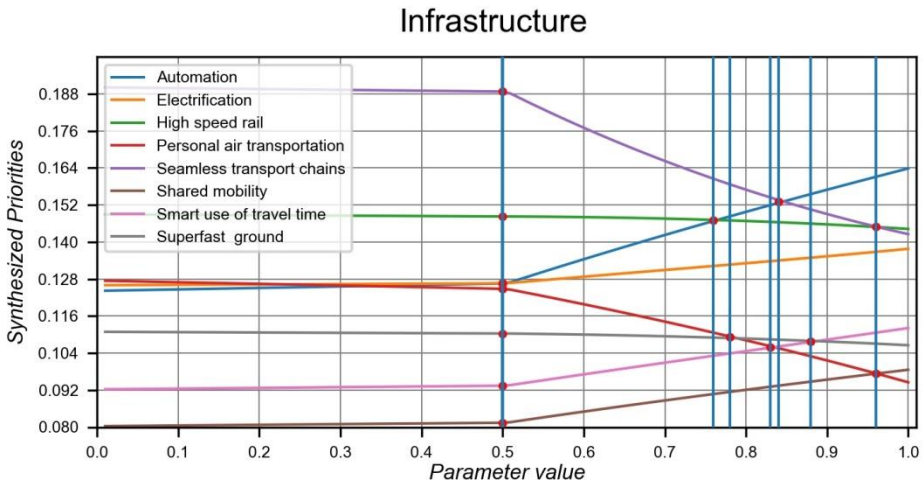




TEHNOLOGICAL ADVANCES

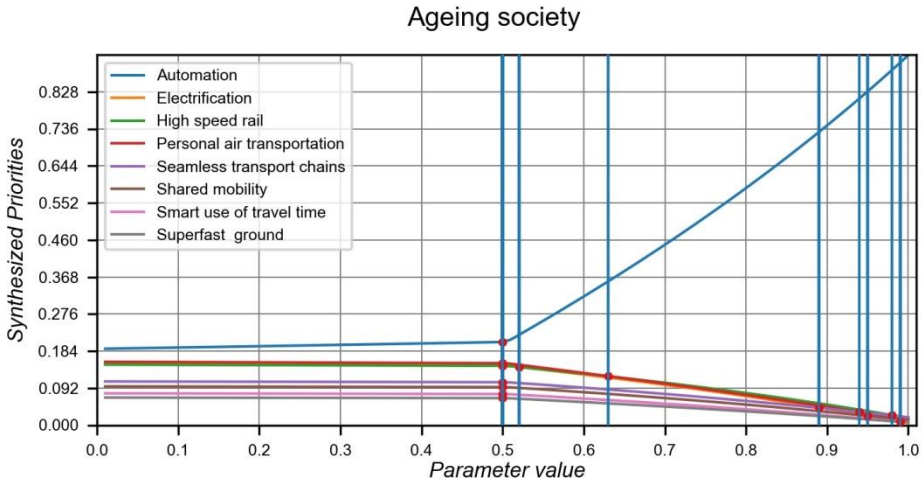


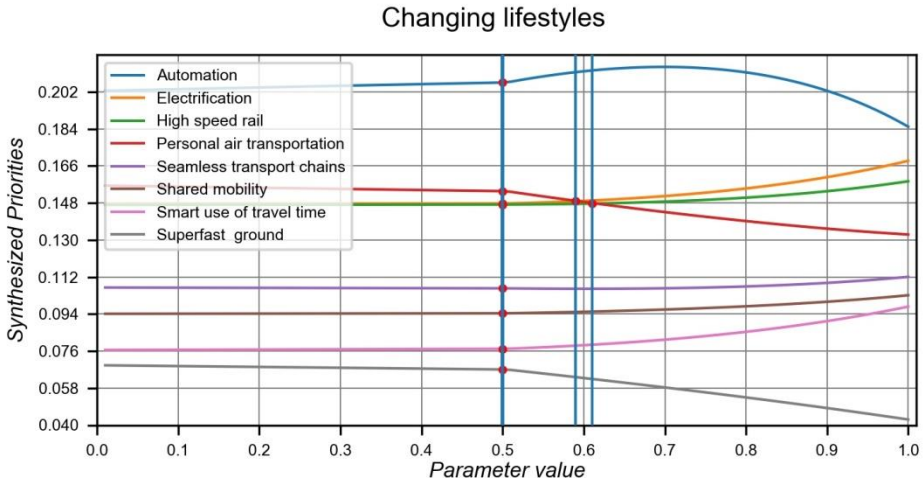


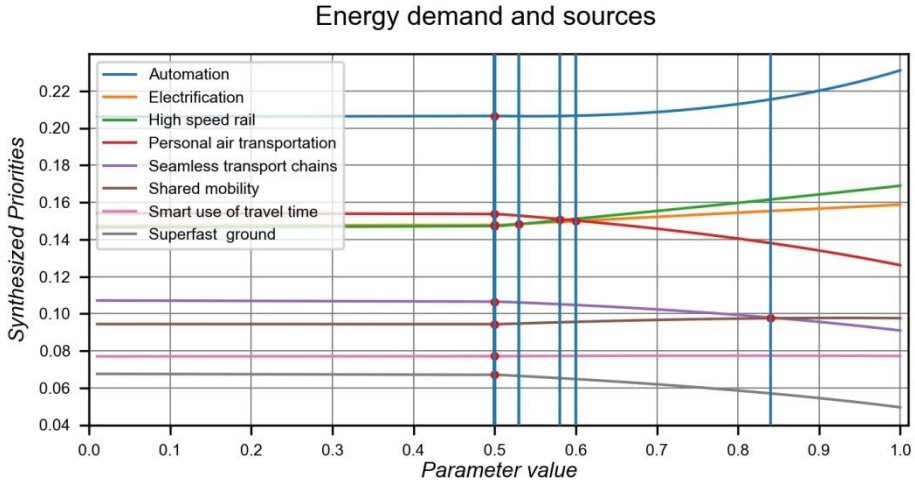

Infrastructure
Automation
Electrification
High speed rail
Personal air transportation
Seamless transport chains
Shared mobility
Smart use of travel time
Superfast ground
Synthesized Priorities
0.188
0.176
0.164
0.152
0.140
0.128
0.116
0.104
0.092
0.080
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Parameter value

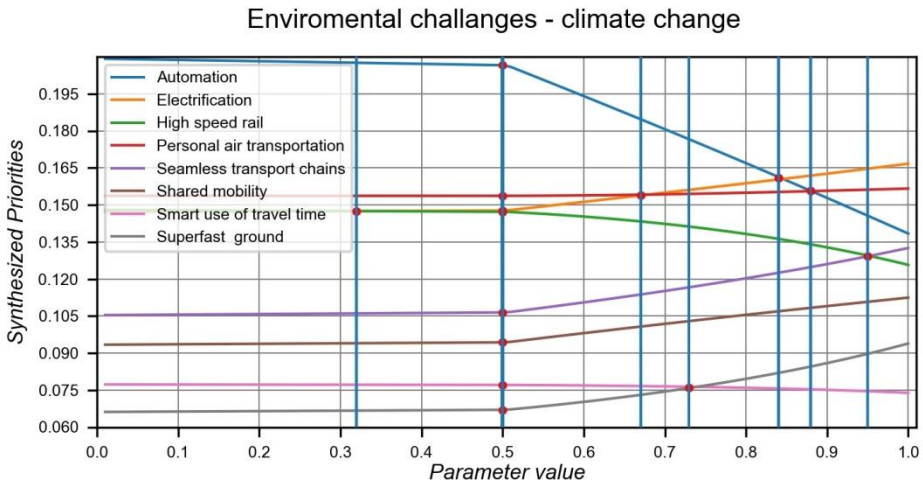
3. POLICY-MAKERS

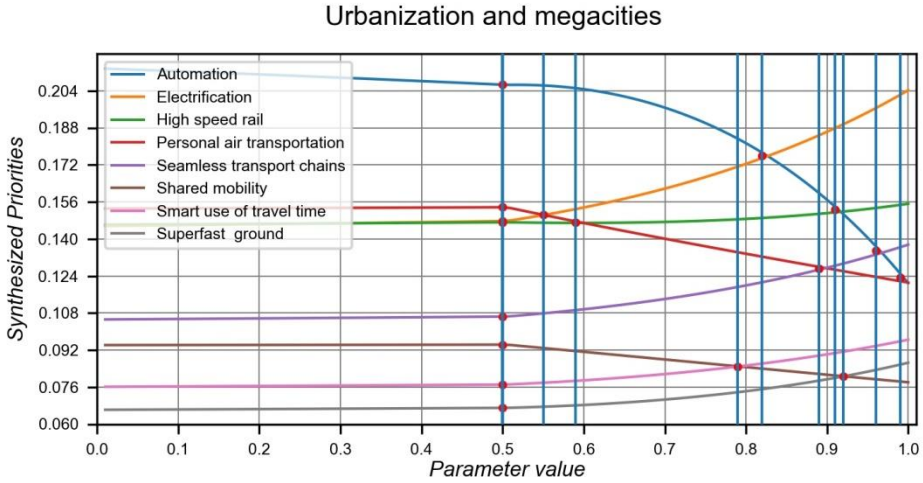
MEGATRENDS



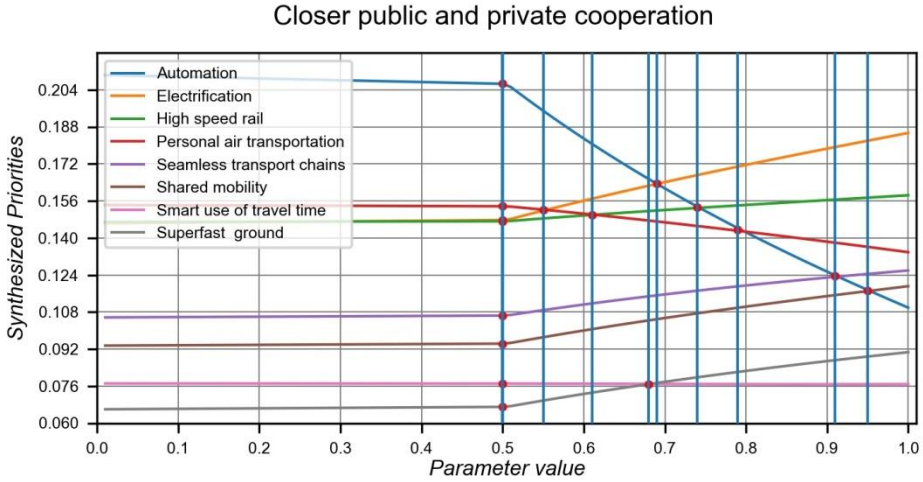




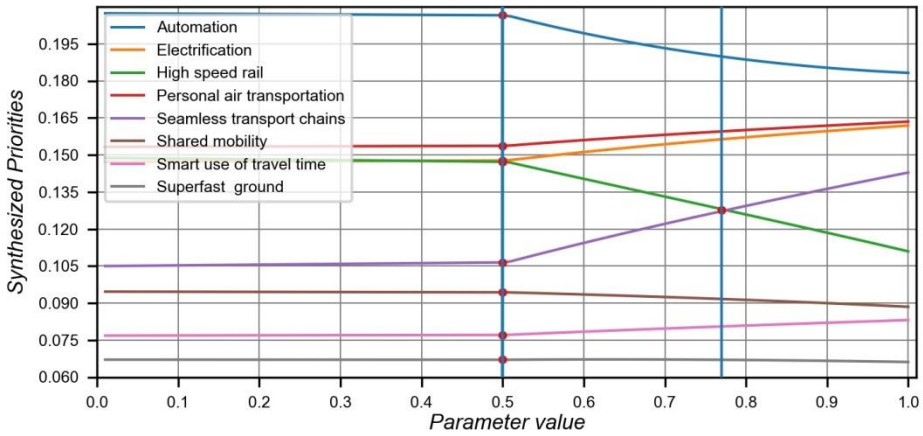




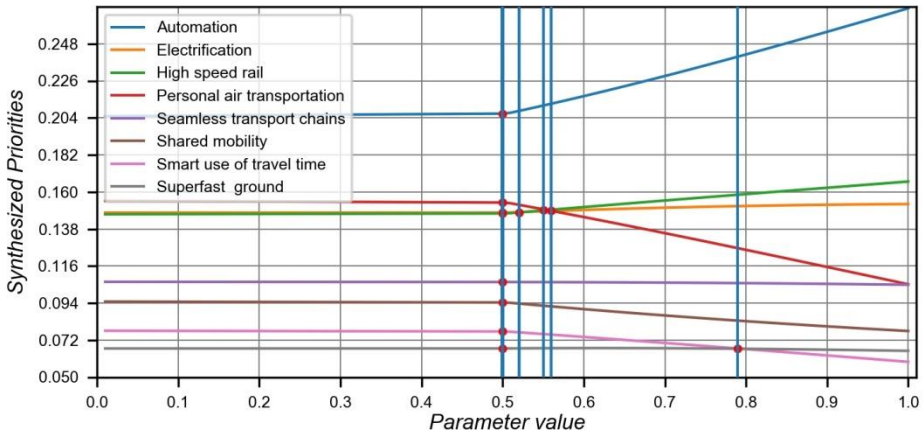
POLITICAL IMPERATIVES



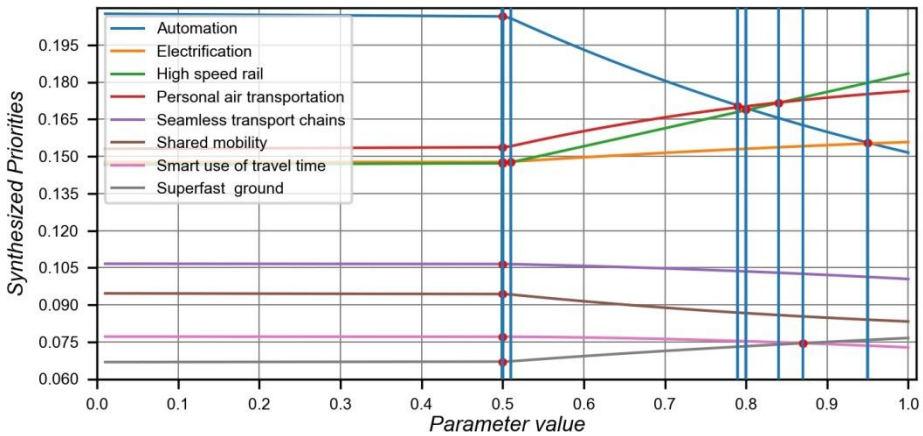
Increasing connectivity, intermodal access and fit-for-purpose network standards

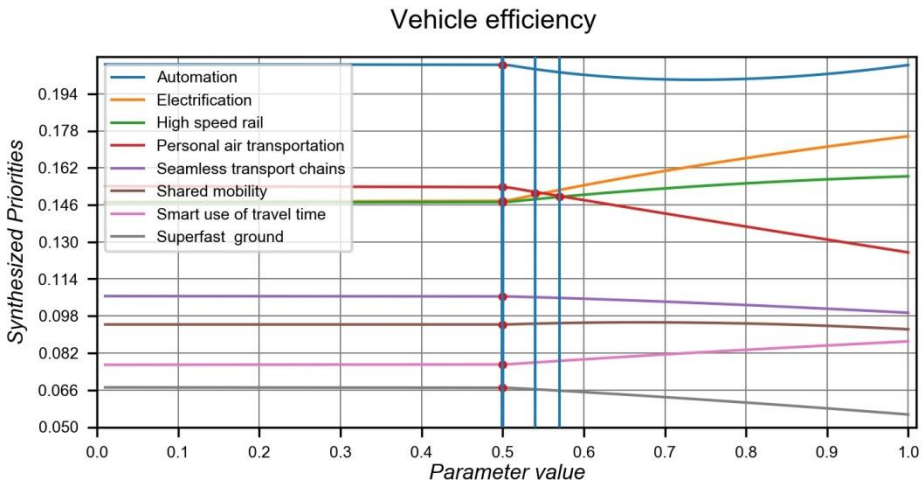


Innovative research system

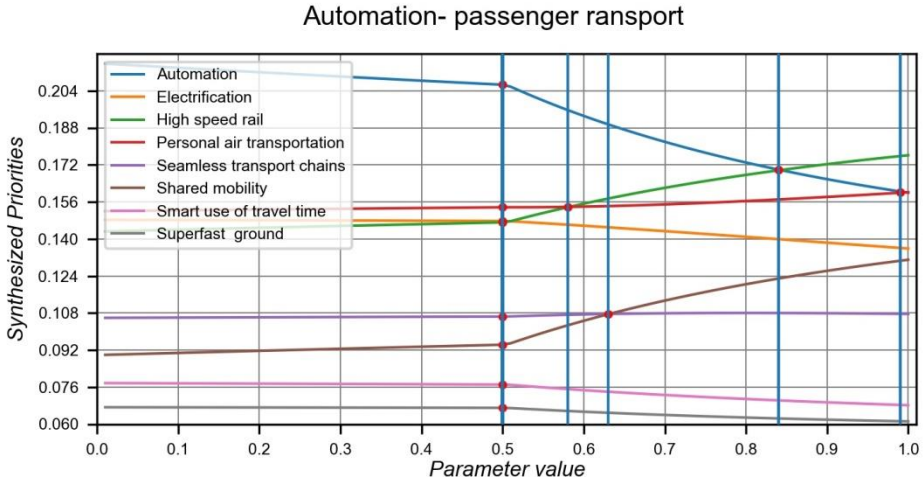


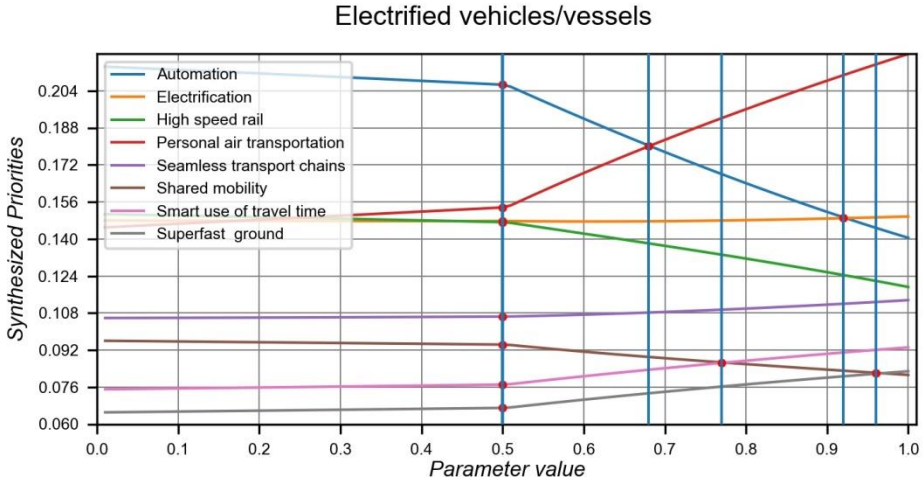
Supporting modal shift

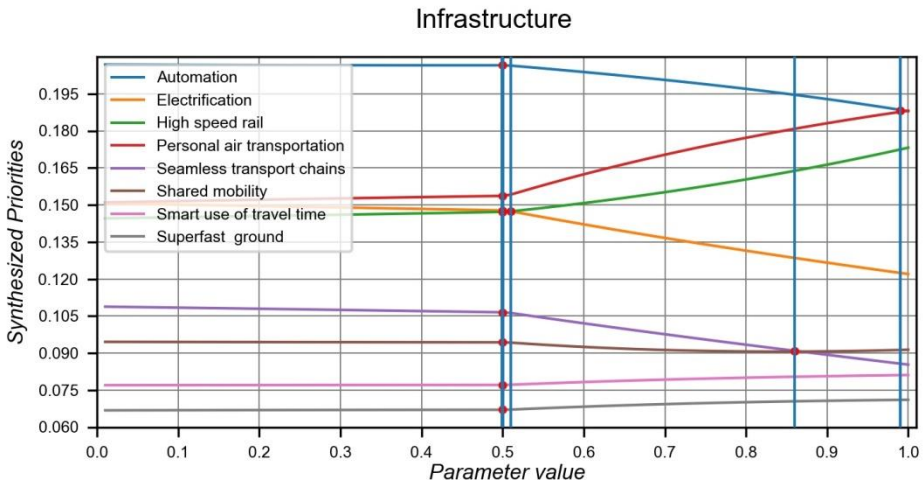




TEHNOLOGICAL ADVANCES

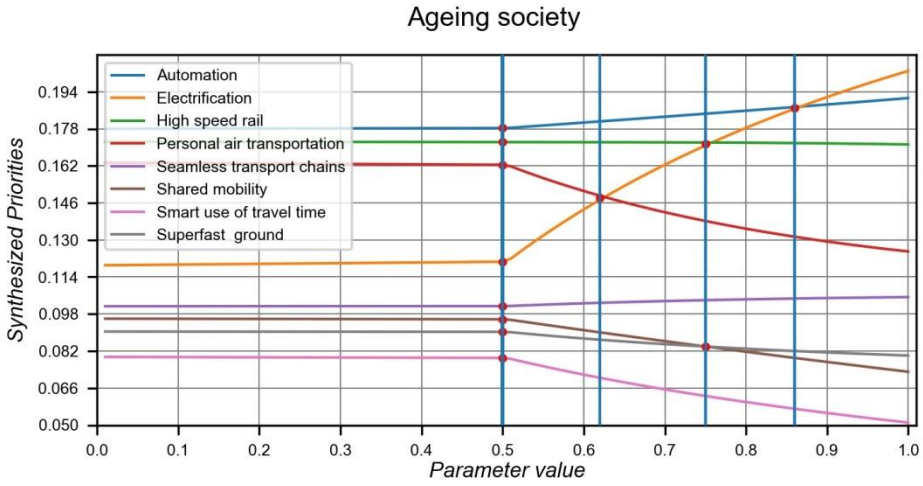


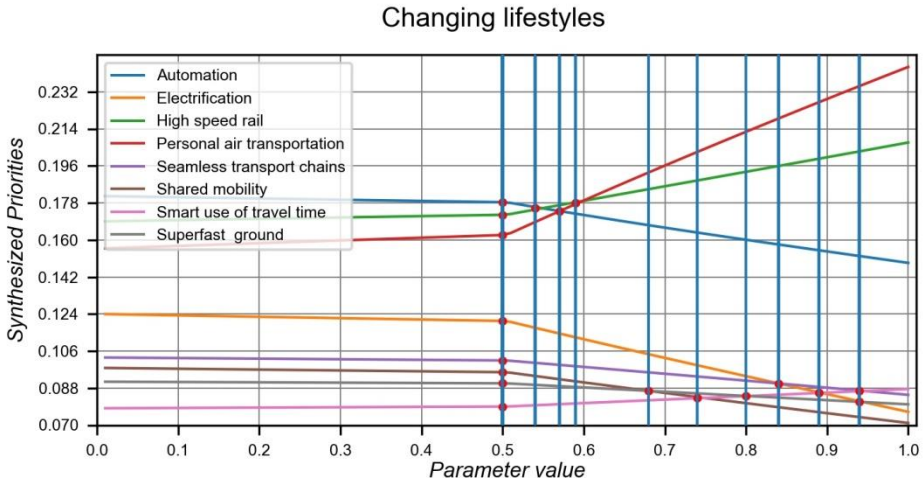


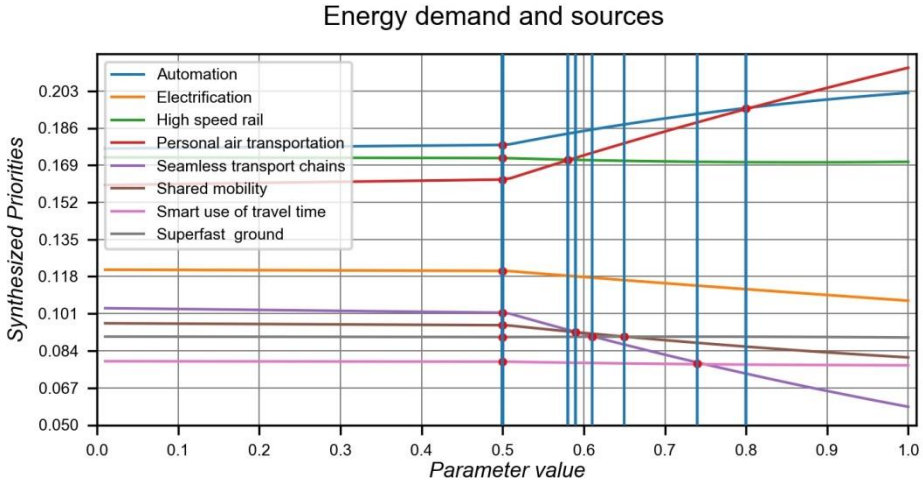

Infrastructure
Automation
Electrification
High speed rail
Personal air transportation
Seamless transport chains
Shared mobility
Smart use of travel time
Superfast ground
Synthesized Priorities
0.195
0.180
0.165
0.150
0.135
0.120
0.105
0.090
0.075
0.060
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Parameter value

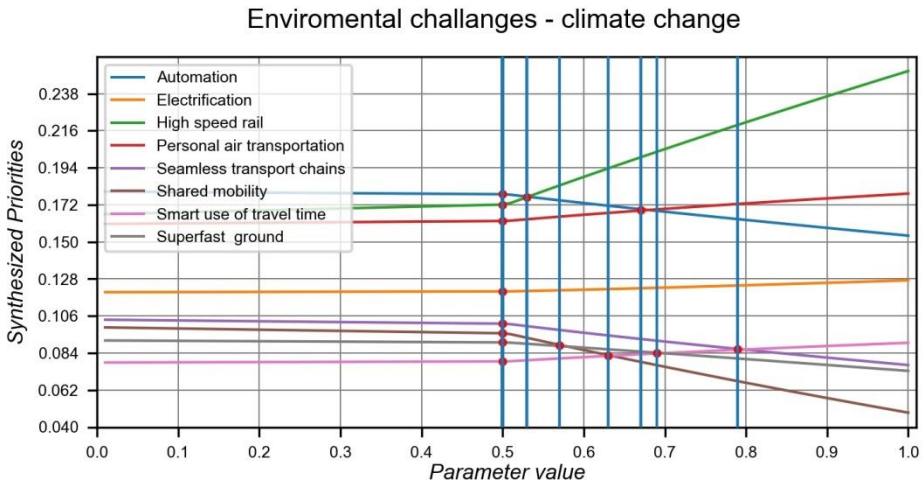
4. INDUSTRY

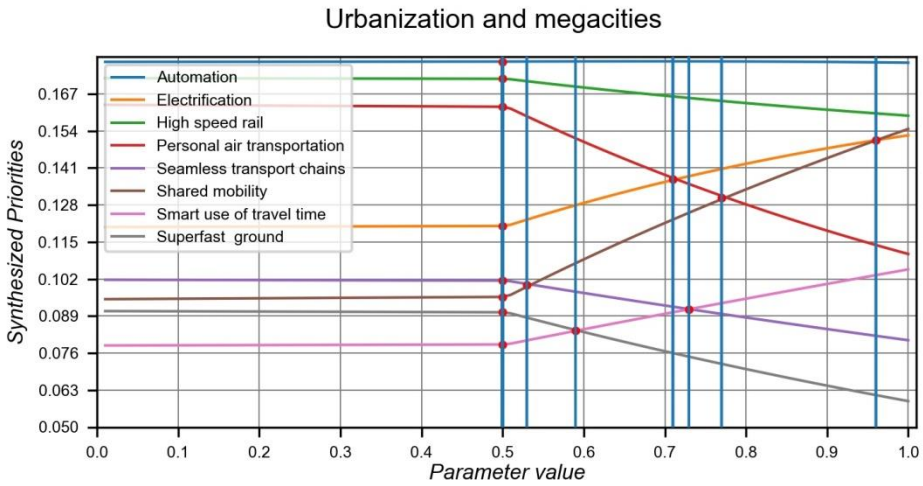
MEGATRENDS



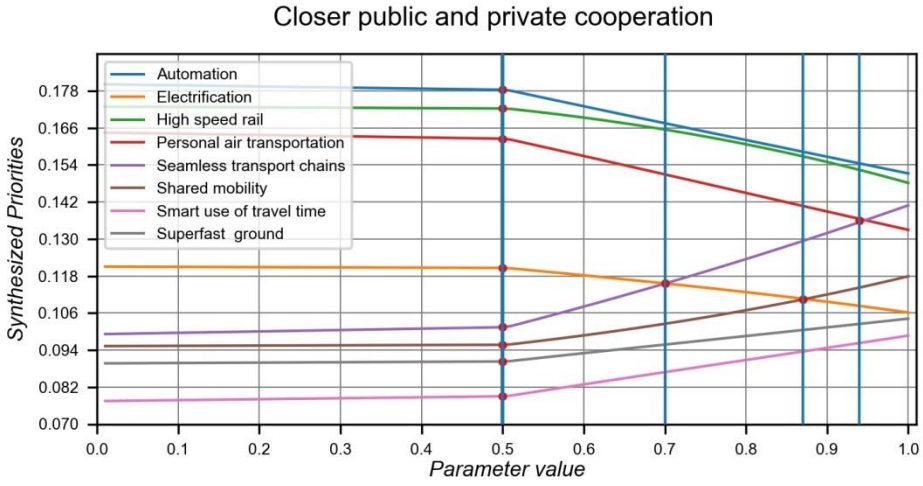




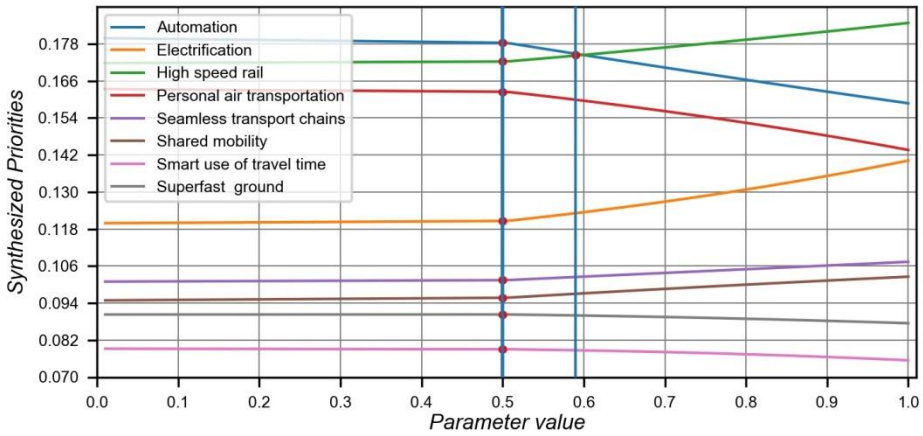




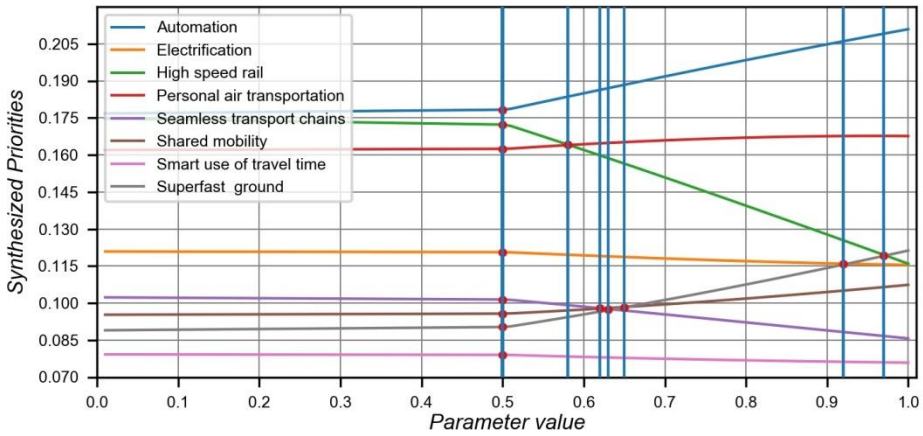
POLITICAL IMPERATIVES



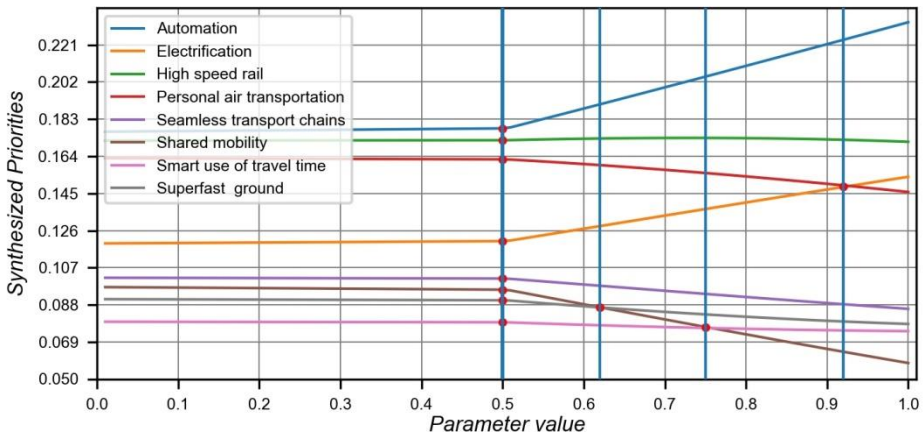
Increasing connectivity, intermodal access and fit-for-purpose network standards

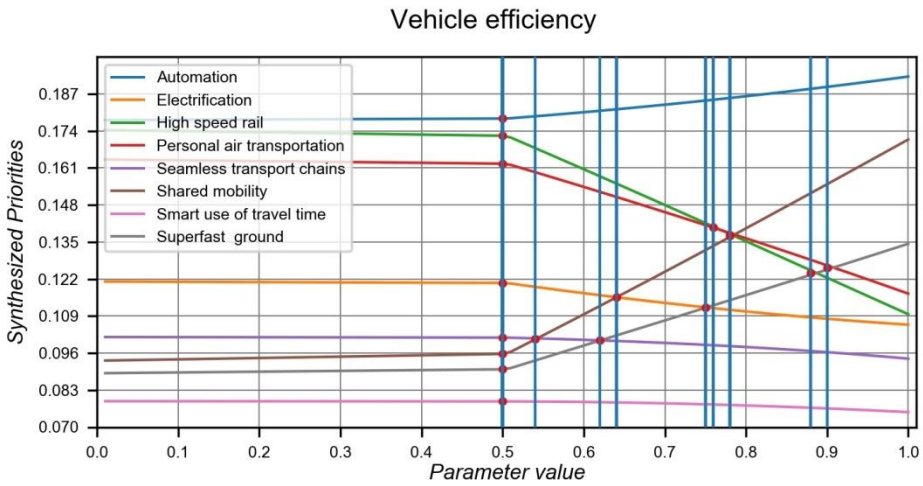


Innovative research system

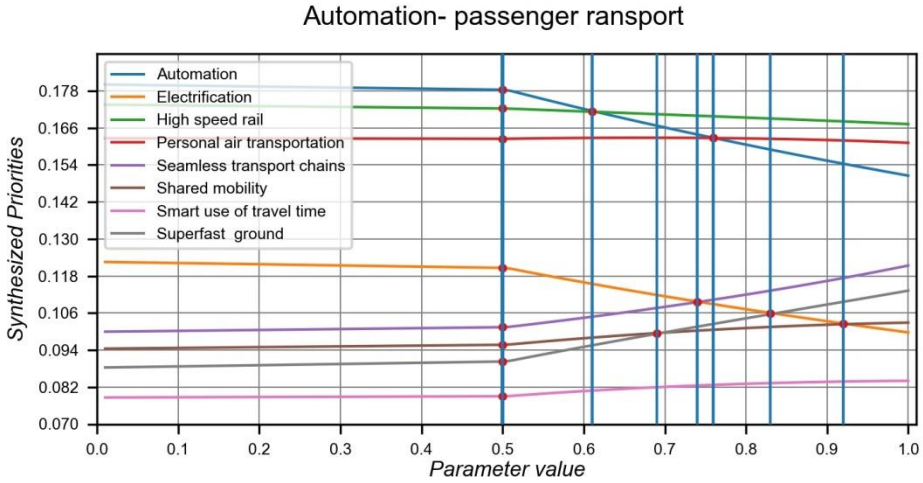


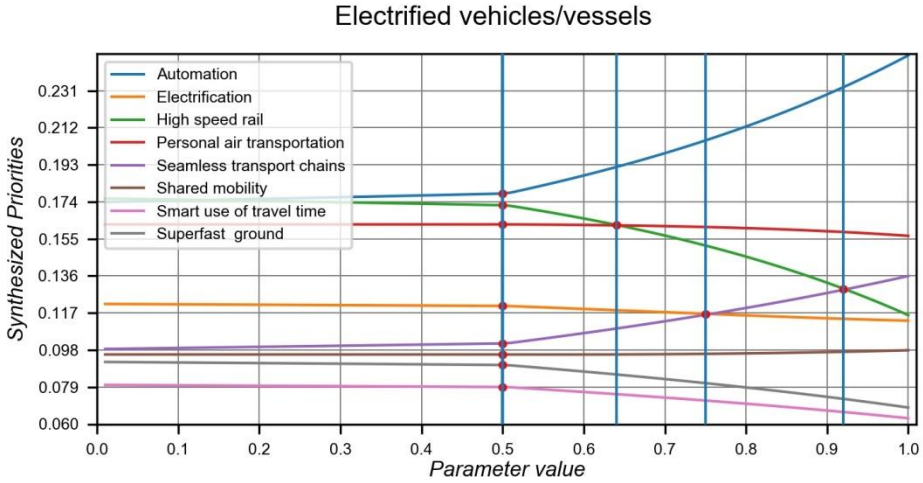
Supporting modal shift

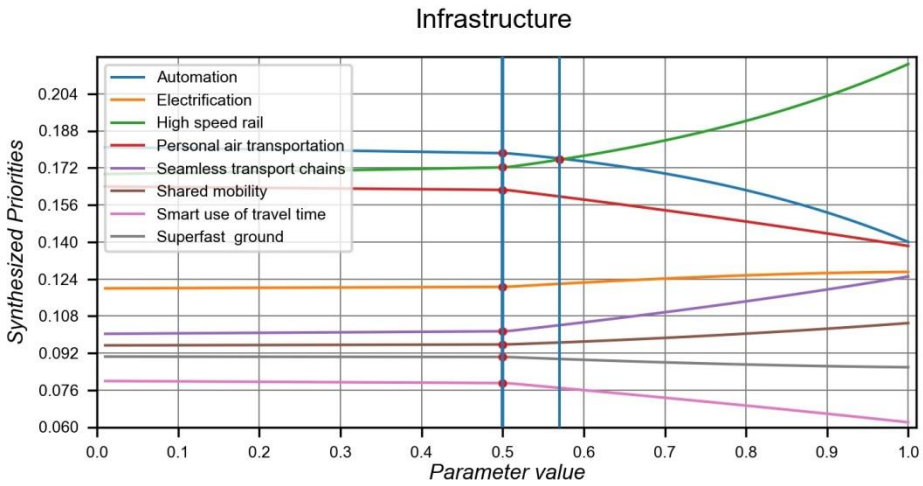




TEHNOLOGICAL ADVANCES



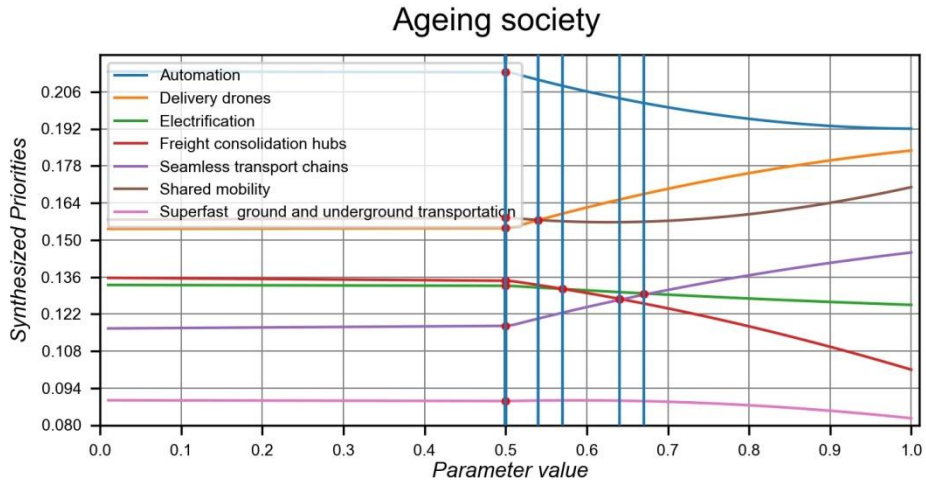


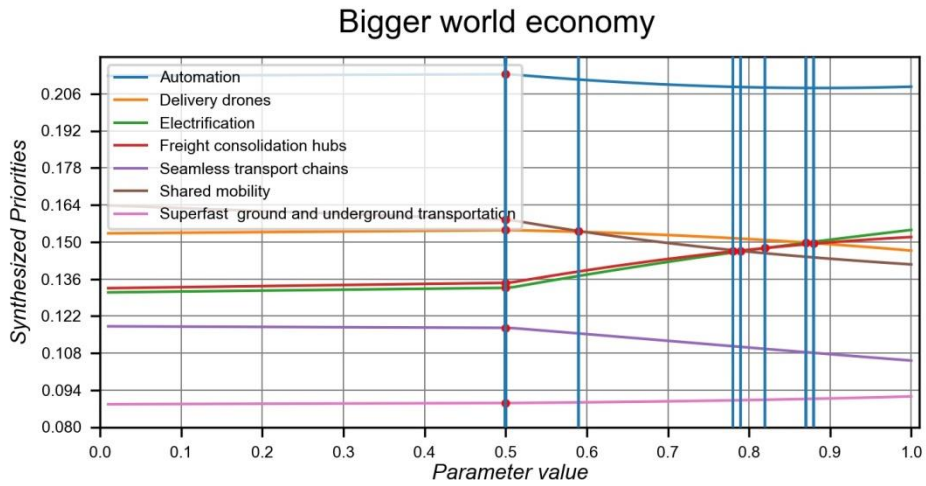

Infrastructure
Automation
Electrification
High speed rail
Personal air transportation
Seamless transport chains
Shared mobility
Smart use of travel time
Superfast ground
Synthesized Priorities
0.204
0.188
0.172
0.156
0.140
0.124
0.108
0.092
0.076
0.060
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Parameter value

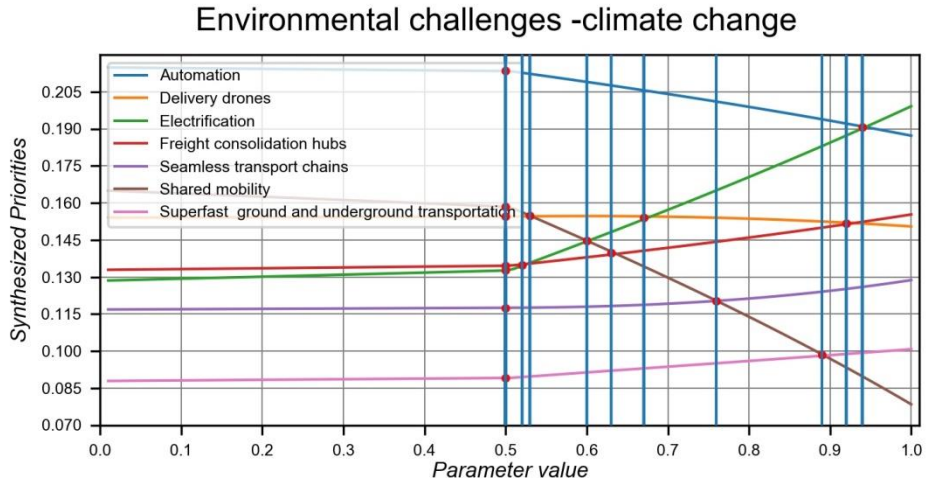
FREIGHT TRANSPORTATION

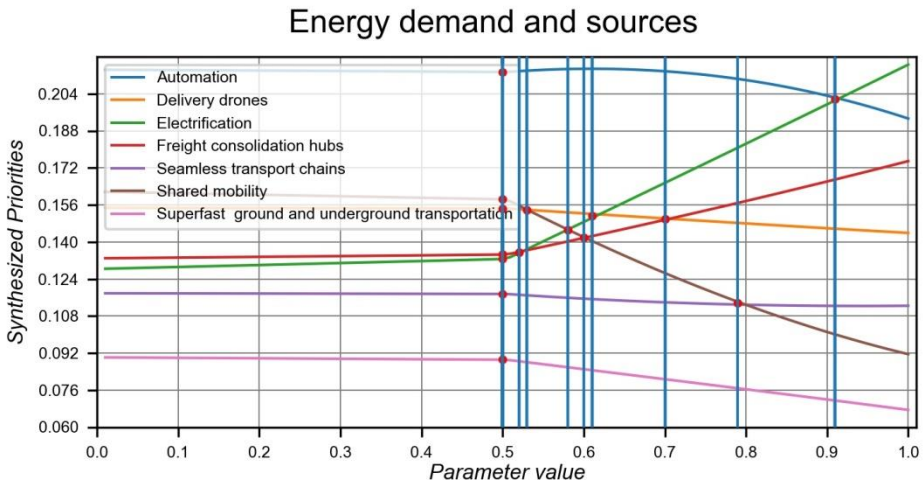
1. OVERALL

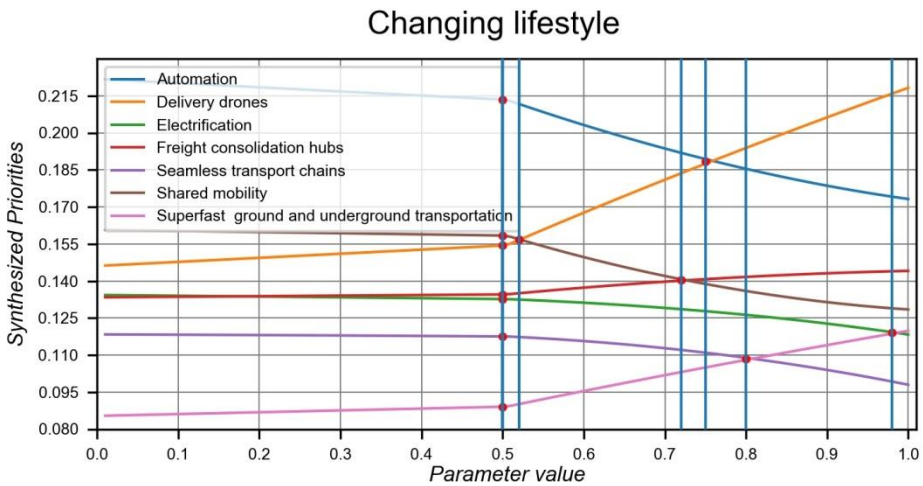
MEGATRENDS

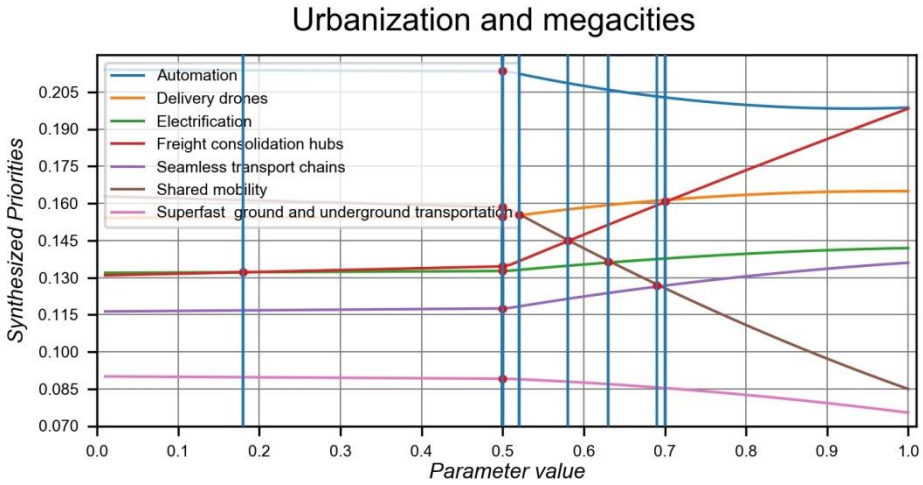




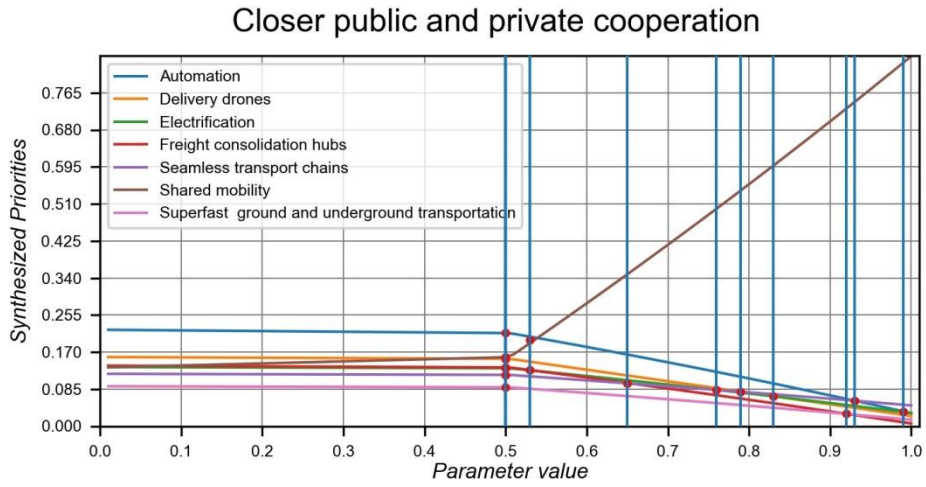


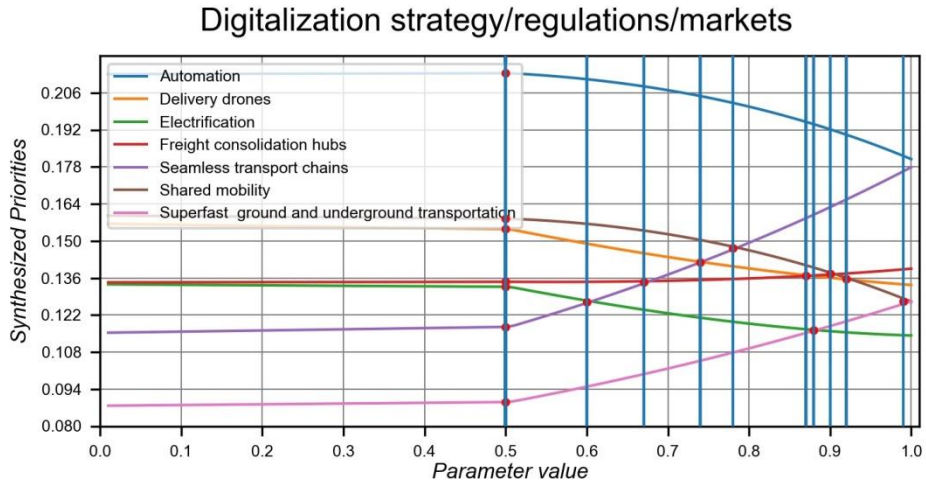

Energy demand and sources
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value

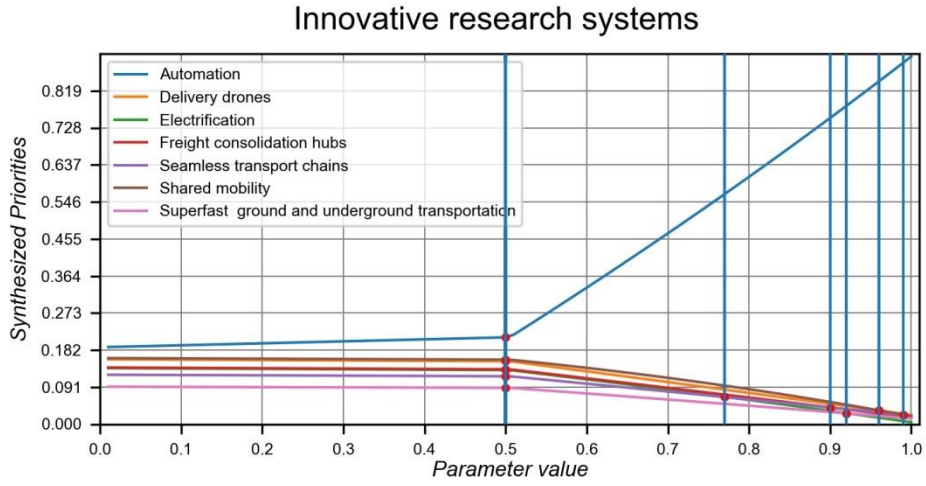

Changing lifestyle
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value

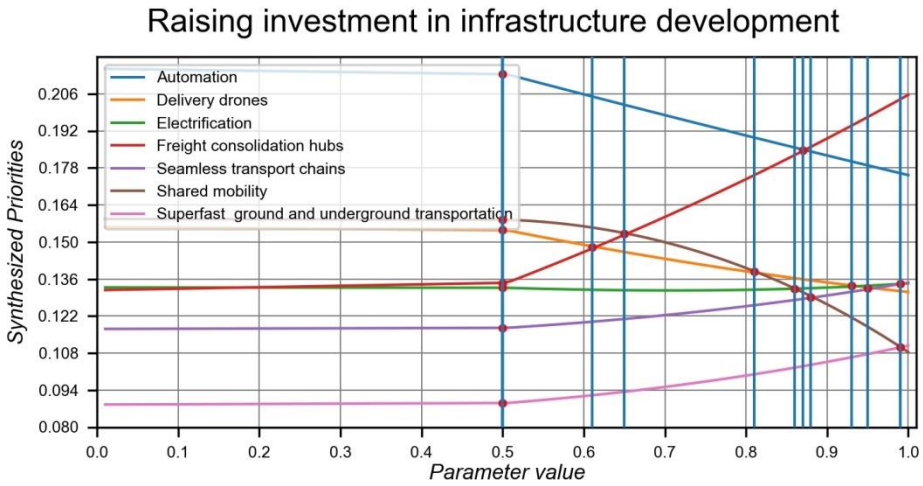

Urbanization and megacities
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value

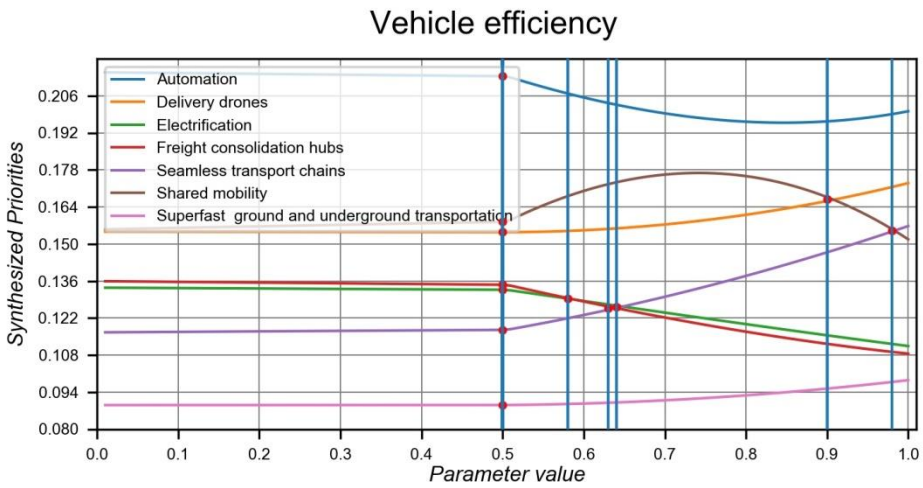
POLITICAL IMPERATIVES



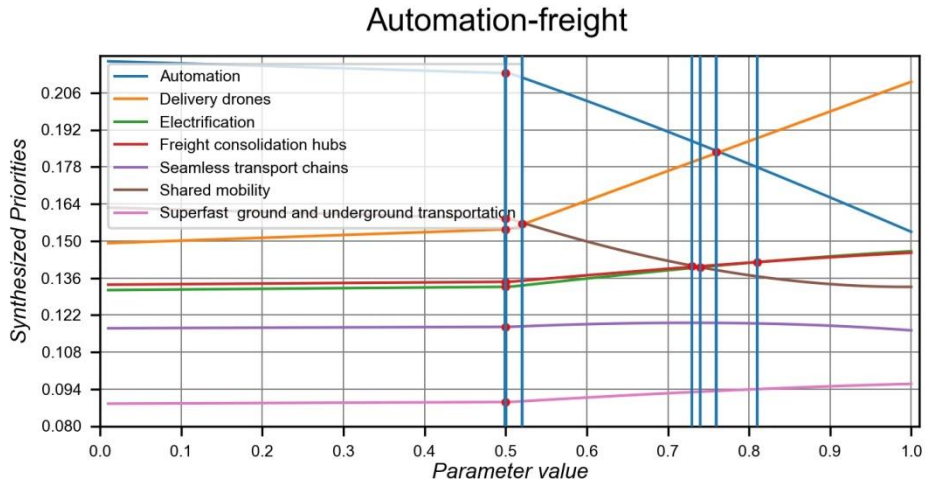


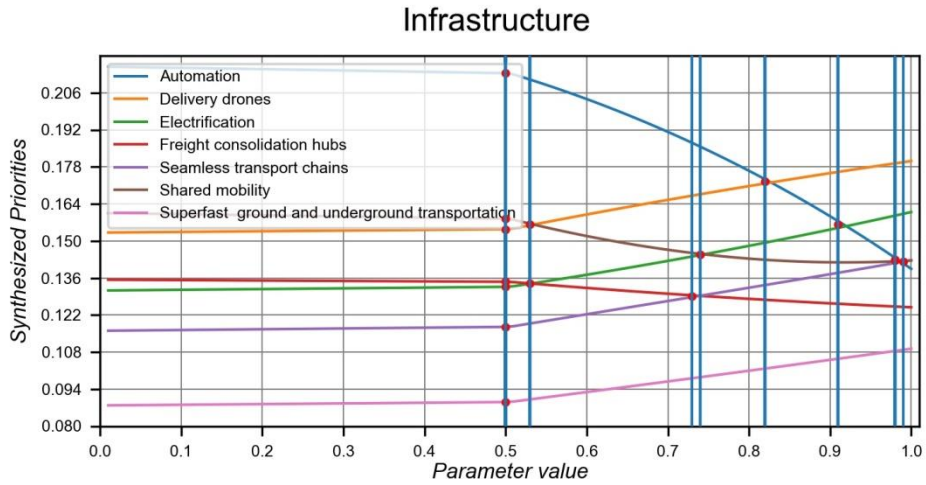



Raising investment in infrastructure development
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value


Vehicle efficiency
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value

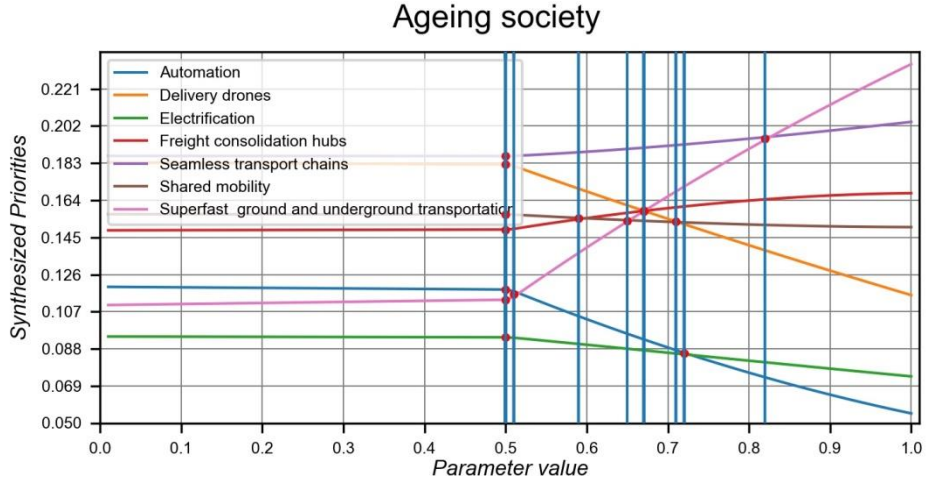
TEHNOLOGICAL ADVANCES

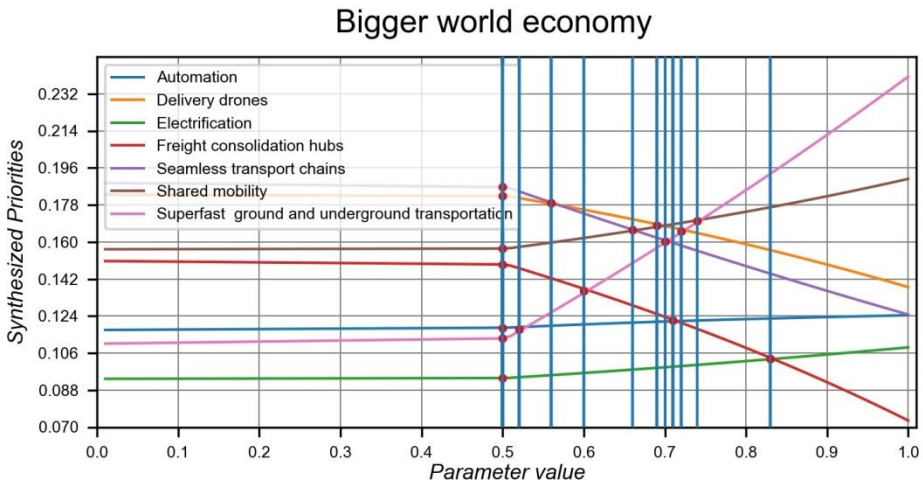


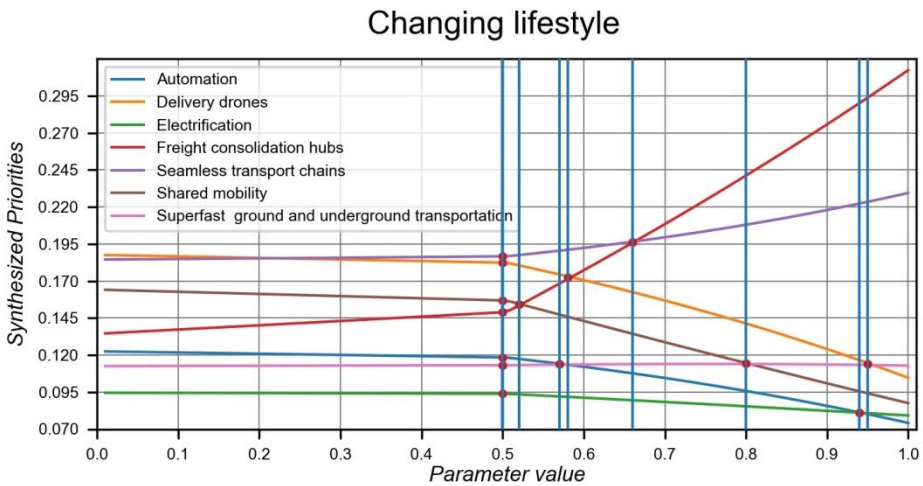


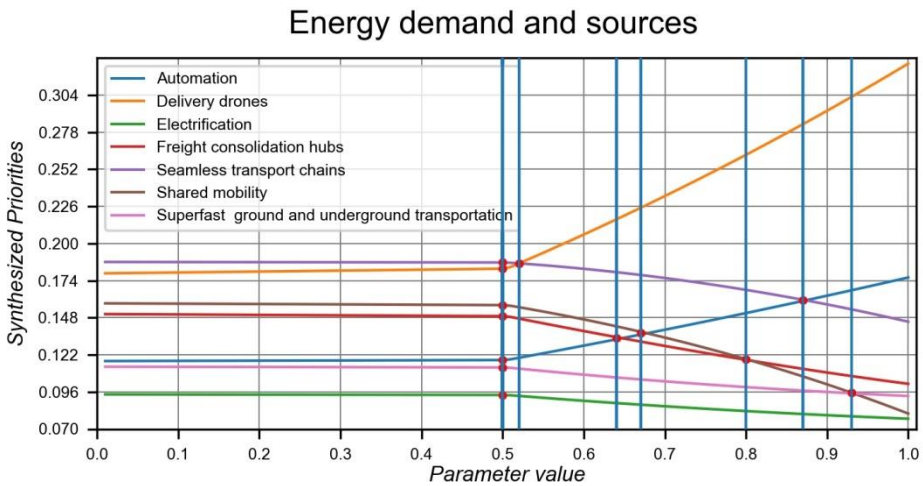
2. ACADEMIA

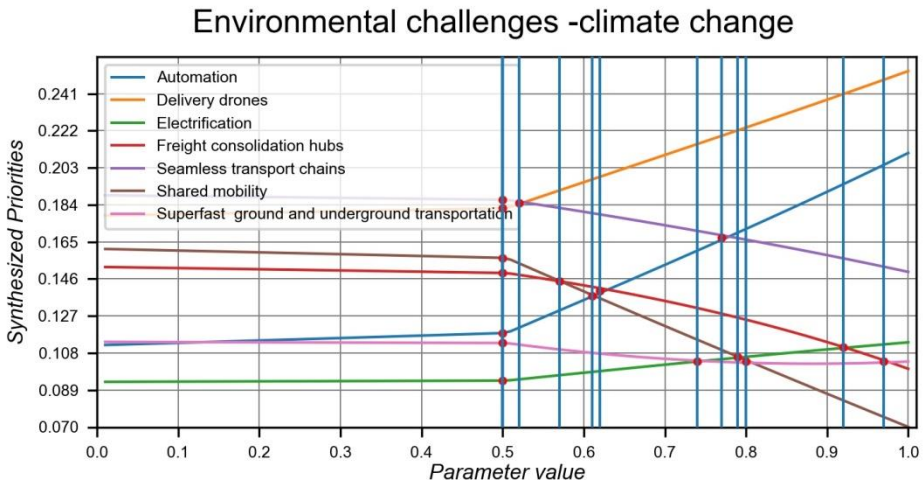
MEGATRENDS

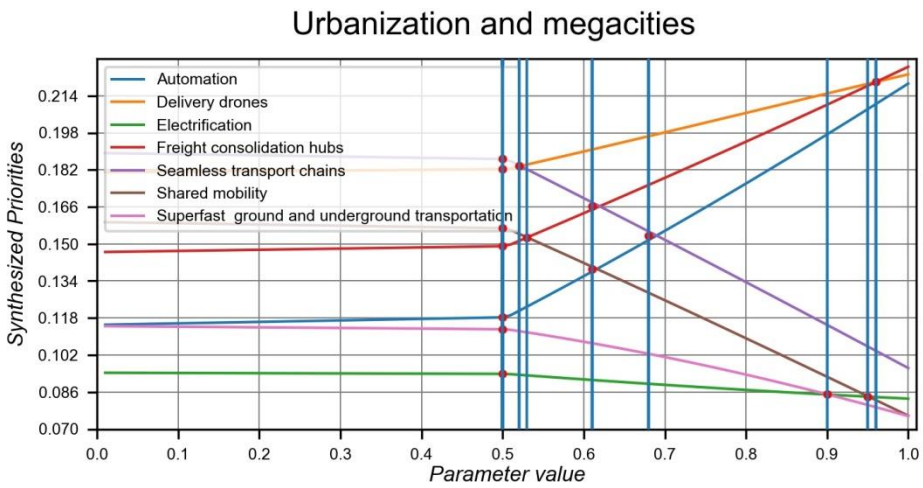



Bigger world economy
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value

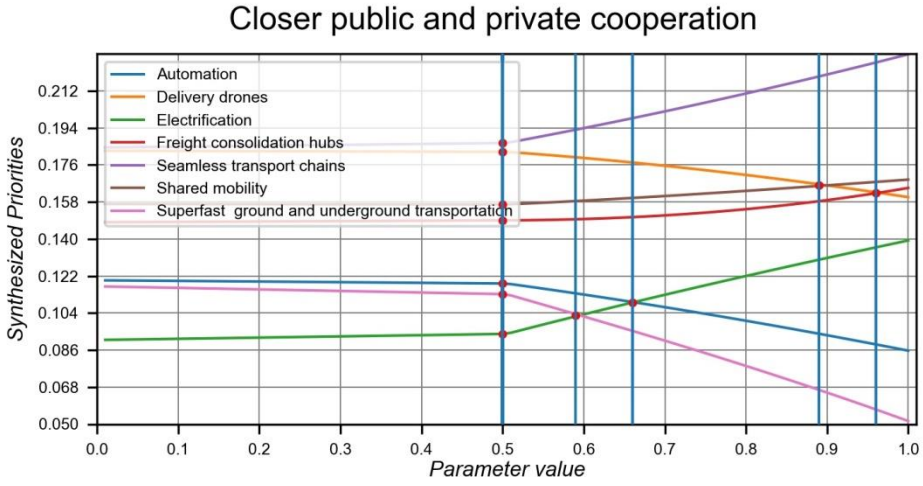

Changing lifestyle
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value

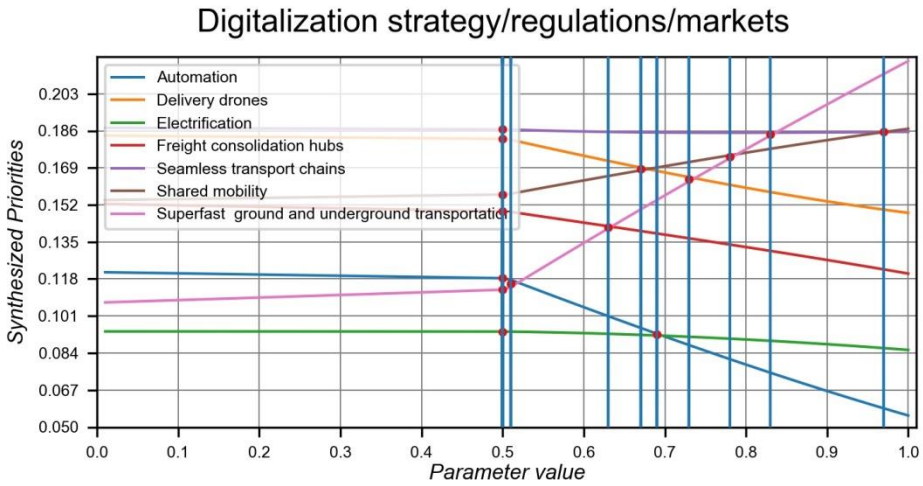

Energy demand and sources
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value

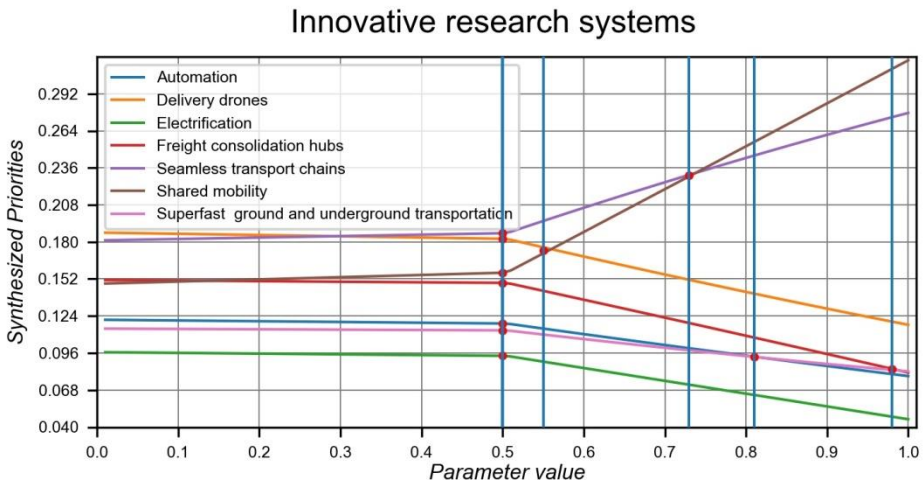


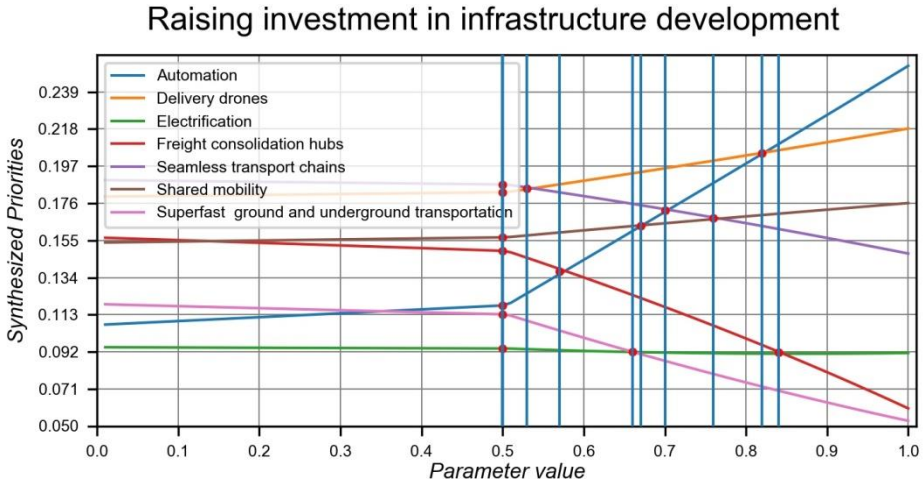


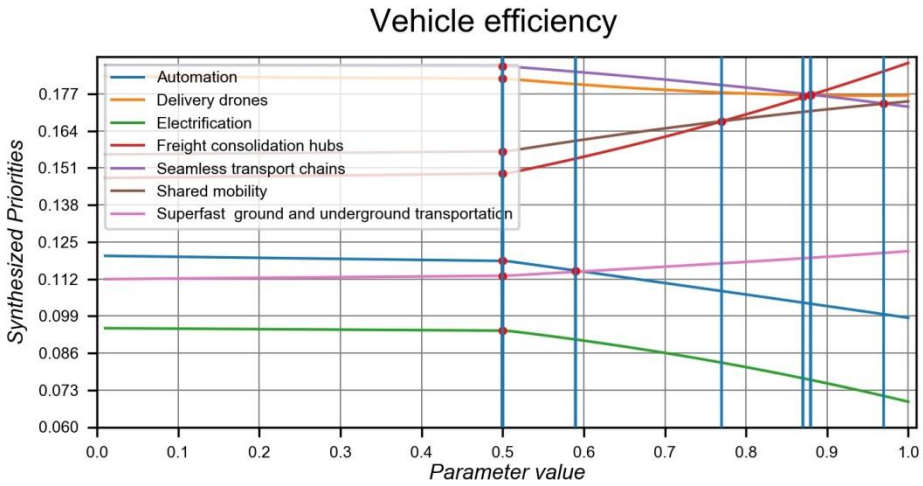
POLITICAL IMPERATIVES



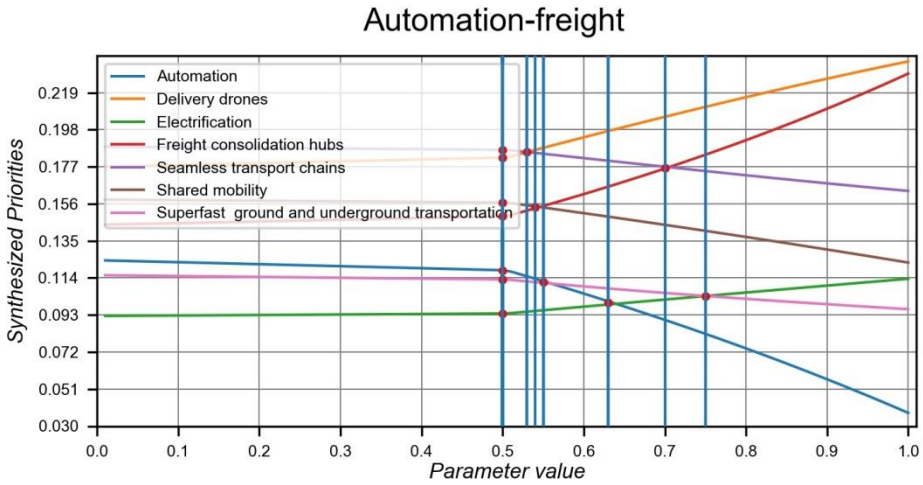

Digitalization strategy/regulations/markets
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value

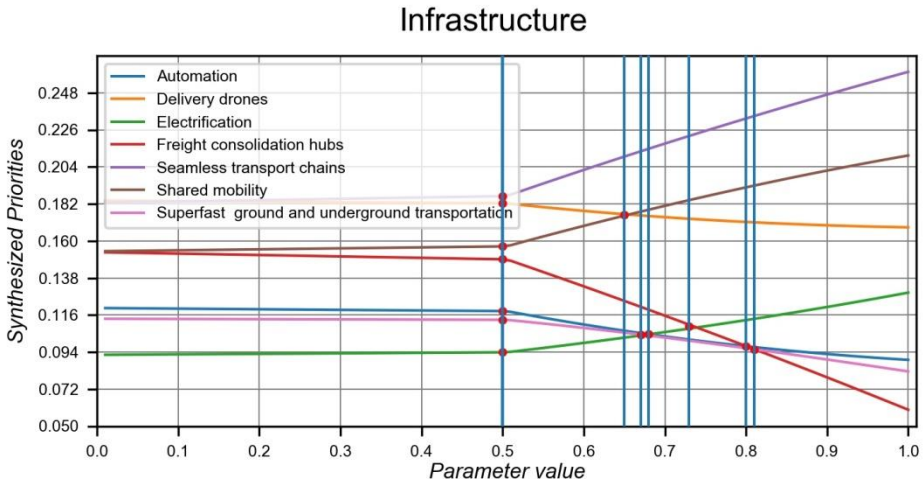

Innovative research systems
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value


Raising investment in infrastructure development
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value



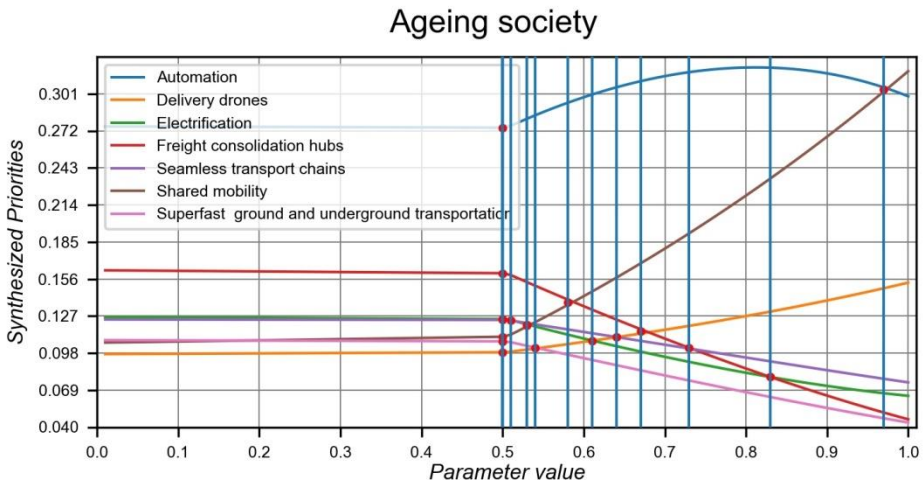
TEHNOLOGICAL ADVANCES

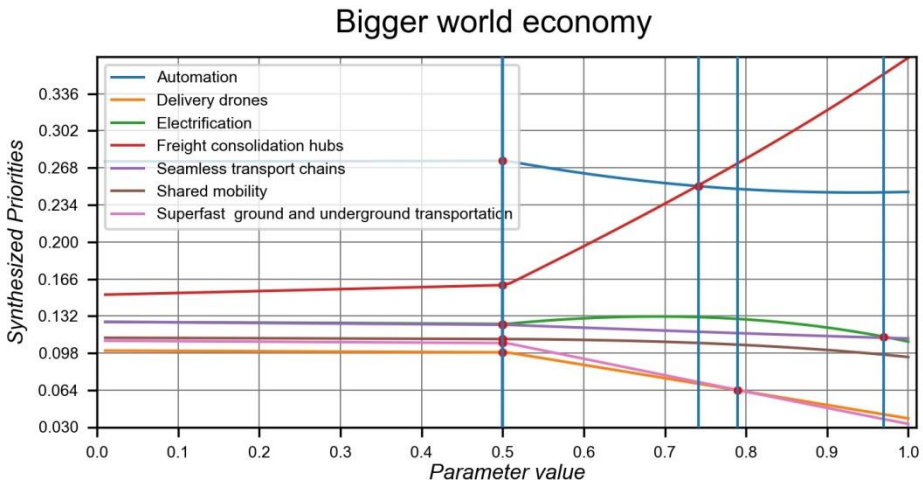


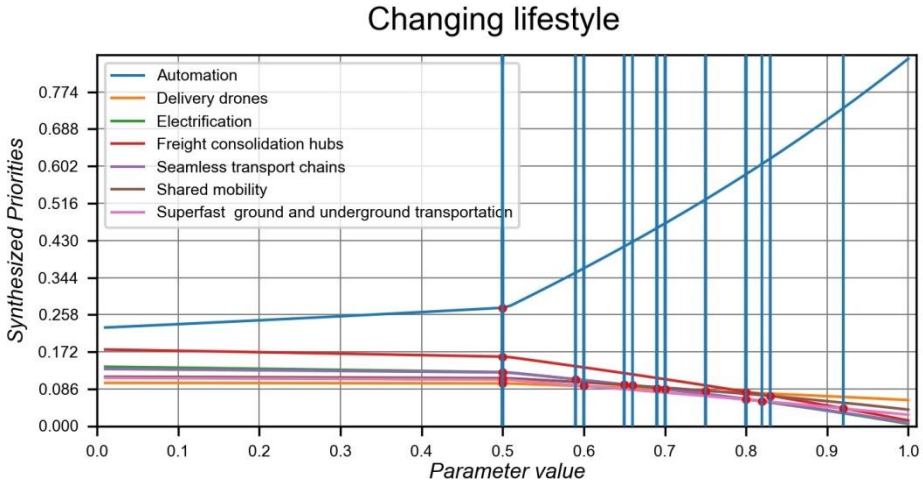


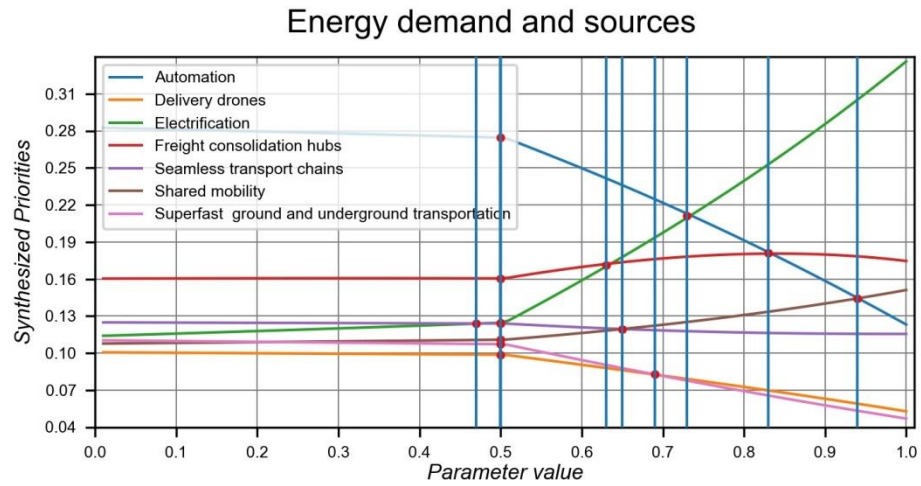
32. POLICY-MAKERS

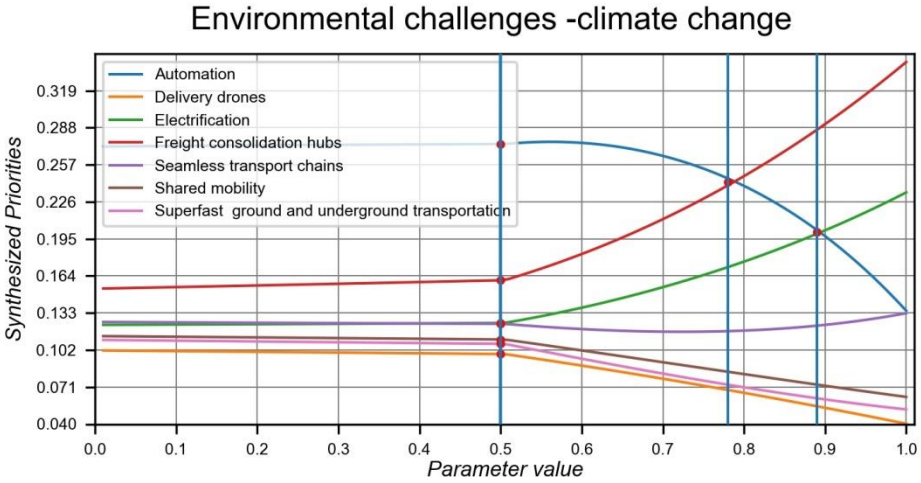
MEGATRENDS

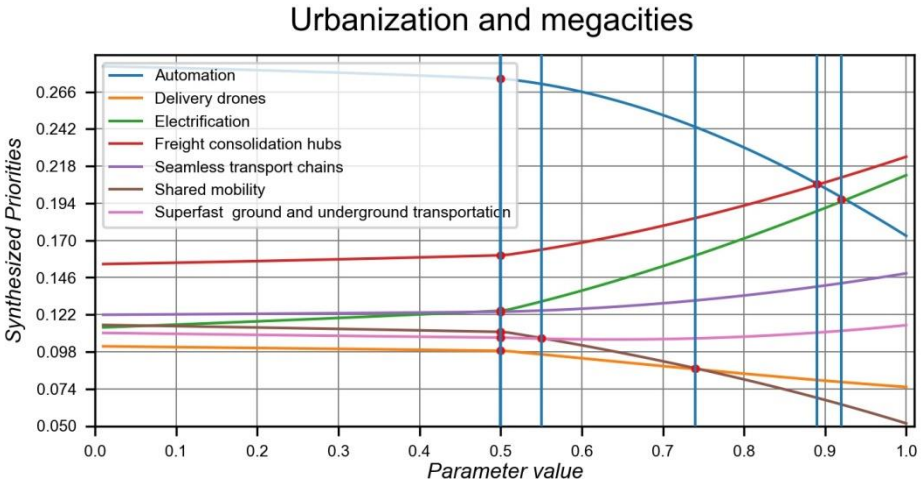

Ageing society
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value


Bigger world economy
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value

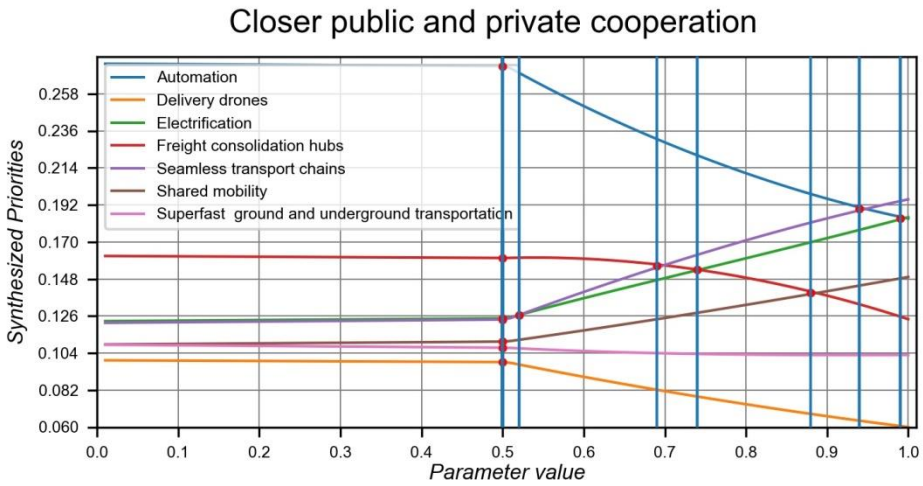

Changing lifestyle
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value

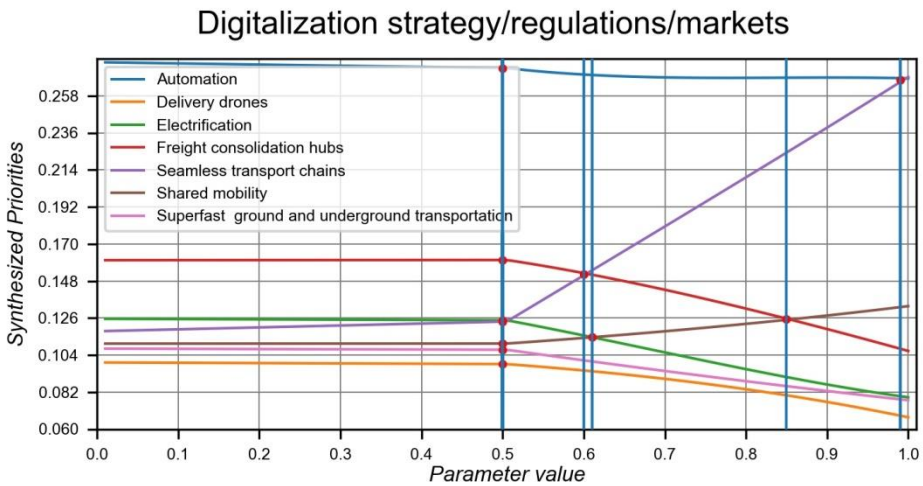


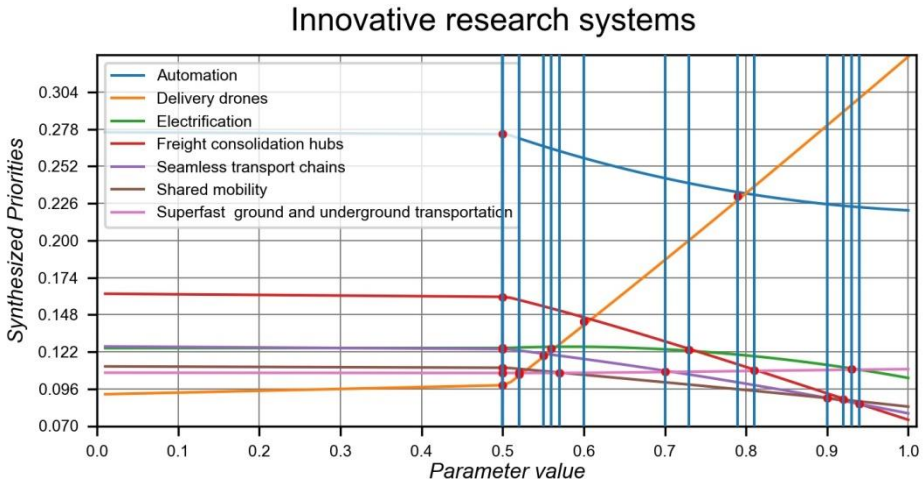


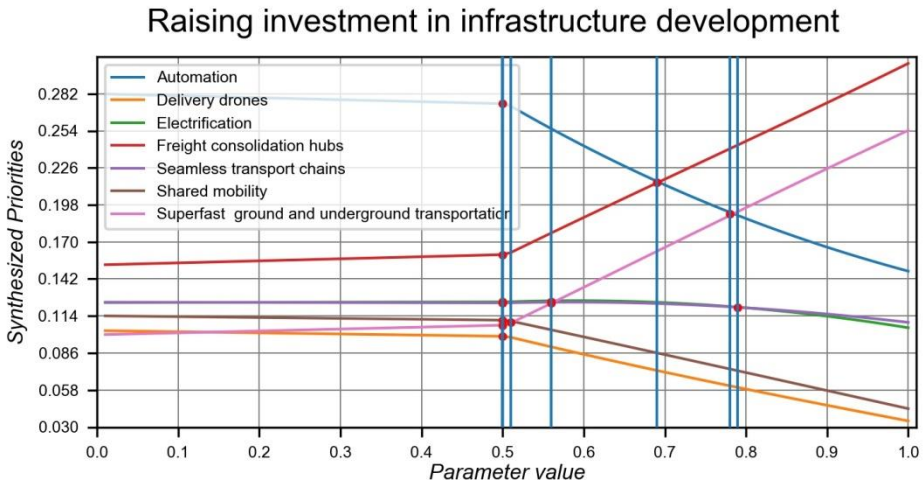


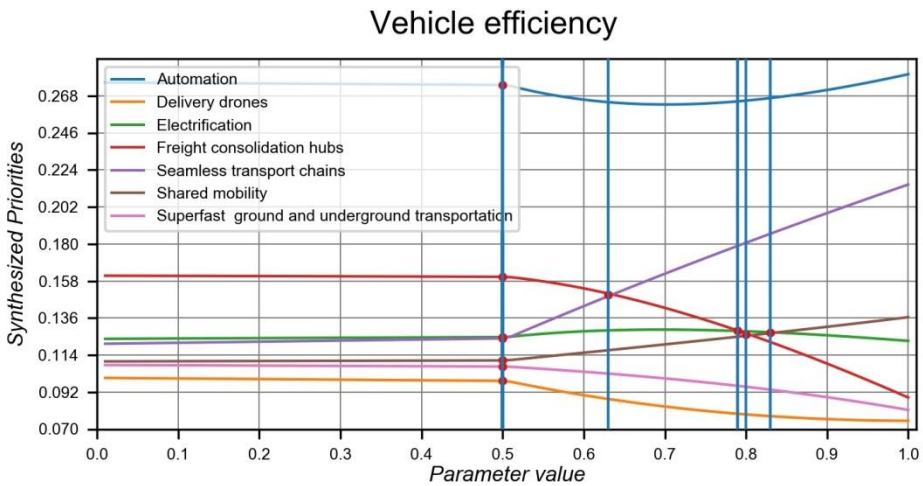
POLITICAL IMPERATIVES


Closer public and private cooperation
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value

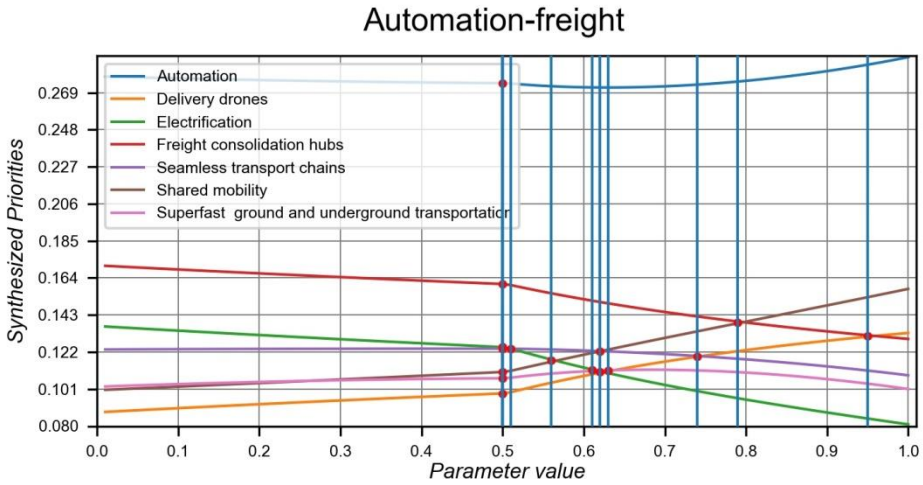

Digitalization strategy/regulations/markets
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value

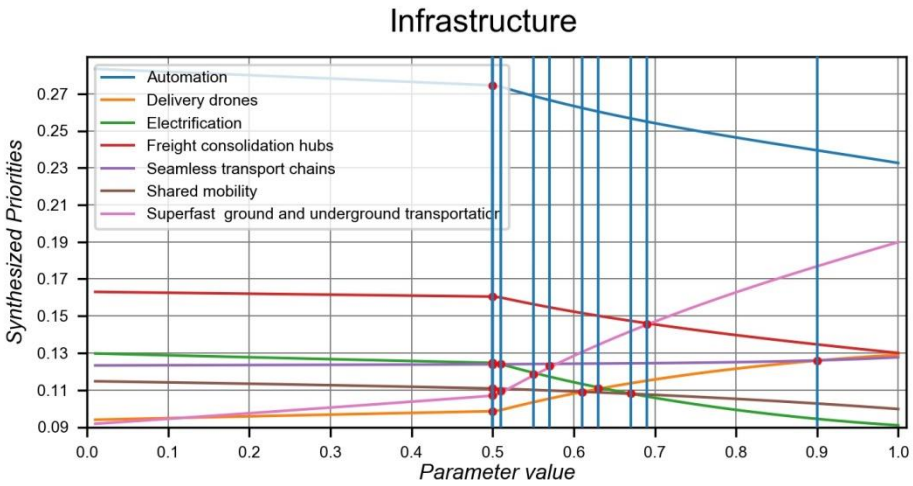

Innovative research systems
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value





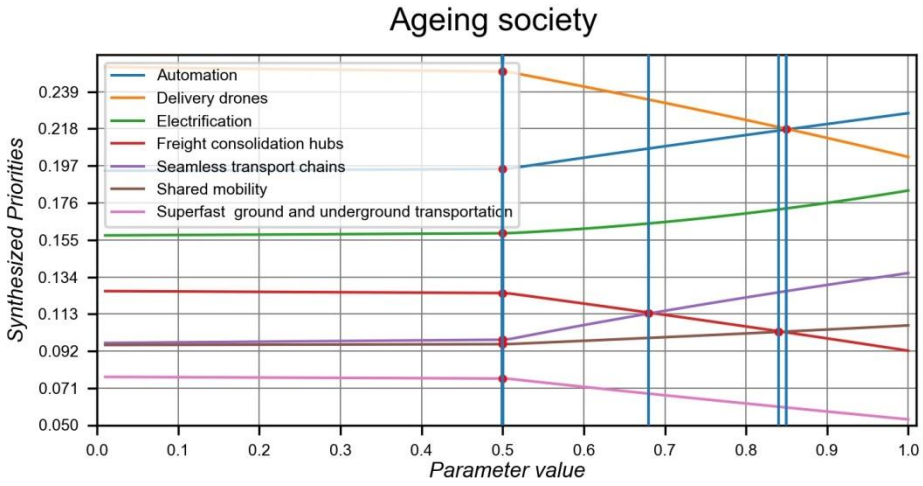
TEHNOLOGICAL ADVANCES

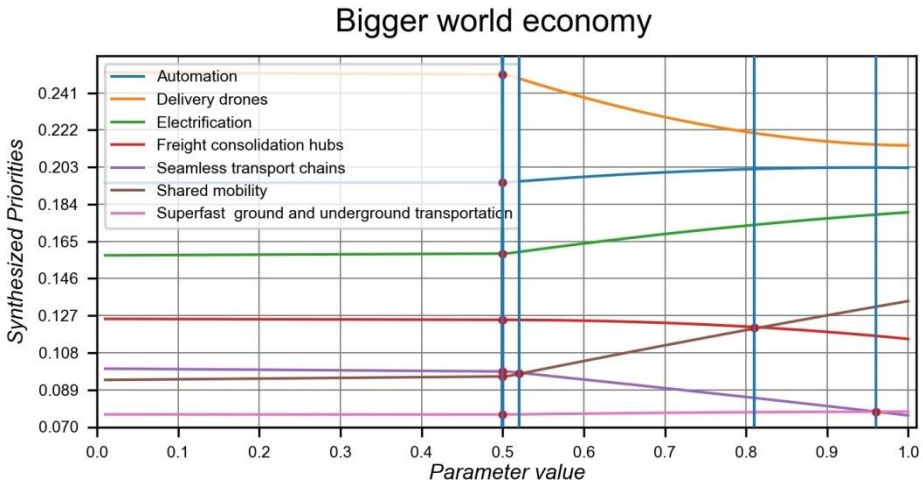


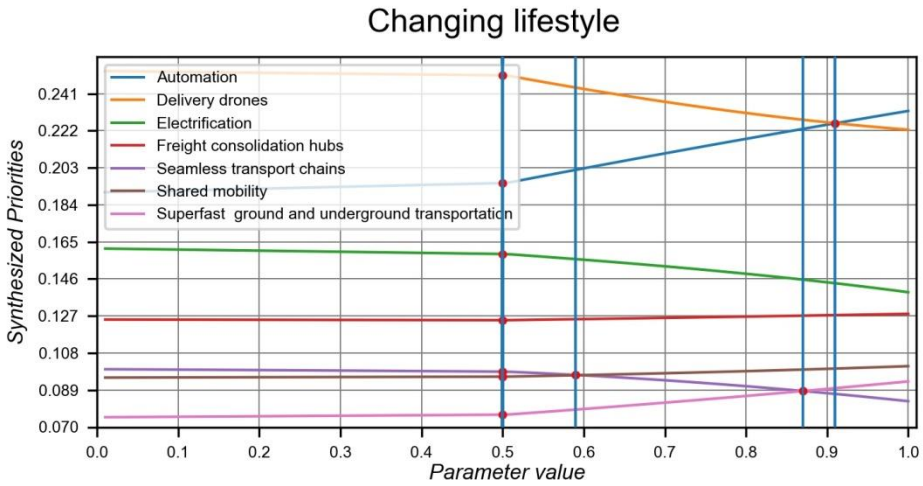


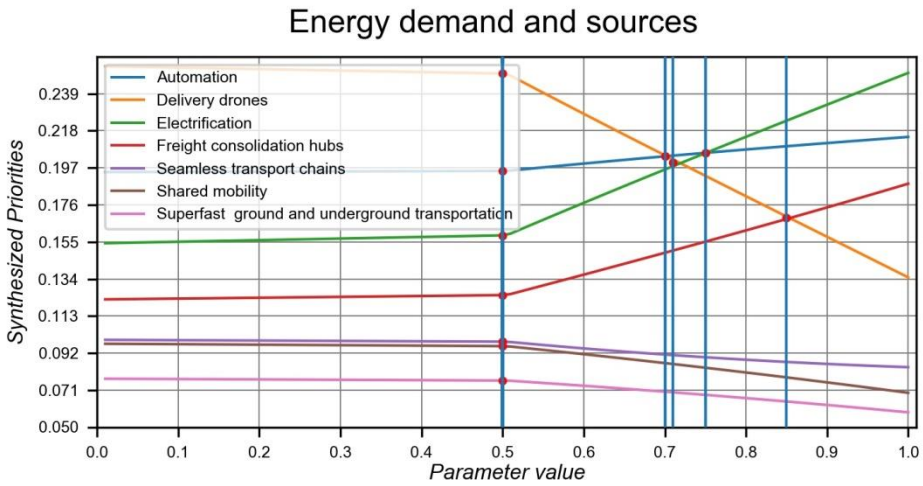
4. INDUSTRY

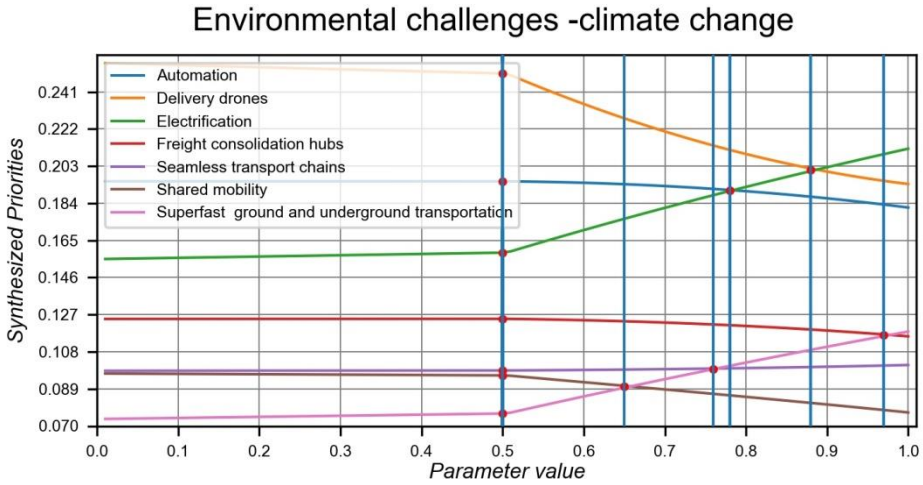
MEGATRENDS

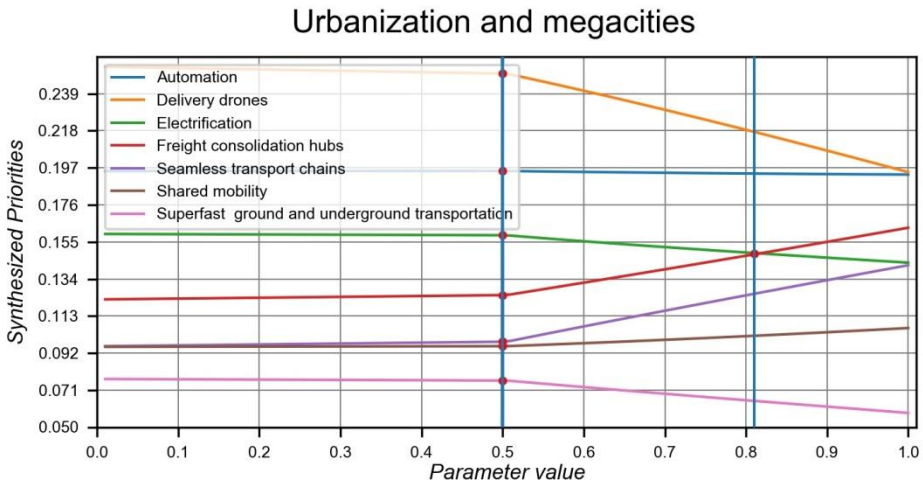




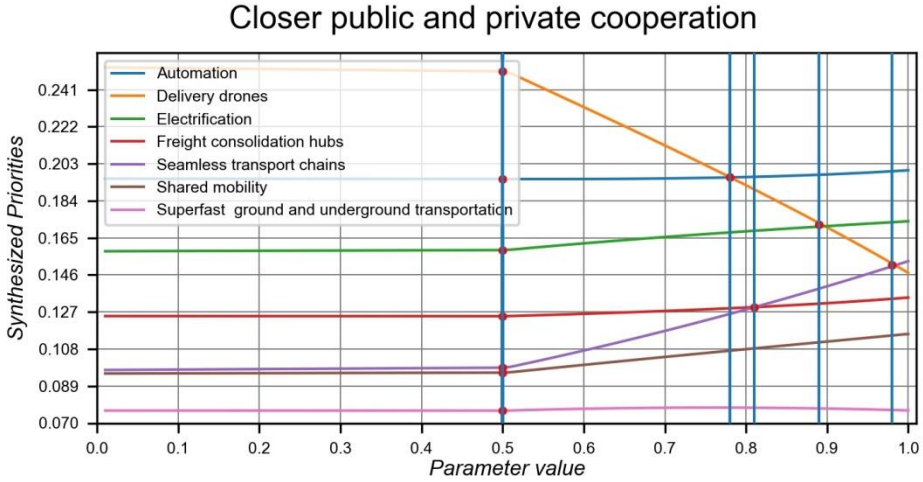

Changing lifestyle
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value

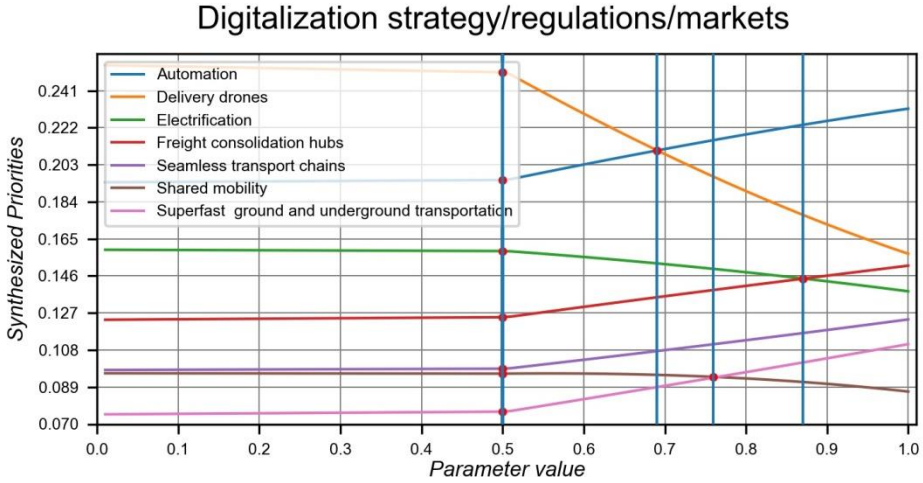

Energy demand and sources
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value

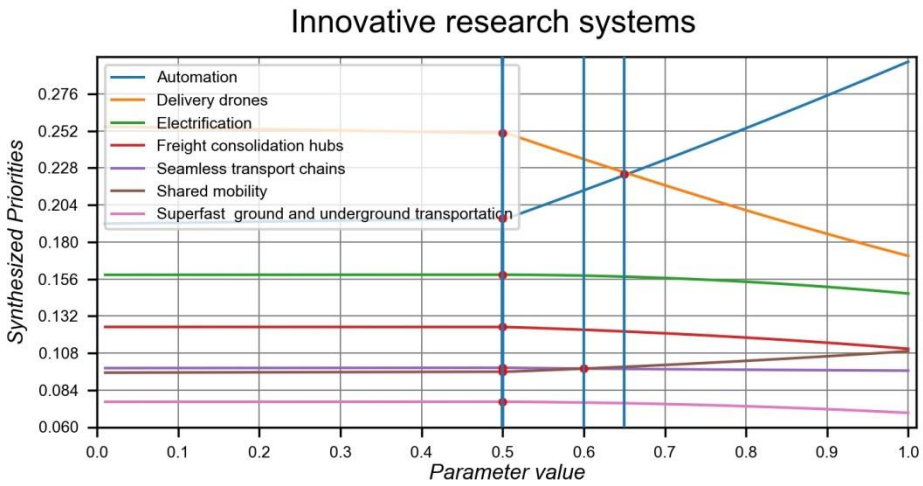

Environmental challenges -climate change
Automation
Delivery drones
Electrification
Freight consolidation hubs
Seamless transport chains
Shared mobility
Superfast ground and underground transportation
Synthesized Priorities
Parameter value

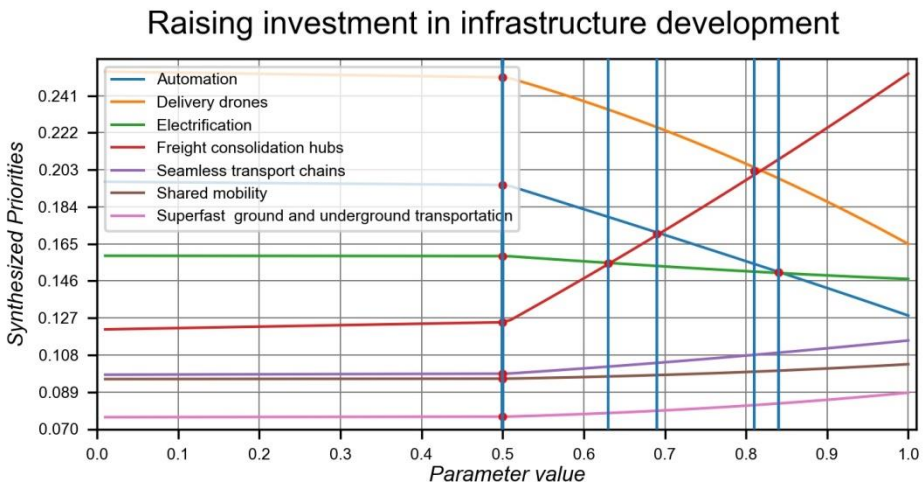


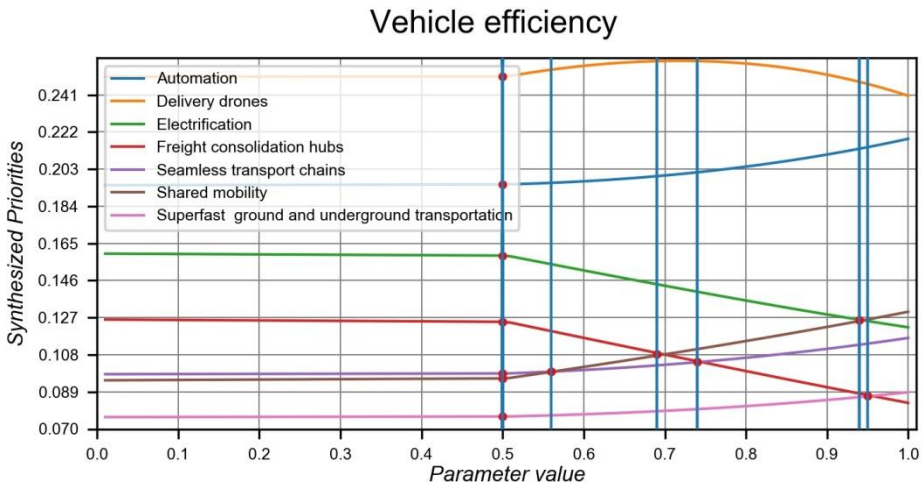
POLITICAL IMPERATIVES



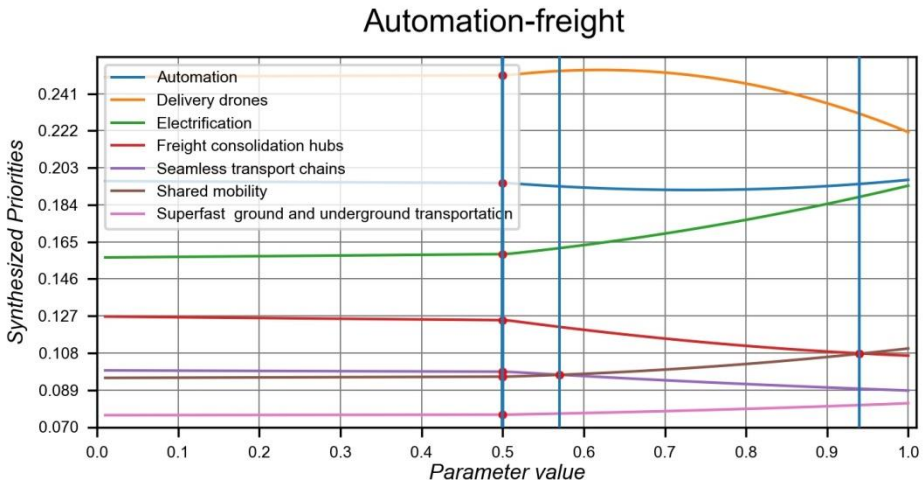


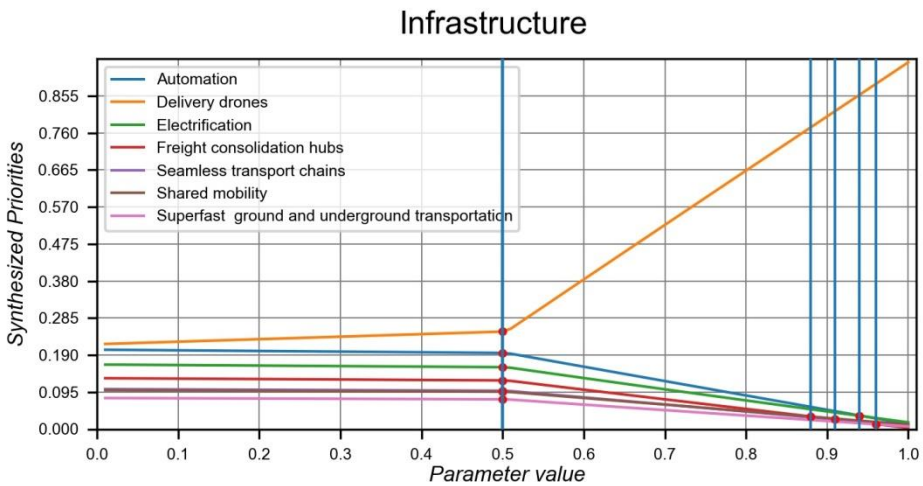




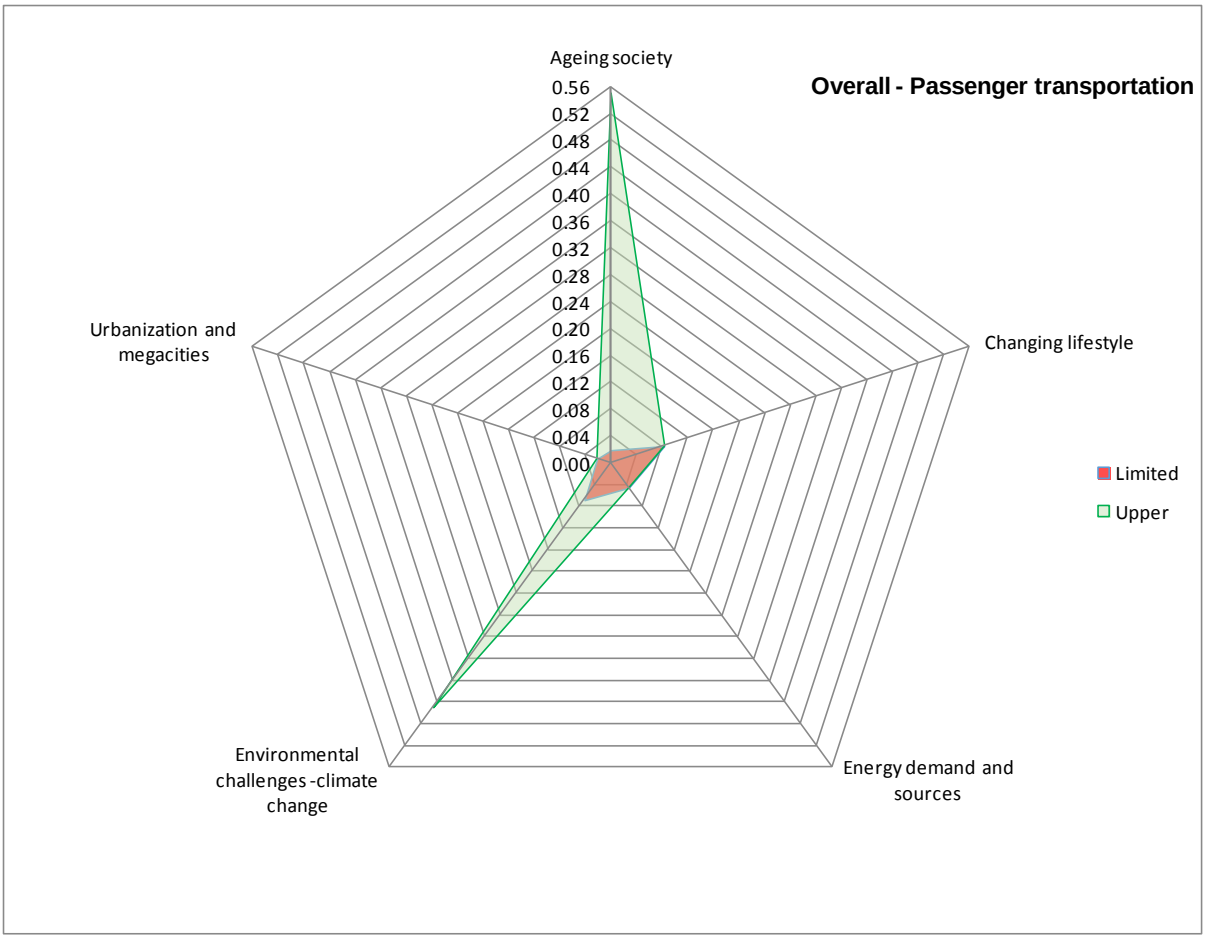


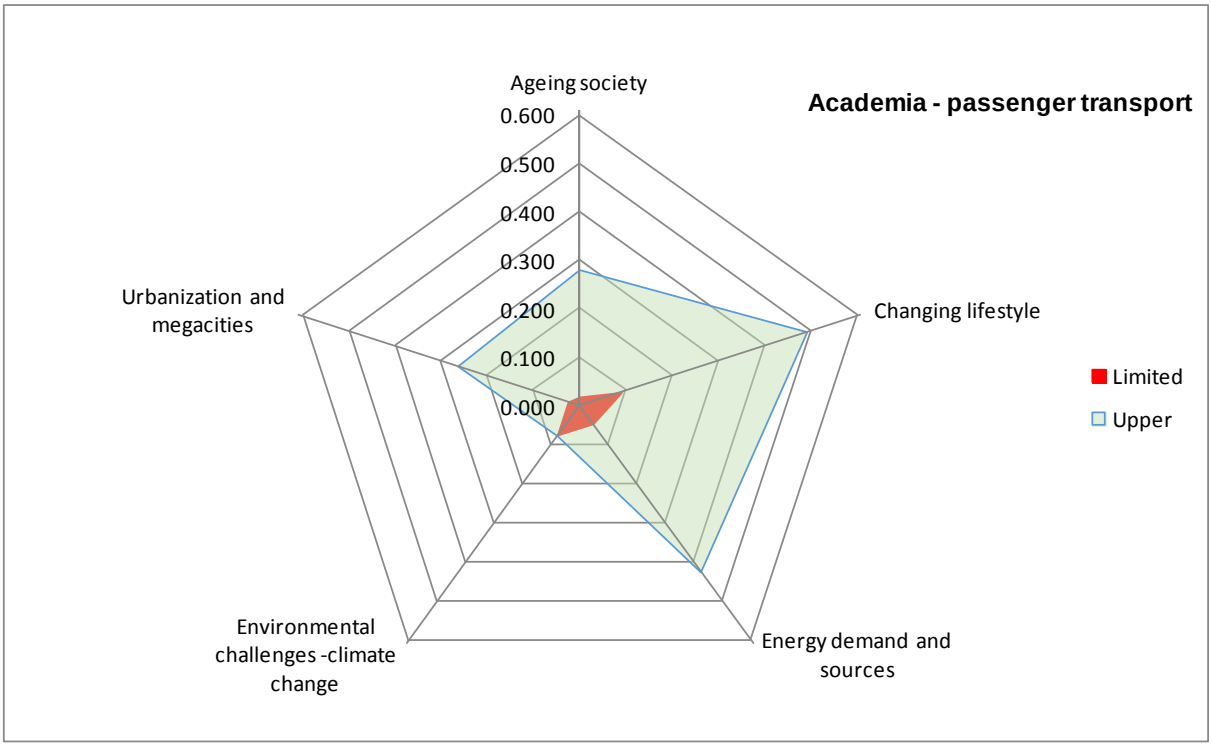
TEHNOLOGICAL ADVANCES

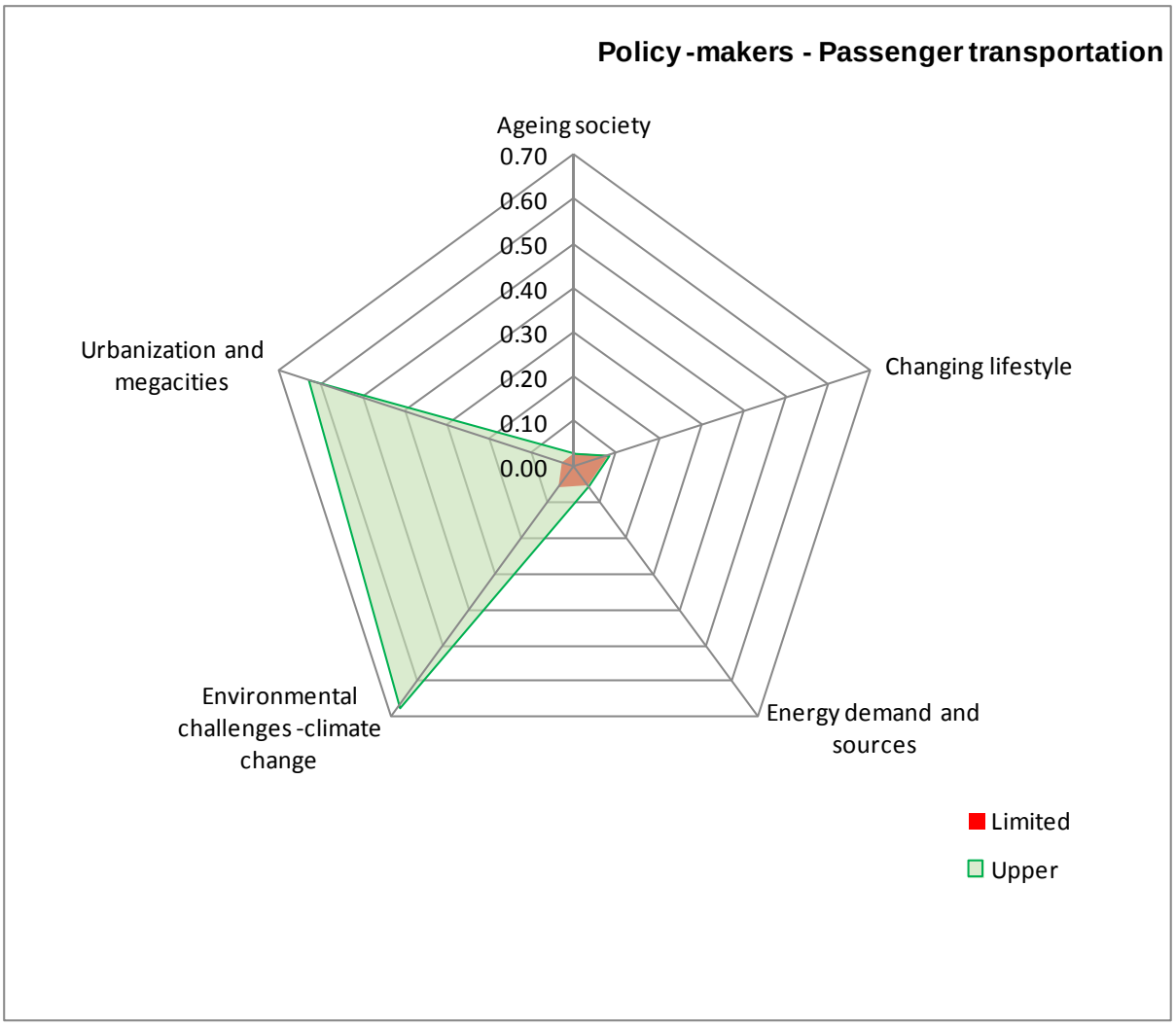


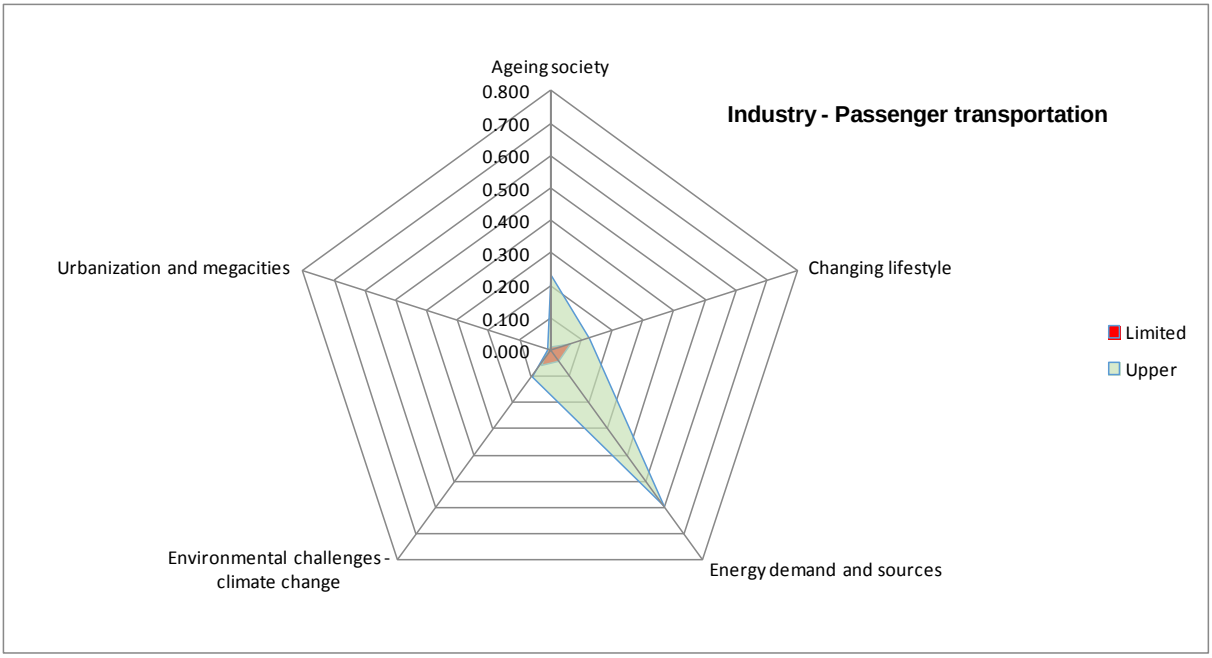


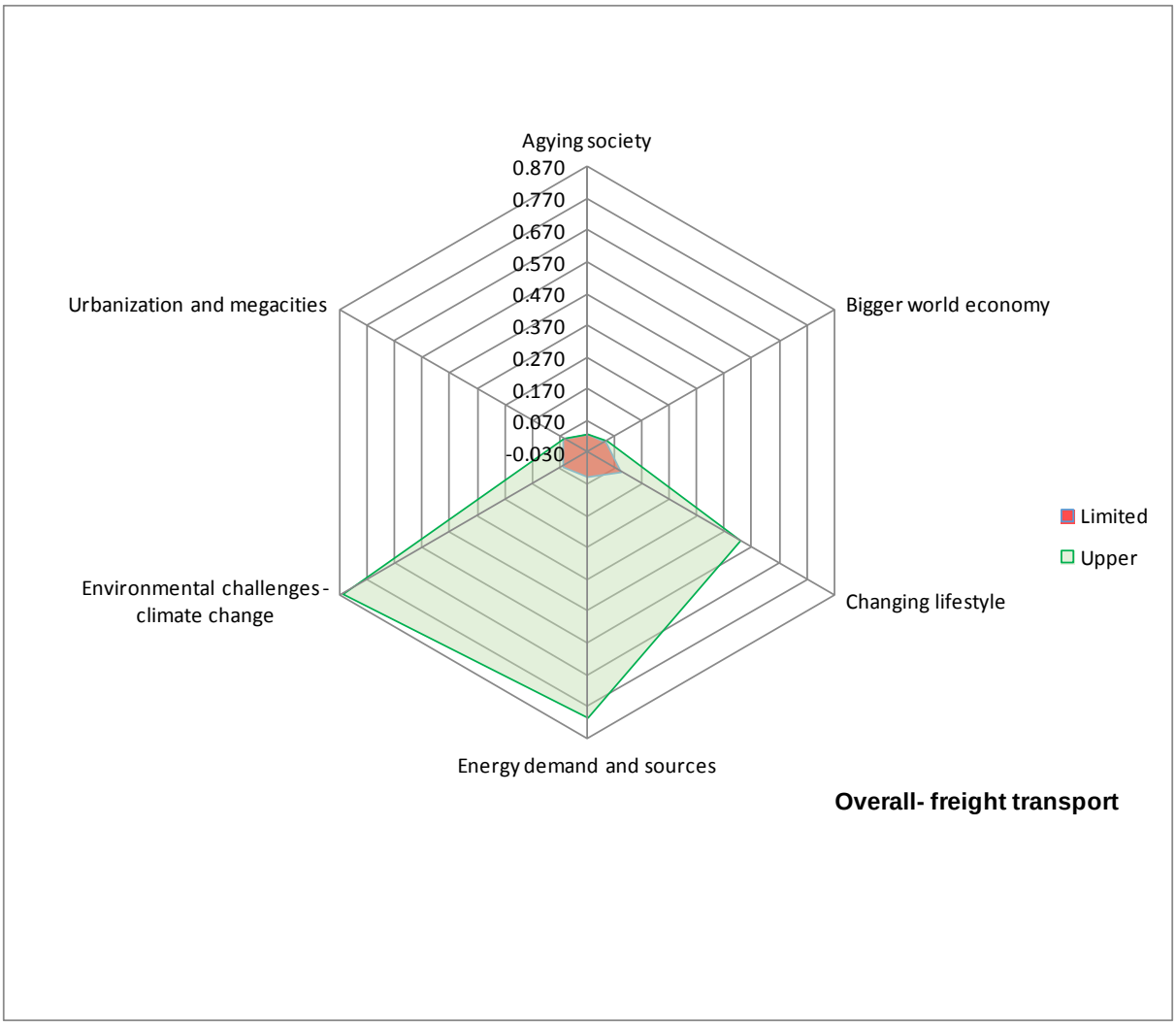
Stability analysis for all megatrends, political imperatives and technological advances for different groups and for overall are given bellow

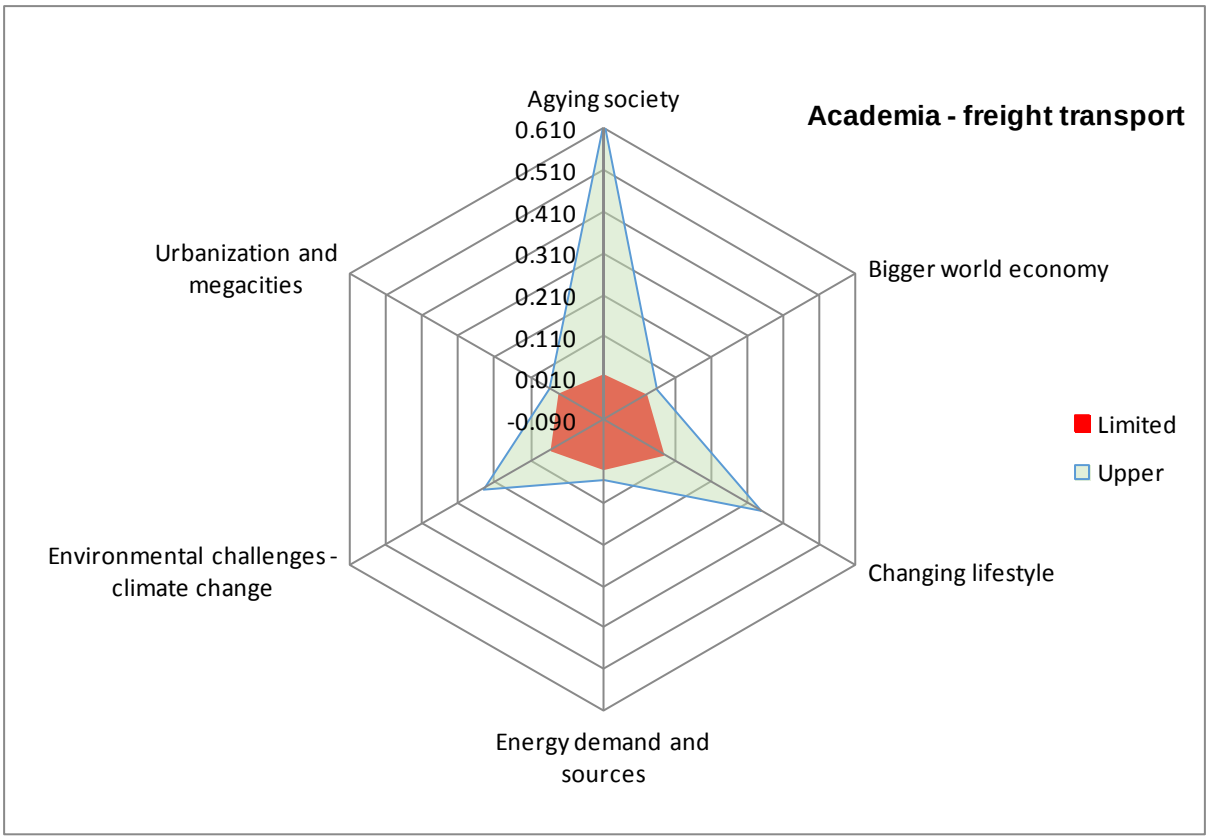

Overall - Passenger transportation
Ageing society
0.56
0.52
0.48
0.44
0.40
0.36
0.32
0.28
0.24
0.20
0.16
0.12
0.08
0.04
0.00
Changing lifestyle
Energy demand and sources
Environmental challenges -climate change
Urbanization and megacities
Limited
Upper

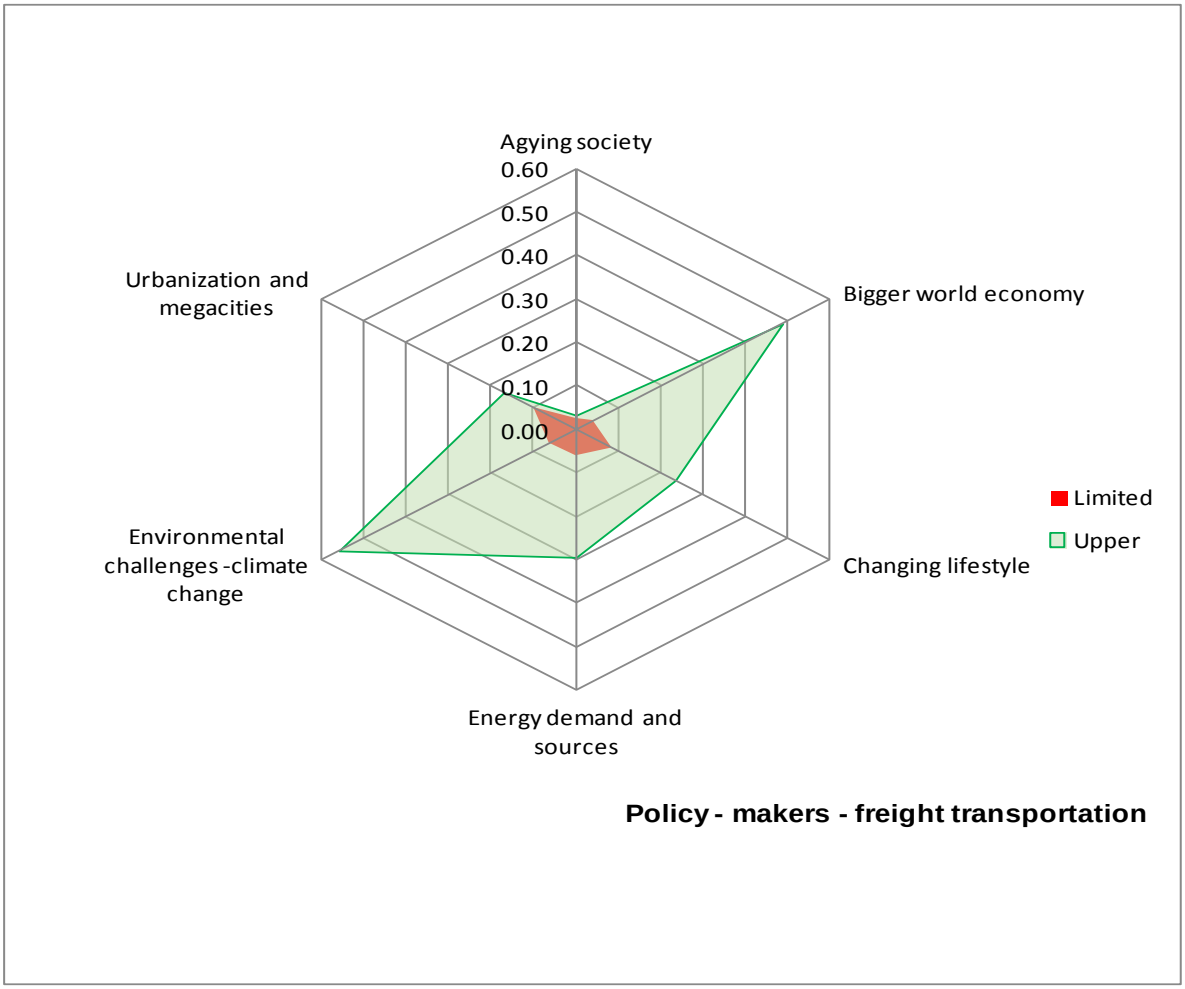

Academia - passenger transport
Ageing society
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Changing lifestyle
Energy demand and sources
Environmental challenges -climate change
Urbanization and megacities
Limited
Upper

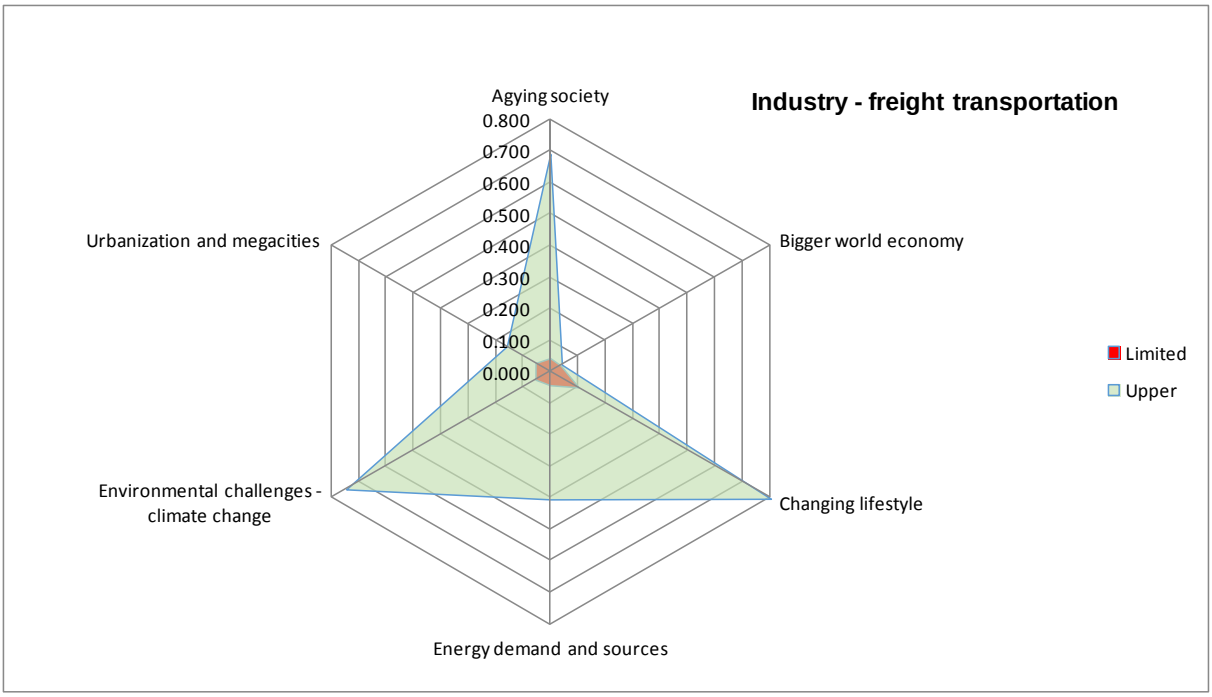

Policy-makers - Passenger transportation
Ageing society
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Changing lifestyle
Energy demand and sources
Environmental challenges -climate change
Urbanization and megacities
Limited
Upper


Industry - Passenger transportation
Ageing society
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Changing lifestyle
Energy demand and sources
Environmental challenges - climate change
Urbanization and megacities
Limited
Upper


Agying society
0.870
0.770
0.670
0.570
0.470
0.370
0.270
0.170
0.070
-0.030
Bigger world economy
Changing lifestyle
Energy demand and sources
Environmental challenges - climate change
Urbanization and megacities
Limited
Upper
Overall- freight transport


Academia - freight transport
Agying society
0.610
0.510
0.410
0.310
0.210
0.110
0.010
-0.090
Bigger world economy
Changing lifestyle
Energy demand and sources
Environmental challenges - climate change
Urbanization and megacities
Limited
Upper


Agying society
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Bigger world economy
Changing lifestyle
Energy demand and sources
Environmental challenges -climate change
Urbanization and megacities
Limited
Upper
Policy - makers - freight transportation


Industry - freight transportation
Agying society
Bigger world economy
Changing lifestyle
Energy demand and sources
Environmental challenges - climate change
Urbanization and megacities
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
Limited
Upper

11 ANNEX 3 – INTEND surveys – screenshots of survey pages sorted by appearance

The first-stage survey – screenshots of survey pages sorted by appearance

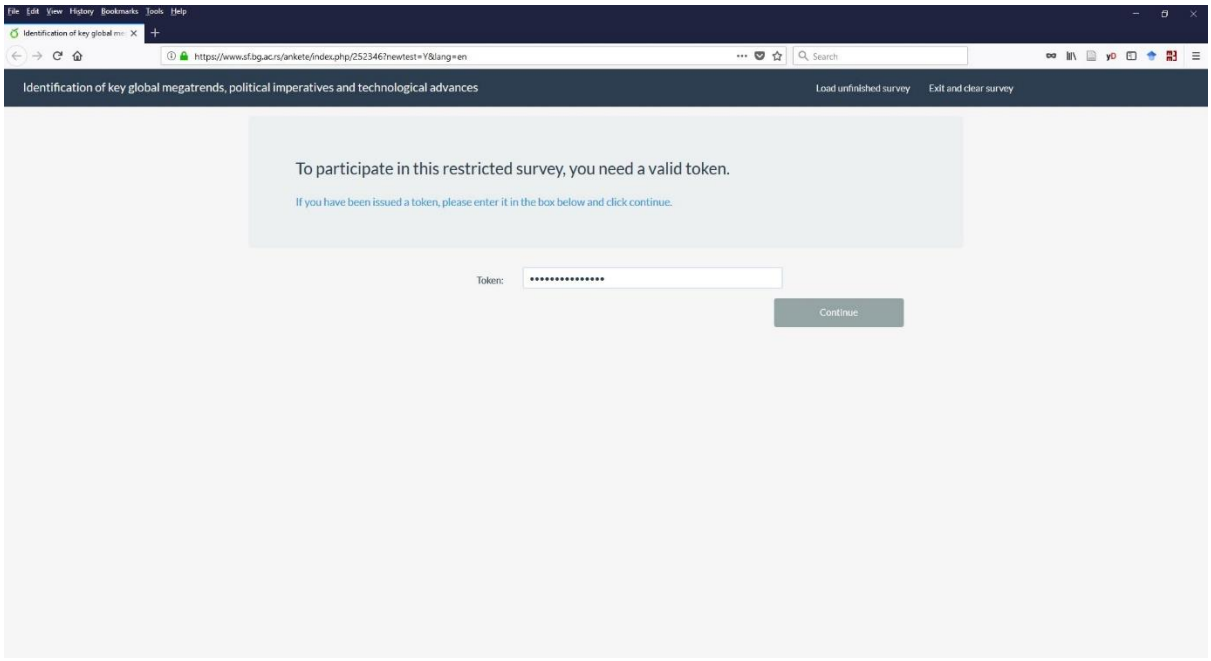


Image 3-1.1 Login page

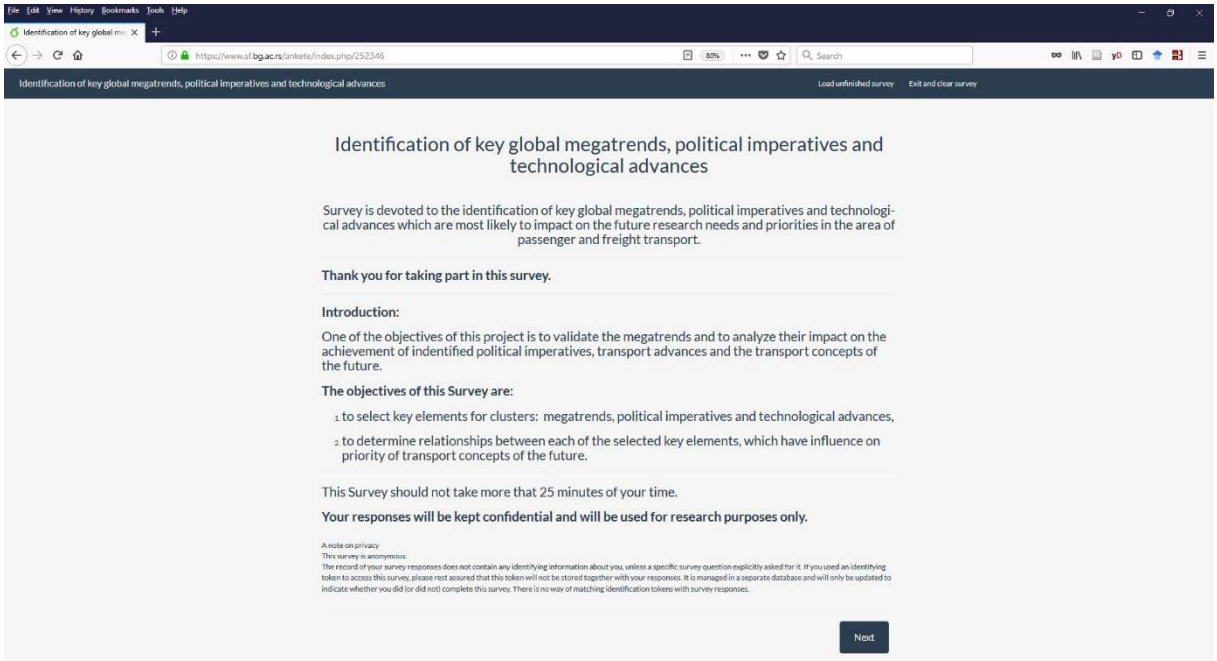


Image 3-1.2 Info page

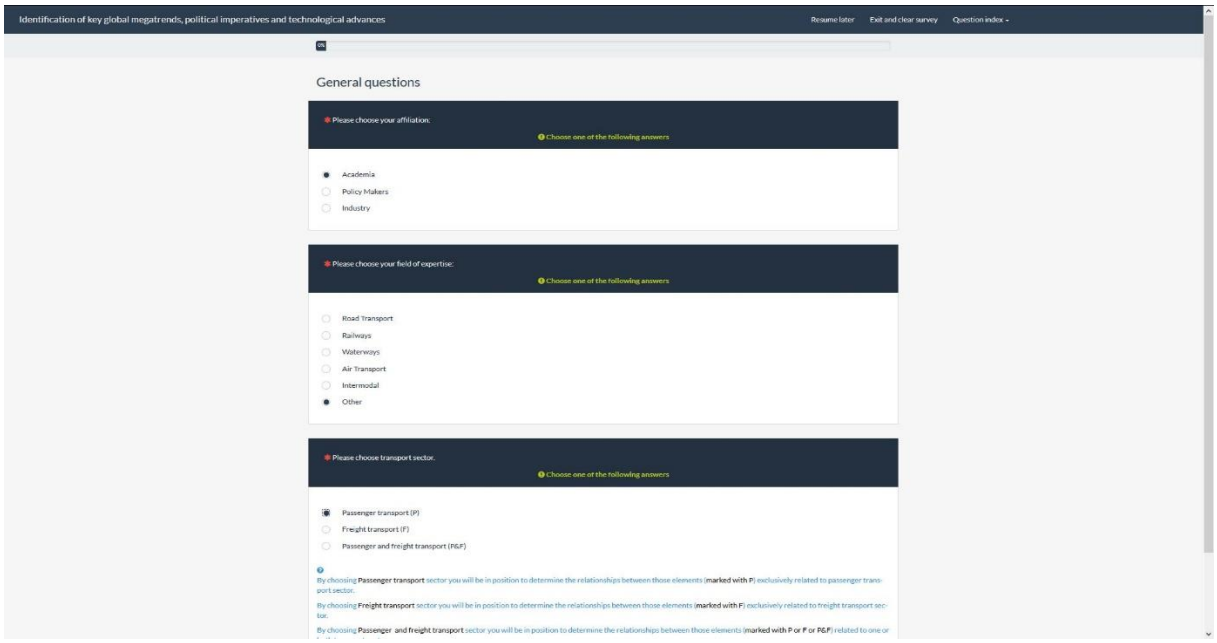


Image 3-1.3 General questions

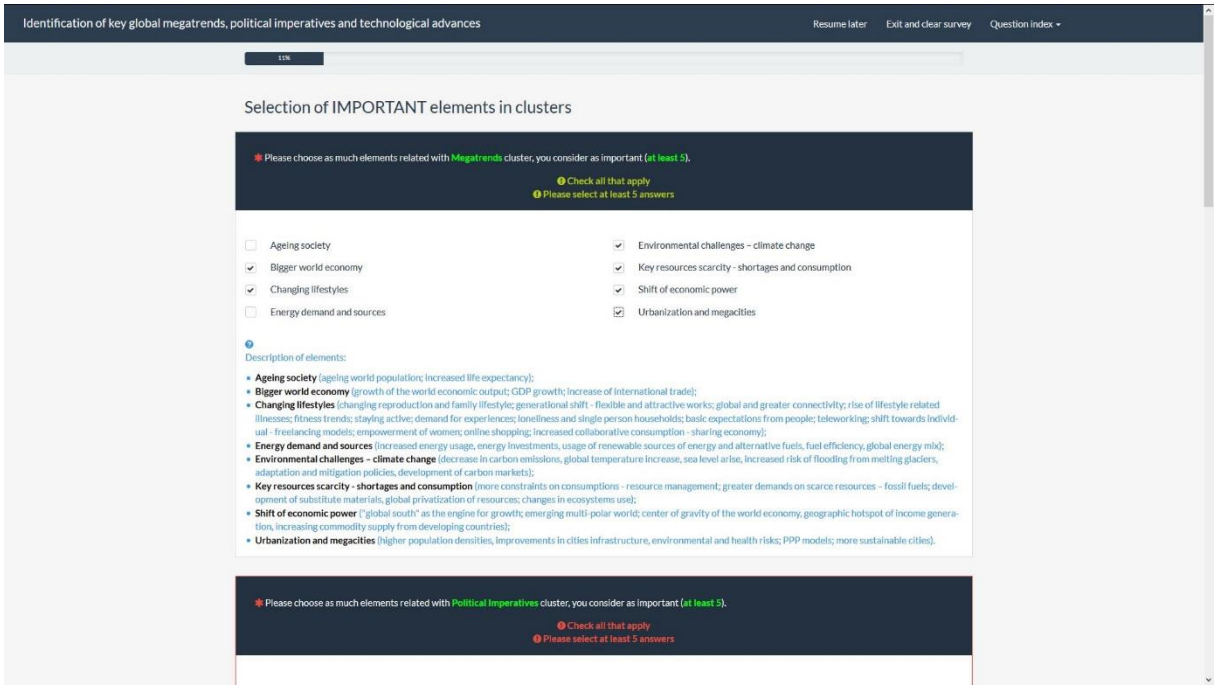


Image 3-1.4 Selection of important elements (Megatrends)

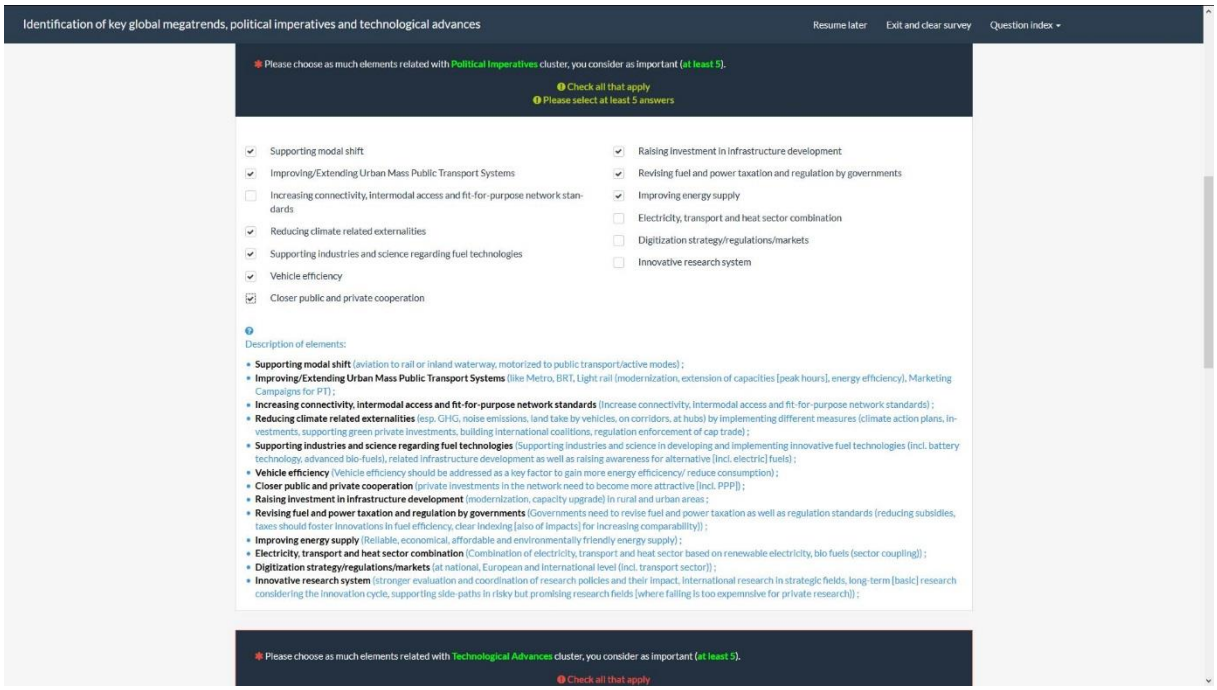


Image 3-1.5 Selection of important elements (Political imperatives)

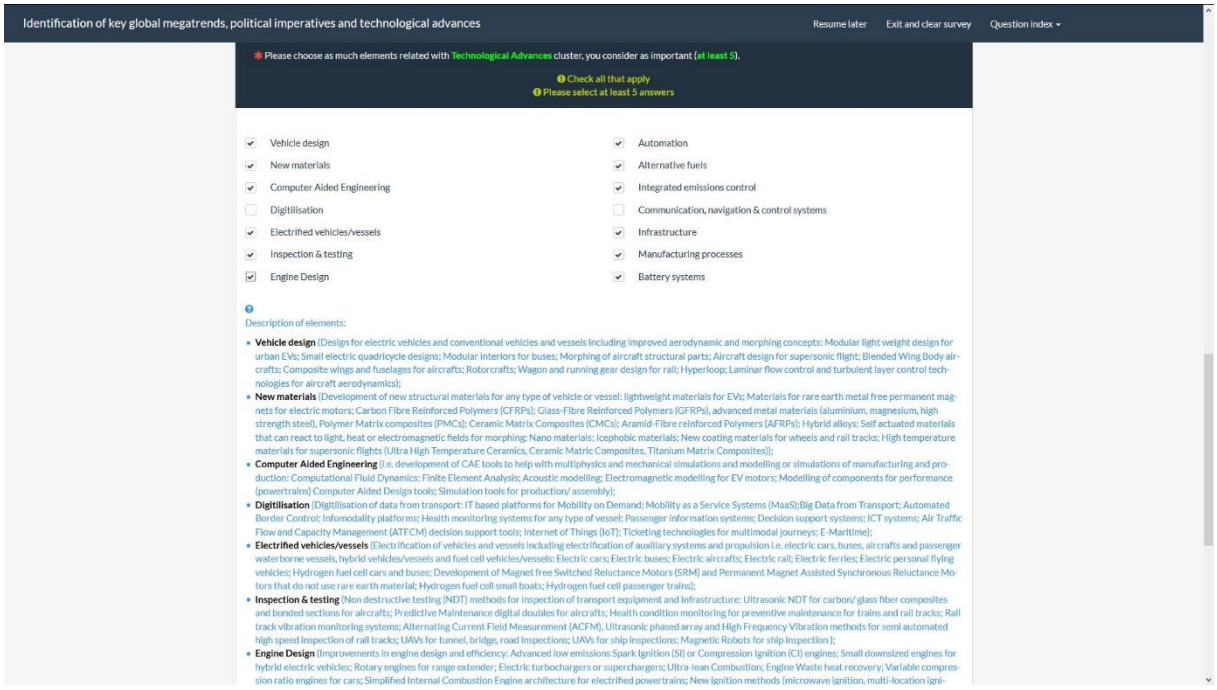


Image 3-1.6 Selection of important elements (Technological advances)

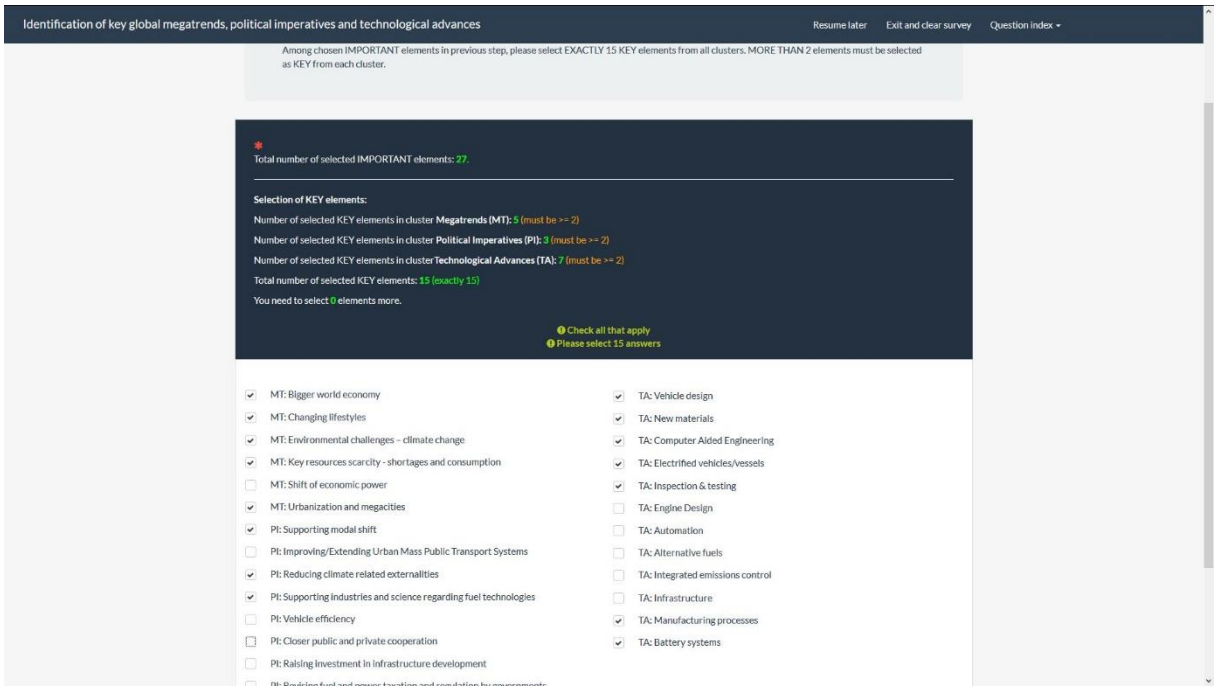


Image 3-1.7 Selection of key elements

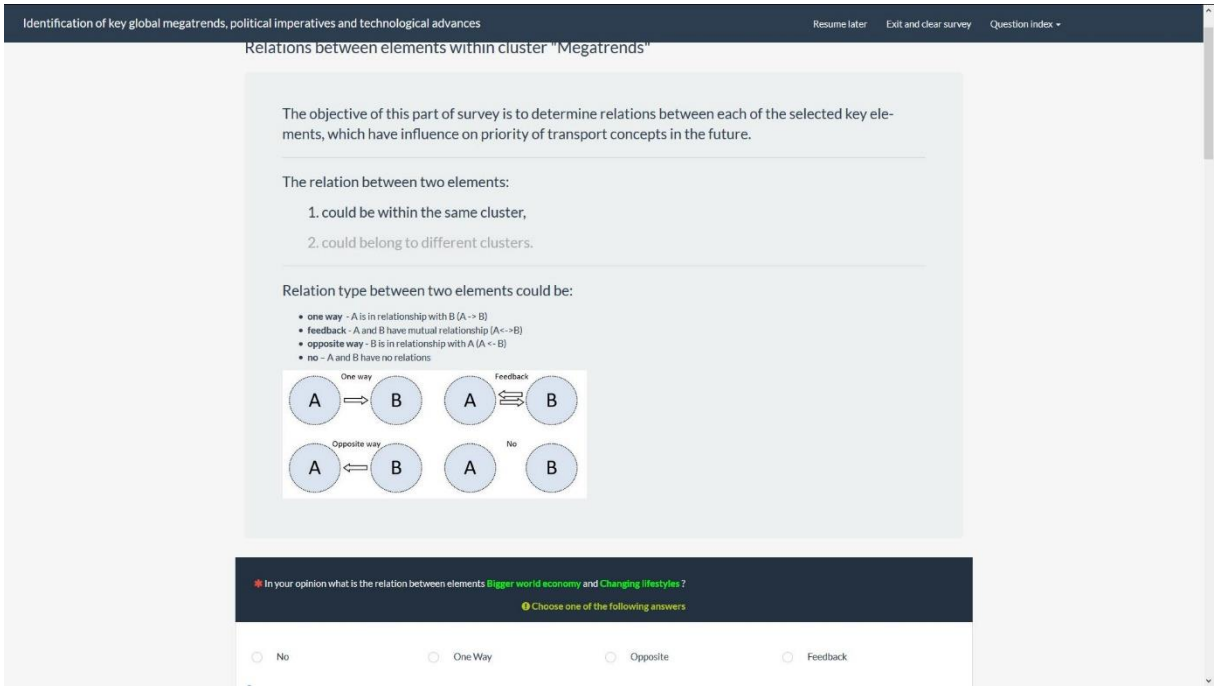


Image 3-1.8 Relation between elements (1/2)

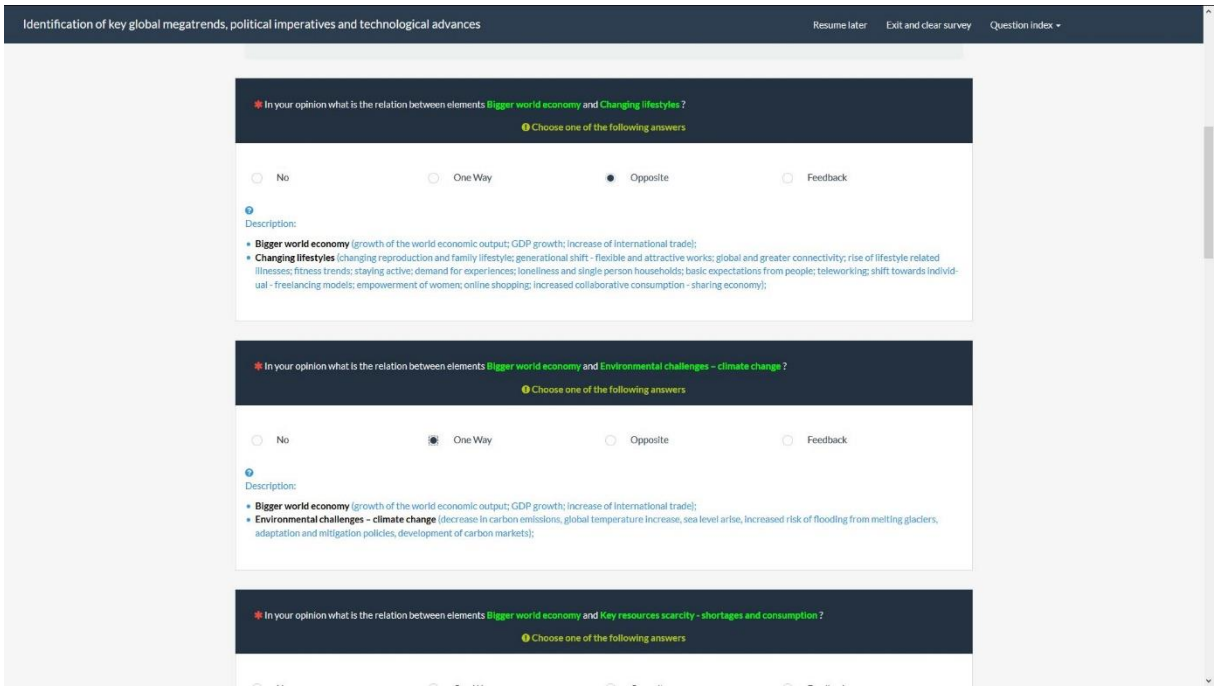


Image 3-1.9 Relation between elements (2/2)

The second-stage survey – screenshots of survey pages sorted by appearance

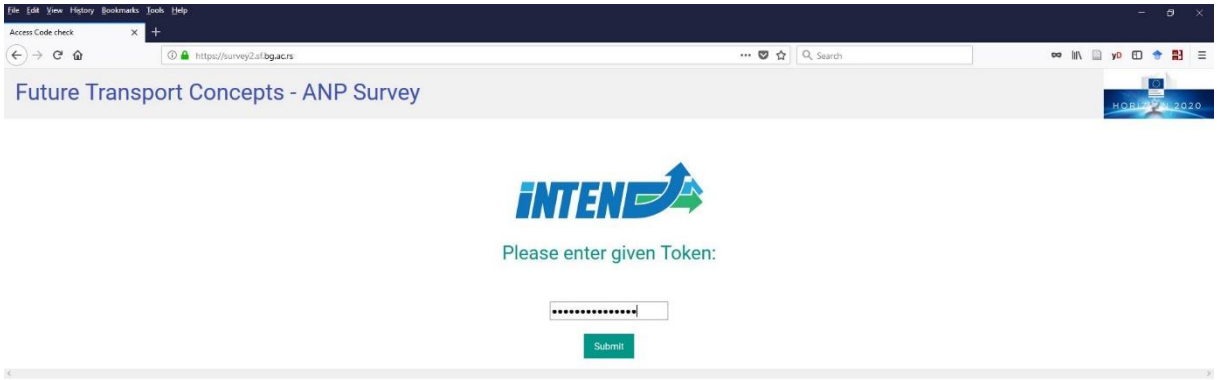


Image 3-2.1 Login page

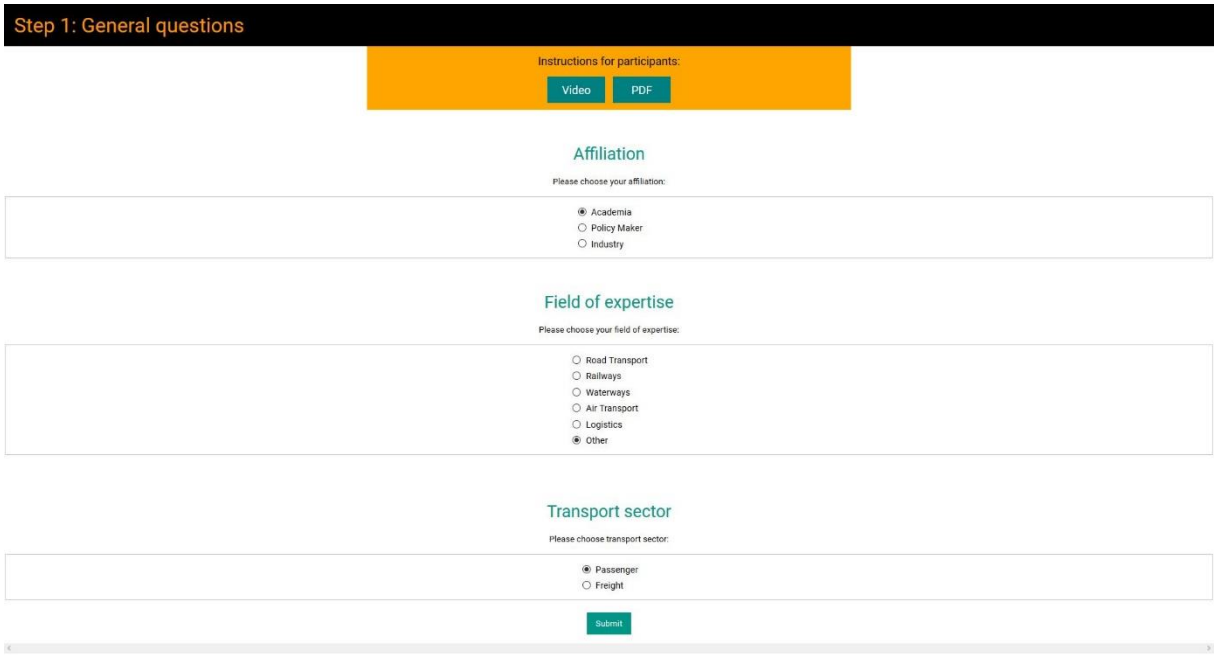


Image 3-2.2 General questions

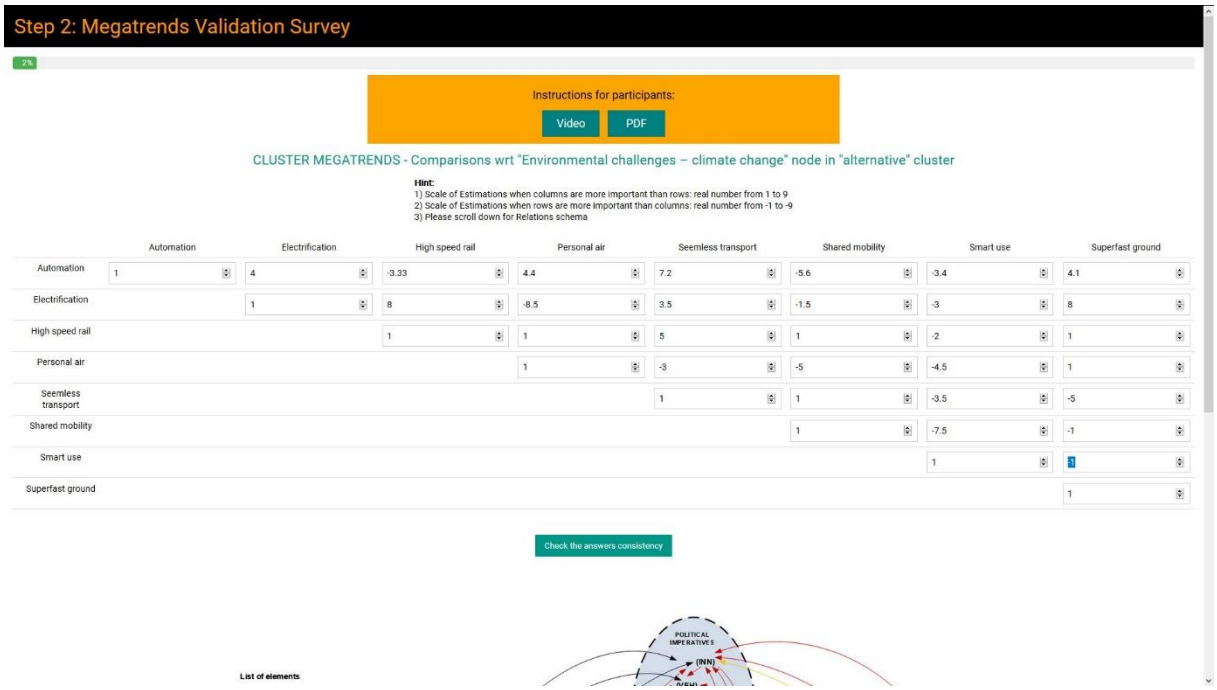


Image 3-2.3 Relationships estimation page (1/2)

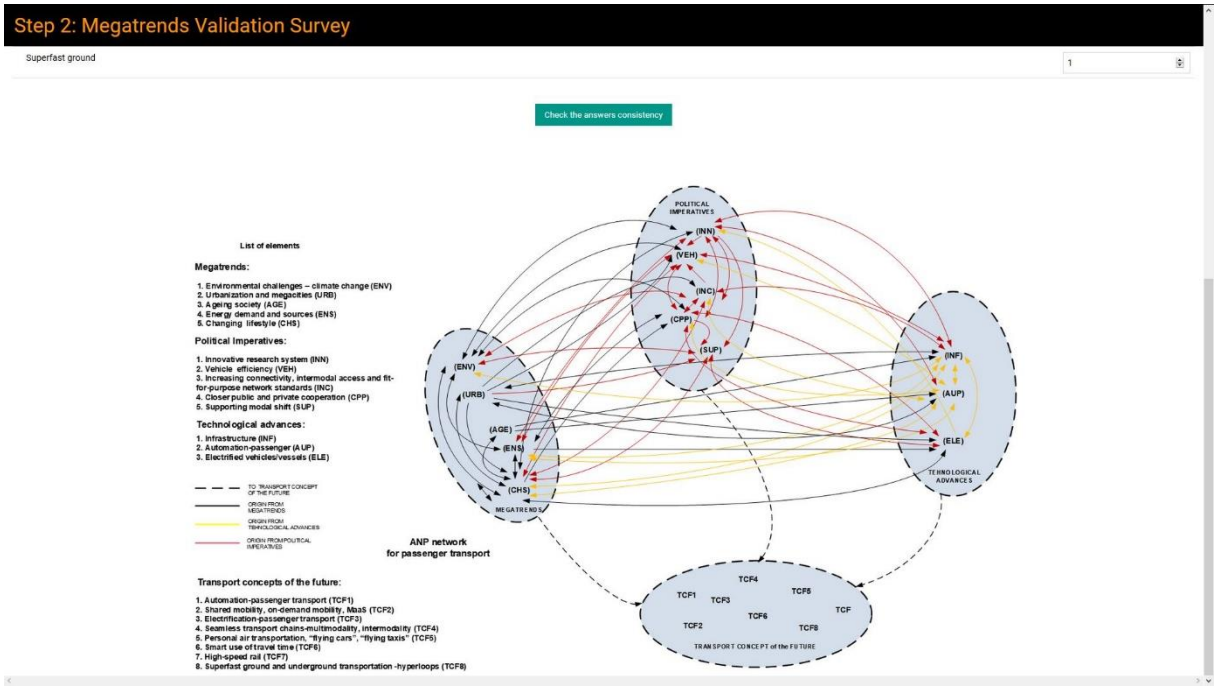


Image 3-2.4 Relationships estimation page (2/2)

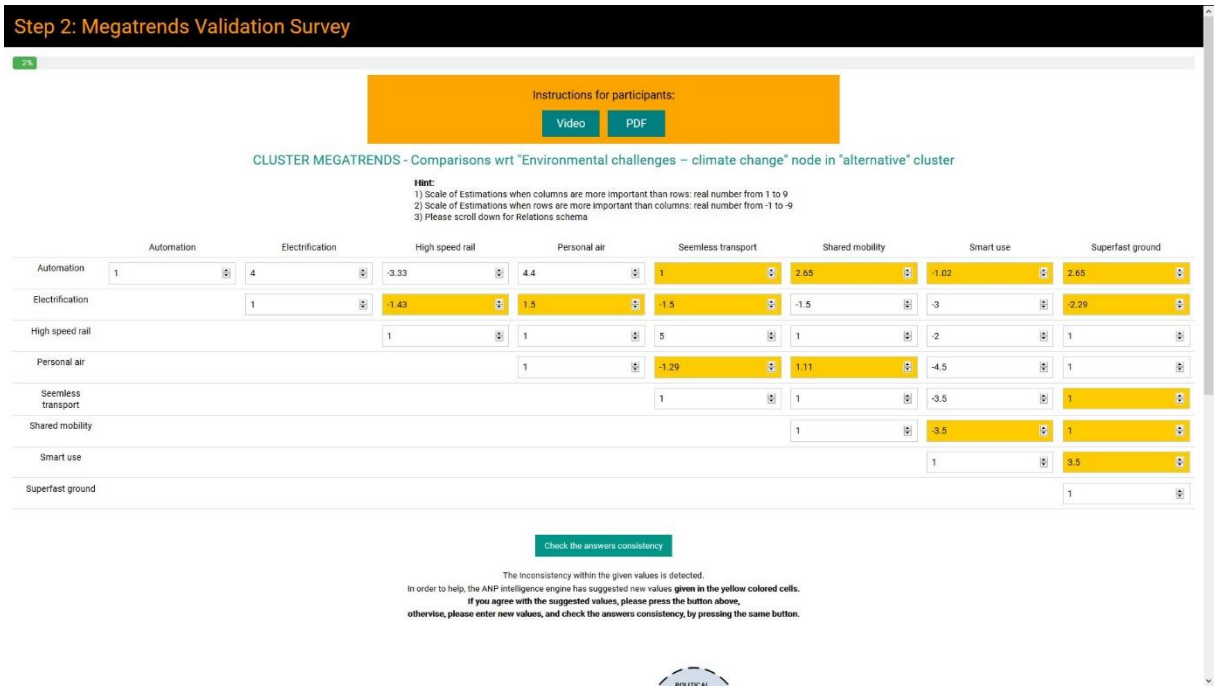


Image 3-2.5 Relationships estimation page – ANP intelligence suggestions

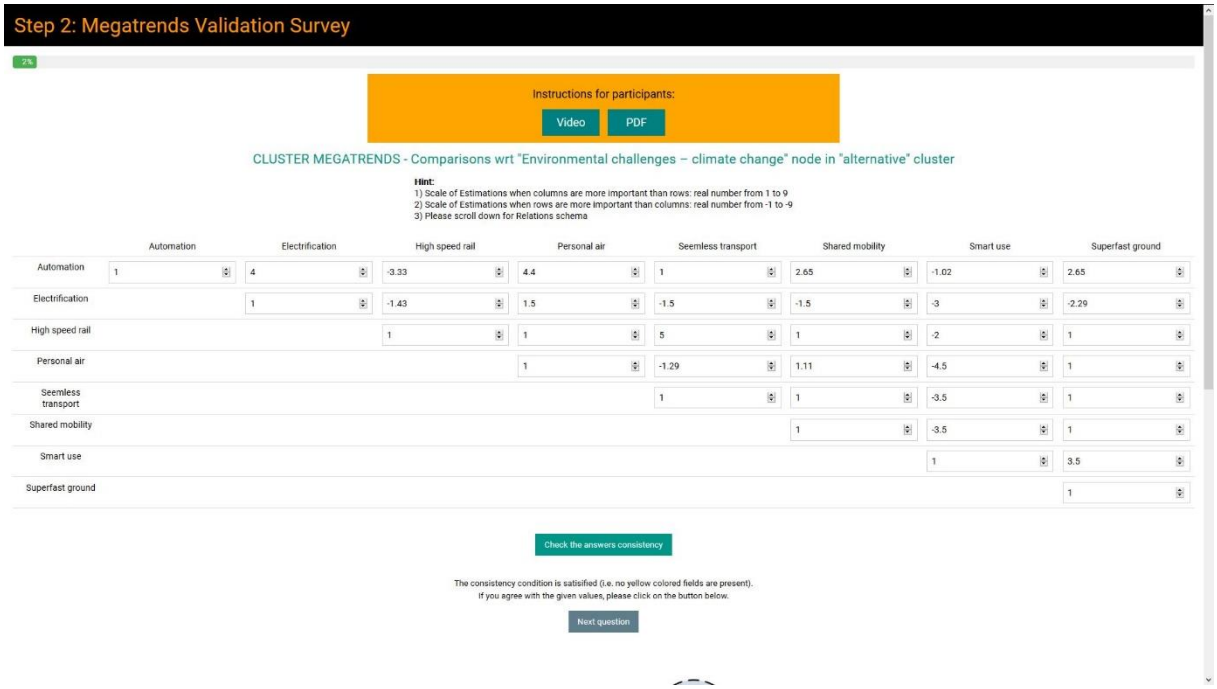


Image 3-2.6 Relationships estimation page – ANP intelligence suggestions accepted