DOCTOR OF PHILOSOPHY

Megatrends - a roadmap to sustainable mobility: policy directions for sustainable passenger mobility based on megatrends

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MEGATRENDS – A ROADMAP TO SUSTAINABLE MOBILITY: POLICY DIRECTIONS FOR SUSTAINABLE PASSENGER MOBILITY BASED ON MEGATRENDS

By

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GLOSSARY

RTD- Research and Technological Development

RDI – Research Development and Innovation

ANP- Analytic Network Process

AHP- Analytic Hierarchy Process

EC- European Commission

EU- European Union

ICT- Information and Communication Technologies

ITS- Intelligent Transport Systems

GDP- Gross Domestic Product

H2020- Horizon 2020 EU Research and Innovation Programme

ETP- European Technology Platform

MCDM- Multi Criteria Decision Making methods

UMP- Urban Mobility Plans

SUMP- Sustainable Urban Mobility Plan

TRIMIS- Transport Research and Innovation Monitoring and Information System

CORDIS- Community Research and Development Information Service

PESTEL- Political Environmental Social Technological Environmental and Legal

PPPs- Public-Private Partnerships

BOT- Build-Operate-Transfer

DBFO- Design-Build-Finance-Operate

EEA- European Environmental Agency

IoT- Internet of Things

MaaS- Mobility as Service

TEN-T - Trans-European Multi-modal Transport Network

DEA- Data Envelopment Analysis

DG EC- Directorate General (DG) of the European Commission

KW- Kruskal-Wallis

SRMC - Short Run Marginal Cost

ABM- Agent Based Model

Abstract

The primary aim of this research is to identify the Megatrends that affect the application of sustainable mobility on a European level. The starting point of the research has been the identification of these Megatrends as their long lasting impact affects the development of the transport system. Furthermore, an analysis of how these Megatrends may affect sustainable mobility was conducted. Sustainable mobility is understood as a long-term vision that needs to be achieved in the context of achieving a more inclusive and competitive society and economy in a continuously changing context.

Fifty-two trends in the political, socio-economic, policy/legal and technological environment were identified in the literature review. These were prioritised in the twelve most predominant ones using the experts' advice by applying the Delphi method. Then three potential future scenarios were developed. These trends and scenarios were further validated and their impact on achieving sustainable mobility was measured using the Analytic Network Process. The most influential Megatrends identified are unemployment, taxation, pricing, charges and sustainable development, with unemployment being the most sensitive trend which can prevent the achievement of sustainable mobility.

The analysis revealed that the expert groups that participated in the research (policy–makers, academics and industry) shared the same views and visions for the future of sustainable mobility if the key Megatrends were taken into account in policy development in a fully interconnected way.

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CHAPTER 1

INTRODUCTION

The overall aim of this research is to identify Megatrends that impact on the achievement of passenger sustainable mobility. Sustainable mobility for the purposes of this research is defined as a long-term vision that needs to be achieved in the context of achieving a more inclusive and competitive society and economy in a continuously changing context and embraces a mobility system which is accessible to everyone, cost effective, limits emissions and waste and it is safe.

Based on Megatrends, policies are suggested that focus on a sustainable way of travelling enabling people to travel more efficiently, cleanly and safely, without compromising their mobility. Although some research projects, mainly initiated by the European Commission, have investigated Megatrends and their potential impact on the transport system, there is a lack of work on Megatrends and their connection and impact to sustainable mobility. As a starting point of the thesis, this chapter provides an introduction on the focus of the research, the motivation behind conducting this research and the research questions that are addressed.

Decision makers and stakeholders in the field of transport and mobility are facing challenges due to changing Megatrends. In this thesis, Megatrends represent cultural, economic, political and technological directions that bear a significant impact on the whole society (Vejlgaard, 2008). The identification of Megatrends is vital in designing a sustainable mobility system given their long lasting impact and effects on the development of the transport system (Delle Site 2012).

A demographic change is taking place in Europe and the demand for mobility is increasing as a result of this. At the same time the energy consumption and emissions should be reduced and access to mobility should be provided for all (EC 2017). Demographic trends and urban dynamics affect travel patterns and are a result of long-term structural variables such as: decline of fertility rate, increase of life expectancy, population ageing, growth of single households and emigration (ESPON 2012).

Ageing population is one of the most important trends in demographics. The projected number of persons aged 60 or over, globally, will increase to 1 billion in less than ten years and double by 2050 and reach two billion (UNFPA 2012). An environment that promotes active ageing, supported by innovative technologies, is especially important as people are becoming old and less mobile. Easily accessible transport is essential to maintain their independence, facilitating social contacts and enabling them to remain active in society. In order to make progress towards a transport system that guarantees mobility for all population groups it is necessary to set priorities. The existing infrastructure must be equipped and adapted to support people whose abilities differ from the normal spectrum of abilities. In addition, a network of affordable transport infrastructures and services needs to be expanded to include destinations that are not currently considered as accessible to the elderly population. Shrestha et al. (2017) identified – for example - older people recognise access to healthcare as their predominant trip for which in most cases there is no public transportation available. Some examples of interventions to improve the travel experience of the elderly include the implementation of measures that offer: 1. a universally accessible system (e.g. elevators in stations); 2. An inclusive transport system (e.g. on-demand public transportation), and 3. Supplementary measures (such as subsidised mobility aids) (Martens, 2018).

Continuous urbanisation and development of large metropolitan cities is increasing urban travel demand. Populations in urban areas are expected to grow substantially up to 2050. However, the biggest growth is estimated to be in developed countries but in most cases increasing the capacity of transport infrastructure does not follow urban expansion (May and Marsden, 2010). Urbanisation impacts on transport infrastructure and transport needs, while transport infrastructure could enhance urbanisation, and help to rebalance all modes of transport: road, river, air, rail, walking and cycling (Kamga, 2015). One of the most important effects of urbanisation on transport is the shift in use of transport modes. This is especially evident on the example of megacities or cities of over 100,000 inhabitants. More than half of the inhabitants do not live in the city centres (Mather et al., 2011).

Key resources scarcity is expected to be an important challenge in the future. According to the Word Energy Council (2016), electricity demand will double by 2060. Given the fact that the EC is investing hugely in the electrification of vehicles, this poses a serious concern about the means of producing energy. The reduction of greenhouse emissions is at the heart of the EU policy as the aim is to reduce emissions by 80-95% below 1990 levels by 2050. The type of fuel used in various transport means is very important for achieving environmental sustainability. Currently, most of the 700 million cars around the world use gasoline and diesel engines. Forecasts indicate that the number of cars will double by 2030, and that there will be an increase in oil prices (Clausen et al., 2014). Thus, the growing scarcity of oil reserves will be particularly reflected in the transport sector. Bearing this in mind, transport companies might increasingly focus on using alternative energy sources in the future. In addition, scarce resources, cost increases, negative environmental impacts and legislation have caused significant research on alternative sources of propulsion, so progress is seen in areas of electro-mobility, hybrid solutions and natural gas propulsion (Clausen et al., 2014). Although there is criticism about the electric car battery production as currently it damages the environment significantly (Romare, 2017), the NGO Transport & Environment conducted a study (2017) where it was stated that the battery manufacturing process is expected to improve in the coming years.

National climate commitments made to date will not be sufficient to keep global warming to below 2°C, as agreed by Prime Ministers at the UN conference in Paris in 2015. Transportation has the highest growth of CO2 emissions of any industrial sector. The UN Conference recognised the importance of reducing emissions and building more sustainable, greener and smarter transport systems. Increased environmental pressure impacts on a number of interrelated socio-economic trends. According to the

Paris Agreement of 2015[1], the reinforcement of innovative transport technologies and innovation support is an important part of the solution. It is particularly important to collect, analyse and disseminate information on technology development to support action on transport and climate change in the context of strengthening the 'technology mechanism' (Para. 67 Decision -/CP.21) including assessment of technologies (Para. 68 Decision -/CP.21). Technology Mechanism was set up in 2010 by the UN to accelerate and enhance climate technology development and transfer.

Transport users already pay a significant amount in taxes and charges, but the amount they pay often bears little connection to the real costs on society of their travel choices (Ricci, A. et al., 2006). Transport is a complex system that depends on multiple factors including the changing geographic distribution, the location of employment and other activities, urban form, patterns of consumption, the organisation of production and the availability and quality of different types of infrastructure.

A goal of the EU, in recent years, is to establish a transport system that meets society's economic, social and environmental needs and is conducive to an inclusive society and a fully integrated and competitive Europe (Hoppe, M. et al., 2013). The ongoing trends and future challenges point to the need for satisfying rising demand for travel or accessibility in the context of growing sustainability concerns and in the context of socioeconomic changes. Sustainable mobility is understood as a long-term vision that needs to be achieved in the context of a more inclusive and competitive society and economy in a continuously changing context. For example, the fact that Europe is now experiencing a rapidly ageing population will bring new challenges in terms of how we provide good quality, sustainable transport systems that meet the needs of European citizens and businesses.

[1] Adoption of the Paris Agreement, (2015), United Nations:http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

1.1 Motivation

Transport systems exist to provide social and economic connections, while increased mobility has offered new opportunities to people to connect with each other. However, due to its potentially detrimental impact on the environment and public health, the transport sector also poses one of the greatest policy challenges for sustainable development within the EU. The environmental impacts of transport activity include (OECD 2010): emission of greenhouse gases that are widely perceived as the main cause of global warming, transport activities generating half of the air pollution and the ubiquitous spread of adverse health effects due to traffic noise.

Transport activity is a major user of non-renewable energy resources. In the EU, between 1990 and 2016, there was a 34% growth in the energy consumption of transport while the sector is responsible for 31% of energy consumption and 27% of EU greenhouse gas emissions (GHG) and is the sector where GHG emissions have increased constantly since 2014 (EEA 2016).

The European Commission, in an effort to achieve a 'Smart, green and integrated transport'[2], has invested significant funds for research addressing societal needs. One of the main objectives is to achieve a resource efficient transport system that respects the environment with better mobility, less congestion, improved safety and greater security. But all this needs to be accomplished '*At a time of public budget constraints, major demographic changes and increasing global competition'* (EC 2010, p4).

Investment should be based on the best, in the sense of accuracy, available projections of where the future is heading. In the last fifteen years, there have been huge advances in future studies and trend detection trends methodologies, particularly in Europe (Popper, R., 2011). New scientific methods for strategic long term planning have been developed in the context of political planning, participatory democracy and shaping the future with Research and Innovation policy initiatives. By detecting the relevant trends and their interrelationships, policy measures for investment directions can be drawn up. Innovations and new fields of R&D can lead not only to an increase of

[2] Horizon 2020 Transport Work Programme 2017

research activities but also a shift within the research fields leading to new opportunities allowing research capacities to strengthen and to expand. The transport industry can also gain new insights and knowledge allowing us to both identify new business opportunities and focus their innovation activities into promising fields. Society can also benefit from identifying and tackling real world and societal problems while policy makers can obtain useful recommendations from evidence-based directions provided from data analysis.

1.2 Background of the idea

The idea of this research builds on the fifteen years' experience gained during the researcher's involvement as scientific coordinator on a number of European Commission funded projects that focused on sustainable and green mobility policy development.

The projects included:

- REACT - Supporting Research on Climate-friendly Transport (2009-2011).
- OPTIMISM - Optimising Passenger Transport Information to Materialise Insights for Sustainable Mobility (2011-2013).
- INTEND - Identify future transport research needs (2017-2018).

REACT's main objective was to articulate a long-term vision and a Strategic Research Agenda (SRA) for climate-friendly transport. The project involved an expert consultation process using the Delphi method to identify key future research themes at EU level that would support better-informed decisions by the EC on how to prioritise investments.

OPTIMISM's main objective was to define different sets of strategies and methodologies for achieving sustainable mobility based on co-modality ICT solutions such as Intelligent Transport Systems. The project conducted a foresight study to identify the main Megatrends using the Delphi method and suggested future ICT policies that would respond to the future needs as identified in the Delphi study.

INTEND was commissioned to identify the key future research topics in transport based on Megatrends. The project also identified the key policy imperatives and technologies. Megatrends, policy imperatives and technologies were evaluated and prioritised using the Analytical Network Process method. The ANP framework and related results were presented in the European Commission in September 2018, where the approach was presented as a foresight technique to support transport policy development.

These projects offered the opportunity to build a rich database of key transport experts at a Pan-European level; this database was used to identify potential expert participants for the current research. Furthermore, this research has built upon the methodologies used in all three projects identified above, combining them into a single process starting with Delphi to identify the most prominent key Megatrends, followed by the ANP where the key Megatrends were validated. Lastly, this research involves a comprehensive approach to sustainable mobility policy development that spans multiple aspects of the challenge, covers all passenger transport modes and measures the impact of Megatrends on achieving sustainable mobility.

1.3 Research aim and objectives

The aim of this research is to identify Megatrends and scenarios affecting sustainable passenger mobility in order to inform future policy directions for transport investments. The research contributes to the development of a wider knowledge base for decision making, including concepts for different scenarios which will contribute to the articulation of a catalogue of guidelines to advise transport policy and planning.

As transportation and mobility are parts of a complex system it is necessary to build a synthesis of the different influencing factors and to estimate how they will be affected by future Megatrends. Megatrends, as described in Chapter 2, are defined, according to Vejlgaard (2008), as cultural, economic, political and technological changes that have not yet happened and their effects or implications are reflected on the whole or almost entire society. Megatrends underpin future developments; there their potential dynamic is mapped for different scenarios allowing their impact on transport demand

and supply to be modelled. The scenario modeling allows the identification of the main problems for future development and shows where action is required.

This study involves a scenario building process to define and assess the impacts of Megatrends in achieving sustainable mobility. Transport strategies supporting sustainable mobility in passenger transport systems are suggested. In particular, the scenario building process aims at identifying those large-scale forces that push the future in different directions. The methodology adopted for the scenario building process is based on the exploratory (narrative) scenarios approach that is building scenarios starting from past and present trends of passenger transport factors. This approach was preferred to the alternative normative scenarios approach that is building scenarios on the basis of a desired or feared future vision. The narrative approach is focused on assessing 'what can happen' as a result of implementing sustainable mobility strategies rather than finding out 'how a specific target can be met' (Bishop et al., 2007).

The scenarios reflected the harmonisation (balance) and feasibility of social, economic and environmental trends. Trends were adjusted in a way to sustain a certain degree of passenger behaviour influence on society, economy and environment. The results revealed the potential impact of various trends in achieving sustainable mobility and identified the most prominent scenarios. The outmost aim is to contribute to a more sustainable transport system in Europe, by focusing on passenger sustainable mobility.

1.3.1 Macro level objectives

Macro-level objectives capture the overall aim of the research that is to deliver potential policies for sustainable mobility in Europe based on Megatrends; these are to:

- Map current policies.
- Review past and current Megatrends.
- Perform a systematic assessment of the main Megatrends and their impact.
- Test sustainable mobility scenarios.

- Elaborate policy directions that may help enable the achievement of sustainable mobility.

1.3.2 Research questions

The ongoing trends and future challenges point to the need for satisfying rising demand for travel and accessibility of transport means in the context of growing sustainability concerns. The most immediate priorities include the better integration of different modes of transport as a way to improve the overall efficiency of the system and the acceleration of the development and deployment of innovative technologies within an approach that keeps transport users of all ages and workers, with their needs and rights, at the centre of policymaking (OPTIMISM project, deliverable 5.3).

Although a great number of studies have been carried out, at EU level, on trends that affect sustainable mobility and mobility in general, there is still no single reference point where all the information can be found. Some examples of Pan European transport projects financed by the European Commission that produced studies on Megatrends include (more can be found at Chapter 2.4, literature review):

- Future prospects on Transport evolution and innovation challenges for the competitiveness of Europe-‘FUTRE’ (financed by Framework Programme 7, 2012-2014). Related reports: 1. Factors of evolution of demand and methodological approach to identify pathways, and 2. Long-term future analysis on transport demand market and drivers.
- European Rail Research Advisory Council – ERRAC (2014), Related report: Strategic Rail Research and Innovation Agenda - A step change in rail research and innovation.
- Collective innovation for public transport in European cities - ‘CIPTEC’ (financed by Horizon 2020, 2015-2018). Related report: Societal needs and requirements for future transportation and mobility as well as opportunities and challenges of current solutions.

- Mobility4EU (Financed by Horizon 2020 project, 2016-2018). Related report: Societal needs and requirements for future transportation and mobility as well as opportunities and challenges of current solutions.
- WaterborneTP (2016) European Technology Platform, Related report: Global trends driving maritime innovation.

As shown by the list above, some of the projects and studies concern specific transport modes (for example, rail) and they are not chosen and validated based on their relevance and impact in achieving sustainable mobility.

The aim of this research is to build upon the knowledge generated in order to further test and validate the technological and socio-economic dimensions that would support sustainable mobility by addressing the question:

What are the main Megatrends affecting the application of sustainable mobility in Europe?

A prerequisite of influencing the transport system through the implementation of efficient policies is to understand the dynamics involved. The analysis of the key drivers of mobility needs and desires helps to model the demand side while, on the supply side; traffic infrastructure and new technologies are critical. To estimate the future of the mobility system it is necessary to identify the main influencing trends. This research is designed to integrate those Megatrends with regards to their impact on the current system as well as in the future. Meta-analysis on Megatrends provides a deep understanding on this issue, estimating their impact on the achievement of sustainable mobility.

To be able to answer the main research question, the system dynamics need to be explored. This leads to the following additional research questions:

What are the current Megatrends affecting the passenger mobility system?

This includes the identification of the major Megatrends based on a comprehensive literature search. The results are evaluated and ranked by experts through the Delphi method.

What is the impact of the top-ranked Megatrends on the achievement of sustainable passenger mobility?

The impact of the main Megatrends identified in Delphi is defined through two rounds of questionnaires built on the basis of the ANP methodology.

What is the interrelationship of the Megatrends?

This is achieved by testing three scenarios that are developed based on the harmonisation of the trends.

How sensitive are the sustainable mobility scenarios' priorities to the changes in the Megatrends importance?

This is tested through a sensitivity analysis focusing on the main trends. This reveals the negative directions that the sustainable mobility equilibrium could take if the most critical trends are not taken into consideration when drafting policies.

1.3.3 Specific questions

The specific scientific objectives are those that shape the research path in support of answering the research questions and achieving the macro-level objectives. They are grouped into three thematic areas each with supporting objectives:

To conduct a Megatrends analysis:

To review the main Megatrends as have been identified by various studies and projects. A catalogue will be developed with the Megatrends grouped into clusters. The relationships between the clusters will be defined in order to complete a set of networked clusters (components). This would allow the assessment of the various Megatrends scenarios.

To validate the Megatrends. The Megatrends identified based on the literature review will be validated by a number of experts through the application of Delphi and Analytical Network Process methodology.

To measure the impact of Megatrends and policies on the achievement of sustainable mobility.

To assess sustainable mobility scenarios:

To identify sustainable mobility scenarios.

To review and assess the key variables (trends) comprising each scenario.

To measure the impact and directions of possible changes within the scenario variables.

To develop directions for strategies to achieve sustainable mobility in Europe:

To review the existing directives and main strategies for sustainable mobility.

To compare and contrast with the findings of the research.

To identify key gaps and suggest new directions or improved policies.

The success of measures for sustainable passenger mobility depends on their feasibility. Principles of sustainable mobility and starting points for decarbonisation are formulated. Policy formulation and planning are often confronted with unforeseen developments. For this reason, the comprehensive and systematic identification of Megatrends will comprise a key cornerstone for the policy suggestions. A major objective of this research is to make the elaborated knowledge potentially valuable; therefore, high-level guidelines for policymaking and transport planning are developed.

1.4 Research contribution

Due to the potentially detrimental impact of transport on many aspects of our lives, such as the environment and public health, the sector also poses one of the greatest policy challenges for sustainable development within the EU. Supporting sustainable mobility is one of the key factors in reaching these objectives, and has been defined as critical to the future of Europe's competitiveness and for enhancing the quality of life. This is increasingly important as political and technological changes open access to the global economy by producing both new markets and increased competition.

Megatrends that will affect the future transport system are identified using Delphi and the Analytical Network Process to ensure validity of the results, with a wide range of experts being involved in the surveys.

This thesis will deliver:

- Development of a comprehensive picture and integrated analysis of forward-looking knowledge in the passenger transport sector with a focus on sustainable mobility.
- Help deliver an improved sustainable mobility policy.
- Involvement of a wide range of high caliber experts in the surveys and validation of results.
- Application and development of two foresight methods combining four rounds of questionnaires (Delphi and ANP) to ensure validity of the results.

1.5 Research Impact

The overall objective of the EC's transport and mobility policy is to focus on enabling future changes in the travel system to take place in a more sustainable way, so that people can travel more efficiently, cleaner and more safely. To this end, this research is expected to have an impact in the following areas:

Societal impact: achieve a better society

Sustainable transport and mobility issues are a topic of strategic importance for everyday life, with major impact in the life of human beings and its quality. Furthermore, sustainability measures define substantially the life of the next generations and the very existence of the planet. The Megatrends identified in this research reflect on the passengers' needs for a more efficient transport system that best serves them. Passengers will benefit from at least partially shifting the focus from path depending research traditions towards real world and societal problems.

Improved research capacity

The policy recommendations put forward in this study also constitute areas of potential further research and development as they are considered as 'key' in achieving sustainable mobility taking into consideration the future challenges and Megatrends. New research opportunities and less considered fields of R&D can lead not only to an increase of research activities but also a shift within the research fields leading to new opportunities and allowing to strengthen and to expand research capacities within economy and research institutions.

Furthermore, the combination of the two-research techniques - Delphi and ANP - in sustainable mobility policy design, introduces a new methodological path that may have wider possibilities for use.

Improved industrial performance

This research provides new insights and knowledge for industry allowing to identify new business opportunities and focus their innovation activities into promising fields. Due to the broad view of the research, systematically scanning the trends, deriving research upcoming needs from Megatrends and giving policy suggestions in combination, a broad variety of different potential research fields can be suggested.

Improved policy

Policy directions are suggested on the basis of future developments. The directions are aimed at improving current policies that are focused on the most influential Megatrends. Spillage of resources will be avoided by investing in measures that have high potential in achieving sustainable mobility.

1.6 Thesis structure

The thesis is structured in three main parts, as shown in the figure below. The first part focuses on defining the landscape by reviewing the status quo in Megatrends and forms the literature review and the methodology chapters. The second part relates to understanding the conditions and includes the analysis of the results. The conditions refer to Megatrends as these are identified and prioritised by the experts. The last part discusses the future and presents the main policy recommendations.

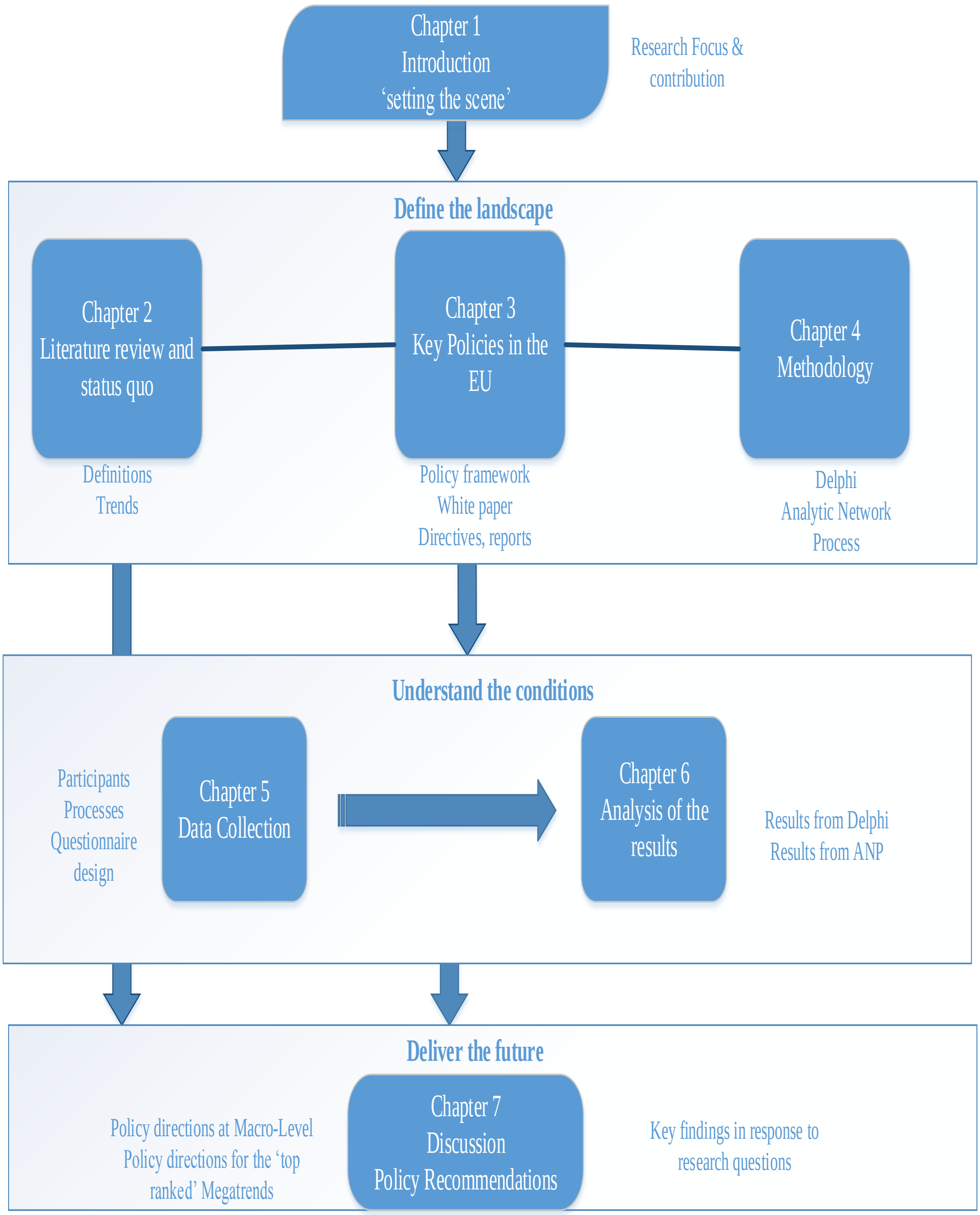

Figure 1.1: Thesis structure

Source: Author

1.6.1 Chapter summary

The thesis starts with chapter one which provides an introduction on the main focus of the thesis. The genesis of the research is explained where the main areas of previous similar work are mentioned. In the same chapter, the research objectives are described both at macro-level and also micro-level of the very specific questions that are tackled in this project. The contributions of the research relate to policy and societal, but also research, impacts.

The aim of chapter two is to define the landscape. A literature review on the main Megatrends is presented. This includes definitions of key terms along with an elaboration of main trends in the social, economic, policy, technological and environmental fields.

Chapter three aims to provide an overview of the main policies in the EU. Some general policy directions are described based on the main objectives set by the European Commission. Sustainable Urban Mobility Plans (SUMPs) are explained. The EU White Paper developed in 2011 and its successor 'Europe on the Move', adopted in 2017, are elaborated since they are the basis for all policy directions setting the objectives and targets that need to be met.

Chapter four explains the main methodologies applied in this research. The Delphi Method was used to identify the key Megatrends based on expert opinion. Using a brainstorming workshop, three sustainable mobility scenarios were also developed which portrayed the harmonisation (balance) and feasibility of social, economic and environmental trends. These trends were further validated and assessed using the Analytic Network Process. Using the ANP, it was also possible to evaluate their impact. The processes involved in both methods are also described in this chapter with particular emphasis on the ANP, which is its first use in support of transport policy development.

Chapter five describes the data collection tools and methods. The identification of participants, based on networks developed during the conducted previous research projects, is described and justified. The data collection process is also outlined which involved various iterations of questionnaires that were provided online, while the potential participants received the link over emails.

Chapter six describes the analysis of the results. These included the results from the two rounds of Delphi where the experts identified the most predominant Megatrends. The results of the ANP are also presented. The ANP used the Delphi predominant trends to further validate them, but also to assess their impact in achieving sustainable mobility.

Chapter seven focuses on the provision of policy directions that are based on the findings. Therefore, policy suggestions are put forward for the main trends revealed from the ANP. Directions for macro-level policy development based on both ANP but also literature review are also provided.

Chapter eight describes the main limitations and the recommendations for future research.

CHAPTER 2

LITERATURE REVIEW

Introduction

The focus of the literature review is to investigate the main Megatrends. These refer to environmental, social, economic, technological and political trends based on European but also international literature. Since the focus of this research is on suggesting EU policies, a review on the main trends derived from European Commission funded projects is included.

The trends identified during the literature review are grouped into clusters in order to enable their further validation through the Delphi and ANP methods. Both grey and scientific literature have been used while bibliographic database sources used are journal, conference proceeding and EC project reports repositories such as TRIMIS and CORDIS.

2.1 Object of investigation

A literature review-based methodology and search on the term 'Megatrends' in both passenger transportation and mobility reports, but also in foresight studies, was applied. The literature review aims to:

- Provide definitions of key terms used in this research.
- Review the trends that have been identified by European Commission funded passenger transport projects.
- Elaborate on major trends in the fields of society, economy, policy, technologies and environment.

Particular emphasis was given to the EC, European Technology Platforms and worldwide projects that have studied Megatrends affecting the transportation sector and the roles of Megatrends in forward looking projects. After review of relevant and available literature, a categorisation of Megatrends that impact on passenger transport was made. The same analysis was performed for general foresight studies.

Figure 2.1 below summarises the process followed in the literature review:

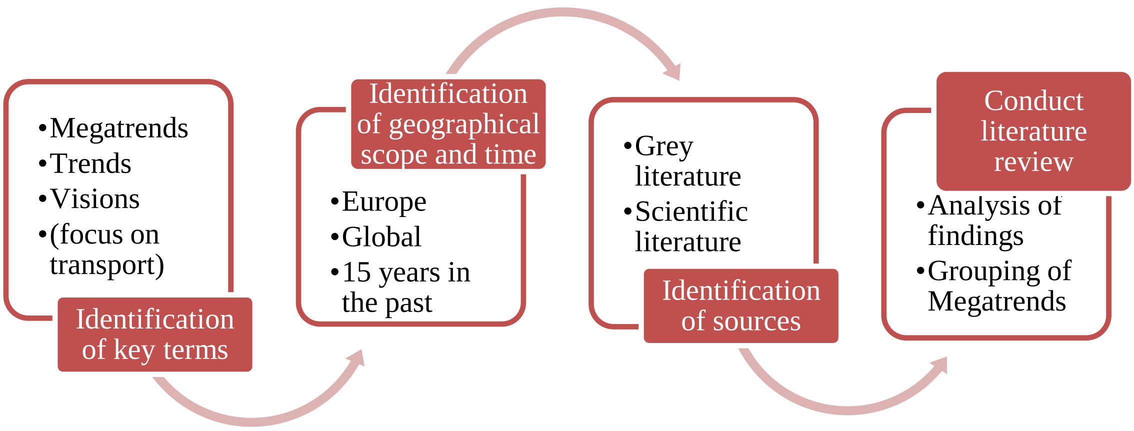

Figure 2.1: Literature review process

Source: Author

2.1.1 Literature review taxonomy

The categorisation of the trends was based on the three pillars of sustainability as derived by the UN Assembly in 2005. More specifically, the 2005 World Summit on Social Development recognised three components of sustainable development. They are economic development, social development and environmental protection as interdependent and mutually reinforcing pillars.

The PESTEL (Political, Environmental, Social, Technological, Environmental and Legal) framework is used as an organising principle for this review. This included analysis of Political & Legal, which implies trends, and Megatrends associated with governmental decisions, regulations, and reforms. Particular emphasis was given to the key transport policy directions provided by the EC and associated policy documents such as White Papers. The Economic trends and Megatrends determine the economic performance over the long term, for example financial recession, GDP changes, etc. The Social trends and Megatrends are the ones that relate to the social environment such as demographics, culture and behaviour. The Technological trends and Megatrends relate to the technological innovations and advances in transport, for example, the introduction of ICT in transport is a major theme. Lastly, the Environmental trends and Megatrends include ecological and environmental aspects such as emissions, renewable energy etc.

The diagram below represents the main areas researched in the literature review.

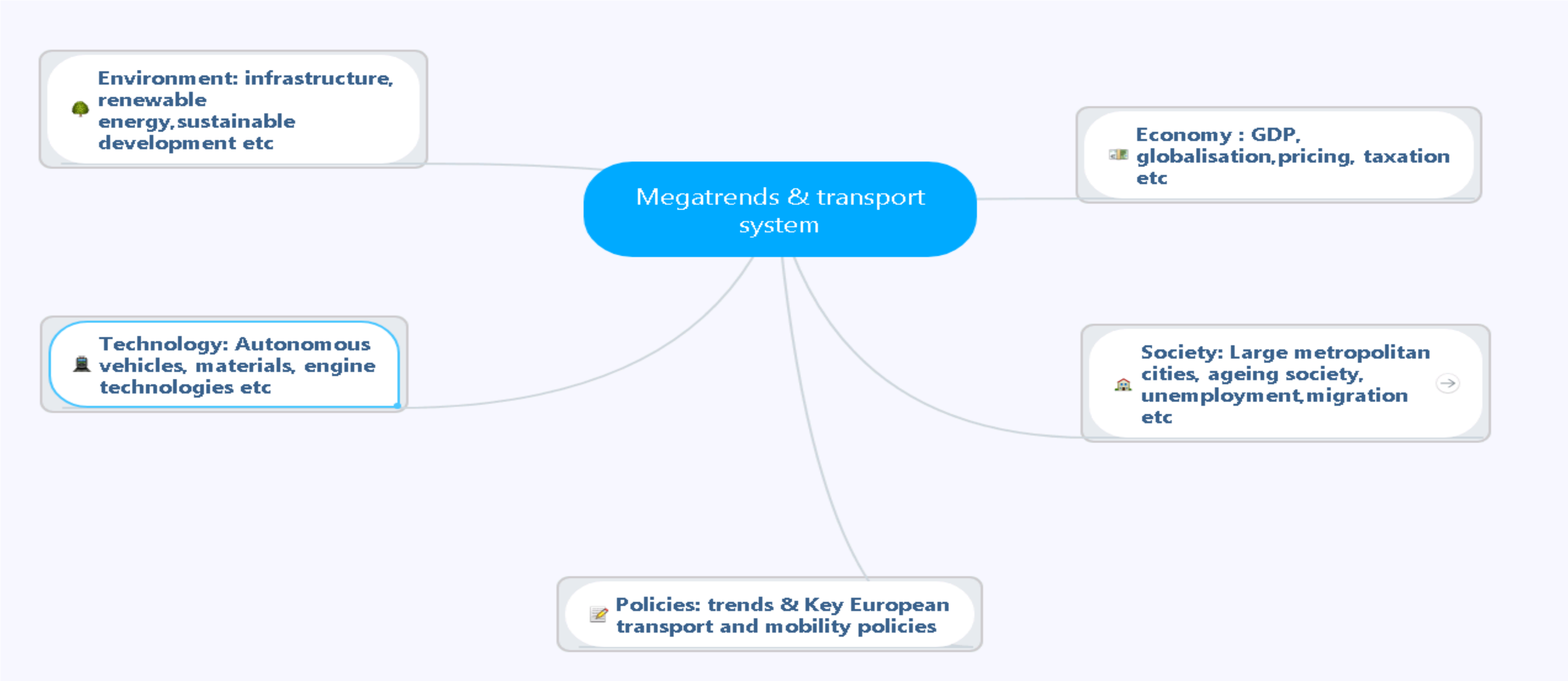

Figure 2. 2: Literature review focus

Source: Author

2.1.2 Sources used in the literature review

During the conduct of the literature review, a number of sources were used.

Grey literature

Grey literature provided a significant source of information. In particular, reports from European Commission funded projects; national governments and European Technology platforms were used. These included:

- European Commission directives and policy documents such as the White Paper 2011, Europe on the Move, Horizon 2020 programme.
- Project reports and deliverables from OPTIMISM, TOSCA, World Energy Council,
  FORD, The Future of Transport, FUTRE, CIPTEC, Future Transport 2056, Mobility4EU, WaterborneTP, ERRAC.
- Foresight studies: World Energy Council, IATA, OECD.
- Industry reports: such as FORD, PWC.

With regards to the European Commission funded projects, the databases that were mainly used included: 1. CORDIS: Community Research and Development Information Service. This is the European Commission's main public repository of all EU-funded research projects and their results. The website includes all public information held by the Commission (project fact-sheets, publishable reports and deliverables), editorial content to support communication and exploitation (news, events, success stories, magasines, multilingual results in brief for the broader public) and comprehensive links to external sources such as open access publications and website (https://cordis.europa.eu/home_en.html); 2. EUROPA is the European Union's Web portal. EUROPA provides information on European integration concerning the European Union's objectives, policies and institutional set-up. All relevant polices and directives can be found there in all EU official languages (http://europa.eu); 3. TRIMIS: The 'Transport and Research and Innovation Monitoring and Information System' was built to support the Strategic Transport Research and Innovation Agenda (STRIA) that outlines future transport research and innovation (R&I) priorities to decarbonise the

European transport sector. The website includes all the EC but also national funded transport projects. Transport innovation roadmaps and country profiles can also be found there.

The diagram below presents the grey literature sources and channels used.

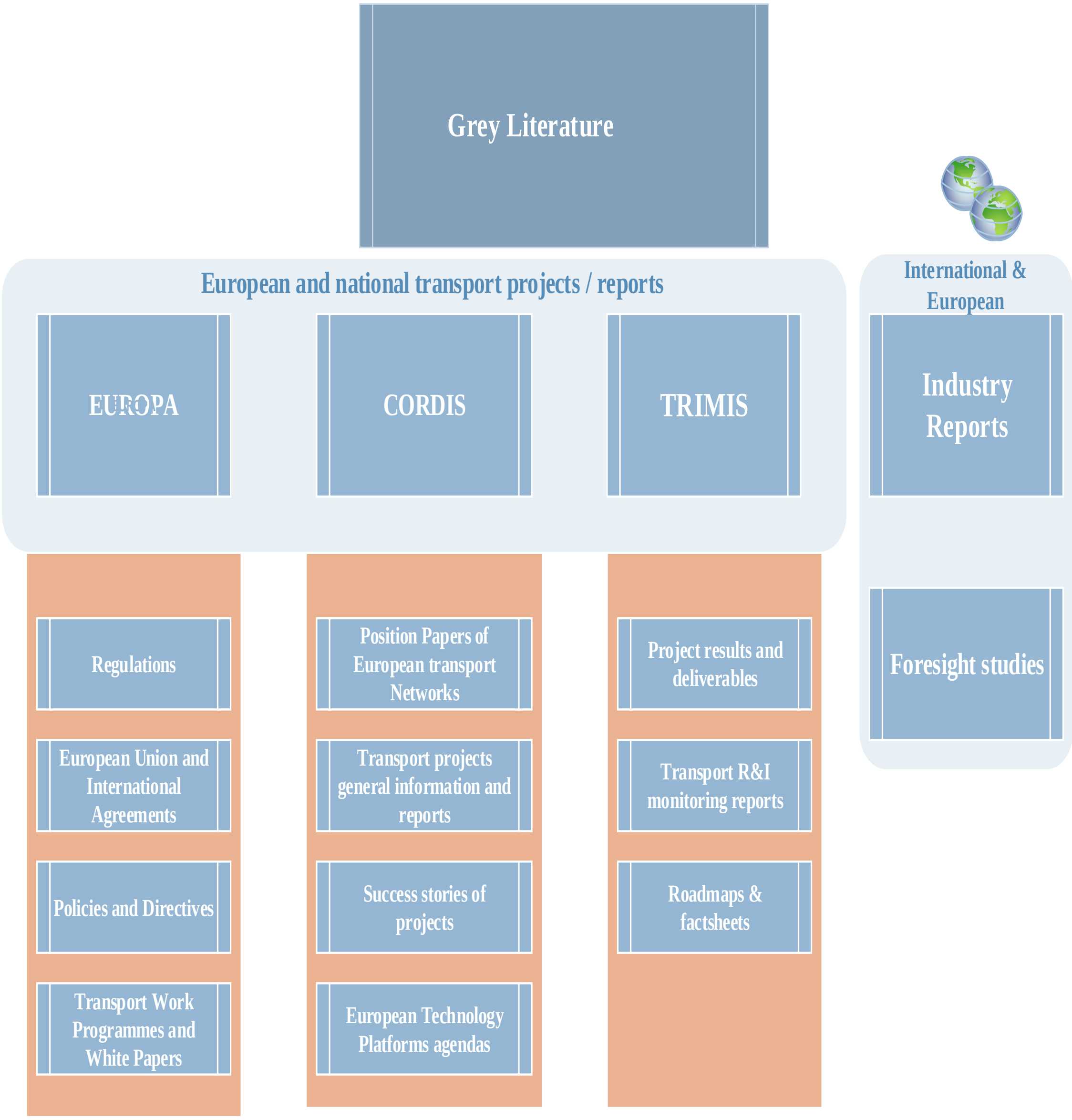

Figure 2. 3: Grey literature review sources

Source: Author

2.2 Definitions

The concept of sustainable development was first introduced and defined from the United Nations' Brundtland Commission (1987) as the 'development which meets the needs of current generations without compromising the ability of future generations to meet their own needs'; a definition which has been subject to differing interpretation and has spawned many variants.

Although sustainability is a concept with a broad range of definitions depending on the perspective; there are, however, some similarities between them. According to Hoppe et al. (2013), sustainability aims to limit the use and consumption of fossil resources and minimise the harm and danger for society and environment contingent on their continued unchecked use. Also, sustainability includes responsible decision-making and aims for integrity of future generations by including a holistic approach including social, economic, technological and environmental aspects. Lastly, sustainability requires global, large scale, long-term and future oriented-thinking, while implementing the sustainability measures on a national, supra national, regional or local level.

The conceptual framework for the identification of Megatrends and the development of scenarios consists of three components that are interrelated:

1. The core is the passenger transport system; the interaction between supply and demand of transport determines system's performance. The transport system's performance comprises of the following dimensions:

- Safety: improved traffic safety
- Environmental performance: less harmful environmental impacts
- Costs/efficiency: the resources committed to a service: the efficiency with which they are turned into outputs.
- Access: equality of access to service

The way the transport system performs generates impacts which can affect sustainable mobility.

2. External key factors and policy actions, which interact and affect the passenger transport system. External key factors relate to those variables, which are not specific to the passenger transport system, but have impacts on it and contribute to shape its development. They include socio-demographic and cultural factors, spatial structure, economy, energy and technologies.
3. Policy actions are key components that drive the development of social and economic system and naturally the development of transport systems. Therefore, policy actions affect the development of both external key factors and passenger transport system key characteristics.

Trend identification and management, as a research discipline, was developed from the concept of weak signals, and introduced by Ansoff (1975; 1982). According to Ansoff (1982) page 12, weak signals are 'warnings (external or internal), events and developments that are still too incomplete to permit an accurate estimation of their impact and/or to determine their full-fledged responses'. Over the last decade, Ansoff's concept of weak signals has been acknowledged in what is now known as 'a trend' (von Groddeck, 2013). Therefore, any trend can be observed through indicators or warnings related to a particular phenomenon, which can lead to significant changes or discontinuities in a particular area over some years, such as transportation. The aspect of change implies that a trend must be considered as a new phenomenon, which can be very complex and whose lifespan cannot be accurately measured. Consequently, studying trends involves research of something novel, with the focus on achieving a better understanding of them and associating them with probable consequences in given areas (von Groddeck and Schwatrz, 2013). Liebl and Schwartz (2010) indicate that innovation and diffusion are two angles from which trends should be observed in order to understand them. Innovation denotes the need for something new in every trend, while diffusion conveys the level of influence of a certain trend on the development of different areas, such as transport. The main characteristics of every trend are the following (von Groddeck and Schwatrz, 2013):

- They cause a fundamental change over an extended period;
- Trends are phenomena that are always complex and whose lifespans cannot be

measured accurately;
- They represent associations that are defined by crossing contextual borders.

When the importance of certain transformation processes is of major significance, the changes are often called Megatrends. Vejlgaard (2008) points out two of the most significant characteristics of Megatrends which are that Megatrends represent cultural, economic, political and technological changes that have not yet happened and their effects or implications are reflected on the whole or almost entire society.

The same author indicates that the differences between trends and Megatrends are that Megatrends last longer and have a more pronounced impact on many areas.

Similarly, Georghiou et al. (2009) describe Megatrends as long-term processes of transformation with a broad scope and a high impact. They are considered to be powerful factors which shape markets. Megatrends vary from other trends in the following way:

- Time horizon: Megatrends can be observed over decades
- Scope: Megatrends impact goes beyond geographical borders, and result in multidimensional changes in politics, society, or economy.
- Intensity of impact: Megatrends impact robustly and comprehensively on all actors involved. This includes governments, individuals and their consumption patterns.

It is known that many internal and external factors influence the transportation system. This research deals with general external factors or Megatrends i.e. 'those variables, which are not always specific to the transport system, but have impacts on it and contribute to shape its development' (Anoyrkati et al., 2016). The analysis is focused on external factors from the socio-demographic, economic, environmental and technological perspectives with emphasis on those that are most often elaborated in the literature. Furthermore, the Megatrends interact with policy actions across the transportation processes.

2.3 Review of trends identified by European Commission funded projects

The European Commission, recognising the importance of trends identification in the application of the right policy mix, conducted a study in 2009 where the main trends in transport were identified and analysed. The report emphasised the following trends: ageing, migration and internal mobility, environmental challenges, increasing scarcity of fossil fuels, urbanisation and global trends affecting European transport policy (EC 2009).

The TOSCA project[3], funded by the EC, identified the promising technology and fuel pathways to reduce transportation-related greenhouse gas emissions through 2050 (http://cordis.europa.eu/result/rcn/55384_it.html). The main finding of the project was that GDP growth and oil prices are uncertain driving forces that will have the largest effects on both passenger and freight transportation demand at the EU level.

The OPTIMISM project[4] (2013) was aimed at development and elaboration of future sustainable mobility scenarios. The definition of the OPTIMISM scenarios considered the process of identification of key factors and their trends affecting the passenger transportation system. Based on the analysis of literature on key factors and expert knowledge using Delphi methods, the project also created a list of potential Megatrends influencing the transportation system and mobility behaviour, that is: urbanisation, shortage of resources, globalisation, climate change and environmental ethics, technology change, mobility and European policy reaction, world population growth, demographic and social change Europe, European market de-regulation, increase of Inter-/Intra-national social disparities and knowledge society and economy Europe.

The FUTRE project analysed the factors of evolution of transport demand behaviour. In this process, the Megatrends with an impact on transport were identified.

[3] Technology opportunities and strategies towards climate-friendly transport, http://cordis.europa.eu/result/rcn/55384_it.html

[4] Optimising Passenger Transport Information to Materialise Insights for Sustainable Mobility

Megatrends were defined as stable trends driven by global forces that impact several societal areas. The methodology used was literature review and expert consultations. Fifteen Megatrends were identified as the most relevant to transport: globalisation, as a pattern of economic, political and social integration at global level, urbanisation, as a trend of appearance of numerous megacities, global ageing of population, knowledge society, as a process of increasing importance of education, know-how and information for economy and society, and migration. There are also more Megatrends that belonged in the group of lifestyle changes. These are: individualism, connectivity (online on a 24/7 basis), immediate needs, slow movement (counter-trend emphasising quality of life and prioritising health and mental health), empowerment of women, awareness/consciousness (reflecting the increased awareness of global social and environmental hazards), consumption 2.0 (use, not own – higher tendency to renting rather than buying), ever young (adventure, gaming and a strong desire for freedom as lifestyle of older people), seeking for experiences (strong preferences towards travelling, meeting other people and cultures) and do it yourself (people as consumers are involved in all phases of product and services development).

The European Rail Research Advisory Council - ERRAC (2014) - acknowledged the following Megatrends:

- urbanisation (will lead to the increased market share in urban and regional markets of well-integrated public transport involving rail, metro, tram and bus transport (and even private modes like bike or electric car; rail passenger transport demand is strongly driven by demand of growth into and between large cities and other urban areas);
- ageing of population (the elderly population will grow significantly by 2050; elderly people will use trains more frequently, particular in urban areas and for long distance journeys);
- lifestyle changes (fewer car owners, preferences towards multimodal travel patterns including walking and cycling);
- technological innovations (expected to produce more energy and resource efficient systems for rolling stock and infrastructure; quality and safety and

security management systems harmonised across Europe; interoperable European wide rail system by 2050; semi and fully autonomous and alternatively propelled car systems are expected to be a major competitor in 2050 to electrified rail mass transit);

- sustainable mobility measures (promote modal shift towards rail transport; enhancing of the long distance rail services by making car travelling in cities relatively less convenient);
- climate change (more resilient infrastructure, with improved emergency maintenance services, is expected to be in place by 2050; comprehensive passenger information to provide advice in circumstances of service disruption);
- adopted rail research and innovation policies at the European level (driven by the need to strengthen European rail industries within competitive global rail markets, reflect a shift to rail strategy with more restrictions on road transport and the phasing out of conventionally fuelled vehicles in urban areas).

ERRAC highlighted that the above Megatrends are the key to sustainable mobility in a low-carbon Europe and is also essential for the growth of the European economy and for social cohesion.

CIPTEC project (2015) reviewed the Megatrends based on literature and conducted a brainstorming session to validate them. The major identified trends followed by their impact on transportation are the following:

- Urban governance: harmonisation of institutional and legislative frameworks, pressure to provide enhanced public services to citizens and business, competition among cities, local urban public transport systems are established within a framework of broader inter-urban service networks.
- Globalisation: increased travel distances; more people work, study and travel aboard; increase of cross border travel; global outreach of ICT system lead to more efficient public transport system.

- Internalisation of transport external costs: This refers to internalisation measures, which discourage the usage of individual vehicles and cars which offers enhanced public transport usage and sharing.
- Shared economy: (especially) young people change cars for bicycles, public transport and train, public transport slides from mobility to mobility as a service.
- Flexible economy: public transport system allows for flexibility and is more adjusted to the business needs.
- Individual empowerment: personalised public transport, flexible working.
- Corporate social responsibility: social innovation initiatives are enabling emergence of new innovative solutions.
- Social innovation and social entrepreneurship: car-sharing and car-pooling, multi-modal mobility, society digitalisation.
- Ageing: mobility decrease, lower average distances of trips made, selection of transport mode depends more on travel costs than on travel time.
- Transforming families and household sizes: household size decrease results in lower car occupancy leading to higher traffic densities, if motorisation rate continues to increase; however, car ownership rate among young people is decreasing.
- Urbanisation and urban sprawl: this results in a higher demand for transport and mobility.
- Sustainable lifestyles: promotion of sustainable transport systems and solutions, such as electric vehicles, advancement of crowdsourced and collaborative service consumption patterns, such as car-pooling and bike sharing, increase of transport related digital services (collaborative platforms with mapping and citizens reporting).
- Innovation and technological development: vehicle efficiency through new engines, materials and design, cleaner energy through new fuels and propulsion systems, more efficient operation, through ITS.
- Internet: smart ticketing and real-time, customised, multimodal travel information make public transport more accessible and user-friendly, internet

of things, and fast development of new mobility services such as Uber, BlaBlaCar and Zipcar.

- Environment: covers climate change, pressure on natural resources and high oil prices, increased global demand for raw and other resources, oil prices will increase due to dwindling oil resources and unsustainable patterns in demand growth, developed initiatives – a) EU has instructed that, by 2020, 10 % of all fuel used in transport will come from renewable sources, b) e-mobility, c) smart cities and smart energy/smart grid.
- Harmonisation of legislation and regulations at EU level: the need for passenger safety and security have increased, EU legislation has strengthened passengers' rights, introduction of public procurement procedure by means of competitive tendering.

The Mobility4EU project (2016) also conducted a literature review of societal, political, economic, technological and legal trends, which were validated from experts through a workshop session. The study revealed 29 trends organised in 9 larger cluster categories. These comprise of:

- Distribution of wealth and labour market developments: adaptation of Europe's economy in the global context of significant relative decline of GDP, location independent working and part-time work.
- Inclusive society, personalisation, accessibility: increasing life expectancy, migration generates long distance flows, inclusion of vulnerable to exclusion groups, less car use by younger generations, move towards more active and healthy lifestyles.
- Urbanisation and smart cities: rising and expanding urbanisation, smart cities.
- Environmental protection: stricter regulations for environmental protection, increasing scarcity of available resources, impact of climate change on transport.
- Digital society and Internet of Things: rise of the Internet of Things, Big Data technologies and automation.

- Novel business models and innovation in transport: new models challenging the individual vehicle ownership model, emergence of new business models, emergence of co-development and co-creation of new systems by users.
- Safety in transport: coexistence of automatic and non-automatic vehicles, insurance and liability.
- Security in transport: introductions of controls and barriers.
- Legislative framework: inclusion of citizens in the governance, legislative models adapts to new transport solutions and businesses, harmonisation in legislative frameworks.

WaterborneTP (2016) identified key global trends and their influence on the future of waterborne industries. These include:

- Population growth and urbanisation: the world population is predicted to increase to 8.5 billion in 2030, the share of people living in urban agglomerations will increase to about 60% in 2030, leading to increased waterborne transport and increased use of ferries, cruise ship and leisure craft in particular; challenge is to build new and upgrade existing port infrastructure.
- Food and water demand: increased food and water demand due to population growth, increased urbanisation and industrialisation, increased need for water transport and aquatic food production, i.e. transport of fresh water, transport of food, food production at sea (fish farming, aqua farming).
- Health, safety and security: users are not willing to accept negative social impacts of maritime sector, such as e.g. accidents and unsafe working conditions, need to improve working conditions due to scarcity of qualified personnel and for stricter safety and security standards in maritime sector.
- Increased environmental concerns: stricter environmental regulations to reduce emissions to air and sea, stricter regulations for offshore activities, stricter emission control in port areas.
- Global economic growth and trade increase: low single digital number of GDP growth in OECD countries, higher growth rates of GDP in developing

countries, future economic growth driven by innovation instead of population growth, increase of middle class in developing countries will drive the consumption of technological products, increased number of ships under European flags.

- Energy production and consumption: world primary energy production grows at 1.5% p.a. from 2012 to 2030, developing countries will increase their energy consumption by approximately 75%, the main energy sources will continue to be oil, gas and coal with similar share of fossil energy consumption, energy production on offshore locations; significant increase in production and transport of clean fuels, need for exploration of reserves in deeper water, and harsher environments; need for port infrastructure for offloading, alternative fuel trade leads to transport of LNG, methanol or hydrogen.
- Climate changes: climate will change dramatically causing extreme temperatures, more severe rainfall and flooding, higher frequency of storms and continuous and increasing polar ice melting, possibly severe operational disruptions, increased requirement for robustness of ships, ports and offshore structures for more severe weather conditions; increased use of weather routing.
- Digitalization: significant increase of digitalisation in all waterborne sectors, higher degree of automation, need for secure connectivity against cyber-attacks.

A summary of the above-mentioned trends can be found in Table 2.1.

Project	Yea r	Geographical Scope	Trends	Mode	Website
OPTIMISM	2013	Europe	Urbanisation, shortage of resources, globalisation, climate change and environmental ethics, technology change, mobility and European policy reaction, world population growth, demographic and social change Europe, European market de-regulation, increase of Inter-/Intra-national social disparities and knowledge society and -economy Europe.	All modes	http://www.optimismtransport.eu/
FUTRE	2014	Europe	Individualism, empowerment of women, awareness/consciousness, consumption 2.0, ever young, seeking for experiences, do it yourself.	All modes	http://www.futre.eu/
ERRAC	2014	Europe	Urbanisation, ageing population, lifestyle changes, technological innovations, sustainable mobility measures, climate change, adopted rail research and innovation policies at the European.	Rail	http://www.errac.org
CIPTEC	2015	Europe	Urban governance, Globalisation, Internalisation of transport external costs, Shared economy, Flexible economy, Individual empowerment, Corporate social responsibility, Social innovation and social entrepreneurship, Ageing, Transforming families and household sizes, Urbanisation and urban sprawl, Sustainable lifestyles, Innovation and technological development, Internet, Environment, harmonisation of legislation and regulations at EU level.	Public transport	http://ciptec.eu/
Mobility4EU	2016	Europe	Distribution of wealth and labour market developments, Inclusive society, personalisation, accessibility, Urbanisation and smart cities,	All modes	https://www.mobility4eu.eu/

			Environmental protection, Digital society and Internet of Things, Novel business models and innovation in transport, Safety in transport, Security in transport, Legislative framework.		
WaterbornTP	2016	Europe	Population growth and urbanisation, food and water demand, health, safety and security, increased environmental concerns, global economic growth and trade increase, energy production and consumption, climate changes, digitalisation.	Waterborne	https://www.waterborne.eu/
TOSCA	2011	Europe	GDP growth and oil prices.	All modes	http://cordis.europa.eu/result/rcn/55384_it.html
INTEND	2018	Europe	Changing lifestyle. Environmental challenges, Energy demand Urbanisation and megacities, Ageing society.	All modes	https://www.intend-project.eu/

Table 2.1: Trends identified in European projects

Source: Author

2.4 Elaboration of major trends

2.4.1 Social trends

According to a study carried out by the European Environment Agency (2015) on global Megatrends, including demographic development and population structure, the global population has been steadily growing during the past 60 years, but with clear regional disparities. The population growth has stabilised in Europe and in the USA, but still has an upward trend in most of the developing economies like India and countries in Africa and Latin America.

Europe and North America has witnessed decreasing child birth rates and increasing life expectancy, which lead to ageing populations (Brög et al., 2005; Rudinger et al., 2006). Currently people older than 65 years make up to over 12% of the total populations in Europe and in North America (Rudinger et al., 2006). Seniors are becoming more mobile than in the past and the amount of yearly trips made by the elderly has almost doubled (Dejoux, V. et al., 2010; Kotavaara, O. et al., 2011).

A study covering six Central and Eastern European countries looked at the demographic development during 2000-2010. Stagnating or declining populations were identified in Germany, Hungary and Croatia (USEmobility 2011; Spickermann A. et al., 2014). Population growth of approximately 5% was shown in Belgium, the Netherlands and Austria. Demographic ageing is also becoming an issue in these six countries. During the research period the average age of the inhabitants increased between 4% and 12% (USEmobility 2011).

The tendency for individual travel will continue to grow in Europe (Kuemmerling et al., 2013). During the past two decades most of the OECD (Organisation for Economic Co-operation and Development) countries achieved motorisation and the domestic expenditures on travel and communication have almost doubled since the early 1900s (Rudinger G. et al., 2006). Motorisation is all forms of travel that includes engine (cars, trucks etc.) while non-motorised is ‘any form of transportation that provides personal or goods mobility by methods other than the combustion motor’ (Guiting et al., 1994, p1).

Evidence from the Netherlands has shown a change in the characteristics of work. Depending on the age, gender, demographic characteristics (single, married, families with children), educational level and job character, remote working has proven to be more or less a suitable option with higher working efficiency (De Graaff T. et al., 2007). An increase in remote working could result in a decrease in the need for mobility.

With regards to spatial structure, land use has changed drastically in Europe during the last fifty years, sometimes with important negative effects such as urban sprawl, soil sealing (destruction or covering of soils by buildings, constructions and layers of completely or partly impermeable artificial material such as asphalt, concrete, etc., biodiversity losses, soil erosion, soil degradation, floods). Land use specialisation (urbanisation, natural afforestation, agricultural abandonment or intensification) is a major trend identified in the last decades (Garcia, G. et al., 2010) and has resulted in an inefficient spatial land use distribution.

The development of large metropolitan cities and urbanisation is another trend that is expected to rise. 75% of Europeans live in cities (where most of Europe's wealth is generated) and this percentage is expected to increase to 85% by 2050 (EC 2009; EC 2011).

Although past trends showed a stable population growth globally, the future projections vary from extreme population growth to a decreasing world population. Stagnation and ageing of the population in Europe and in North America is identified in all the projections. The largest shares of the global population in the future will be in Asia, Africa and Latin America (EEA 2011).

The European Environment Agency projected the age structures for the years 2000 and 2050: an increased life expectancy and a proportional reduction in the age groups below 30 years (EEA 2011). Similar age structures and prognosis for 2060 were shown in a paper published by the European Commission where the age pyramids show a decrease of younger populations and proportionally increasing populations aged over 65 years (EC 2009).

An ageing population has been identified in Europe and North America and specific studies conducted in Germany, the UK and the Netherlands also confirm this (Rosenbloom, S., 2001;Donaghy, K., 2004;Rogge, L., 2005; Schmöcker, Jan-Dirk et al., 2008). By 2030 the last of the baby boomers will be turning 65 (OECD 2001; Rosenbloom, S., 2001). In the UK the number of retired people is expected to be around 23% by 2031 of the total population (Schmöcker, Jan-Dirk et al., 2008). Eurostat statistics predict that the share of the elderly above the age of 65 in Europe is going to grow to 28% in 2050 (Brög, W., 2005; Rogge, L., 2005).

The European Commission suggests long term trends for the demographic development in Europe until 2060 (EC 2009). The study shows similar predictions as the Eurostat paper (Rogge, L., 2005) and expects the population over 65 years to increase its share from 17% in 2009 to 30% in 2060.

The National Intelligence Council (2008) has developed global scenarios for 2025 including the population and demographic development. Among other aspects, ageing population and rising retirement age were identified in the developed countries. Increasing urbanisation in the least developed countries and brain drain from emerging markets to developed countries become real issues. By 2050 birth rate management will lead to an ageing in China, but birth rate management is still encouraged in the emerging economies (Munasinghe, M., 2009).

The mobility sector will be witnessing an influence from the changing household structure. According to Eurostat (2018) one third of households in the EU were single person households in 2018. Key words used to describe the change was the demand for individualisation and flexibility (Rogge, L., 2005). Therefore, demand for individual mobility services will increase. Life styles are becoming more versatile, leisure activities are gaining in importance and everyday life becomes more irregular and quickly changing (Brög, W., 2005; Rogge, L., 2005). Individual mobility needs are strengthened by the liberalisation of working hours and conditions, making working life less regular (Lanzendorf, M. et al., 2005).

Regarding the movement of citizens, it has been observed that mobility within the EU is still low as only 2% of working age individuals currently work in another member state although this percentage is expected to rise (EC 2007). However, migration patterns are difficult to predict accurately, but it is estimated that net migration could increase the EU's population by 56 million by 2061 (EC 2009).

Silva et al. (2014) analysed the crucial driving forces and demand challenges that the European transport industry faces. The authors suggested and elaborated the most influential societal, economic and technological driving forces or external trends that are expected to impact transport systems development up to 2030 and beyond. Amongst the most predominant social trends are ageing society, income growth and distribution, unemployment urbanisation, changing lifestyles and mobility behaviours, and environmental concerns.

Lastly, Schroten et al. (2017) conducted a study on barriers and enablers of Intelligent Transport Systems based on a case study driven methodology. The results revealed that there is still an increased tendency for resistance to accept new technologies by the users. Also compliance with legislation is amongst the social trends observed in users.

Summarising, the main social trends relate to demographics, behaviour, spatial organisation and social structures. Table 2.2 below summarises the key trends with reference to authors.

Areas	**Trends**	**Authors**
Demographics	Migration	ESPON 2011 EC 2007 EC 2009
	Ageing	Brög et al., 2005 Rudinger et al., 2006 Rudinger et al., 2006 Dejoux, V. et al., 2010 Kotavaara, O. et al., 2011

		USEmobility 2011 Spickermann A. et al., 2014 EEA 2011 EC 2009 Munasinghe, M., 2009 Rogge, L., 2005 Schmöcker, Jan-Dirk et al., 2008 Rosenbloom, S., 2001 Donaghy, K., 2004
	Fertility and birth rates	Brög et al., 2005 Rudinger et al., 2006 USEmobility 2011 Spickermann, A. et al., 2014 Munasinghe, M., 2009
Behaviour	Resistance to accept emerging technologies	Schroten et al., 2017
	Environmental concerns	Silva et al., 2014
	Data Privacy	Schroten et al., 2017
	Compliance with legislation	Schroten et al., 2017
Spatial organisation	Urbanisation	Garcia, G. et al., 2010 EC 2011 EC 2009
	Development of Large Metropolitan cities	Garcia, G. et al., 2010 EC 2011 Silva et al., 2014
	Urban Sprawl	Garcia, G. et al., 2010 EC 2011 Silva et al., 2014
Social structures	Unemployment rate	Silva et al., 2014
	Unequal distribution of wealth	Silva et al., 2014
	Remote working	De Graaff T. et al., 2007 Lanzendorf, M. et al., 2005
	Working conditions and legislation	Lanzendorf, M. et al., 2005

Table 2.2: Social trends

Source: Author

2.4.2 Economy trends

According to Naniopoulos et al. (2015), there are three major future economic trends that will be affecting the transport sector:

1. Globalisation, defined as: ‘an increasing internationalisation of markets for goods and services, the means of production, financial systems, competition,

corporations, technology and industries. It gives rise to increased mobility of capital, faster propagation of technological innovations and an increasing interdependency and uniformity of national markets' (OECD 2002, p427).

2. Internationalisation of transport external costs: Some forms of transport do not only affect society in a positive way but also give rise to side effects, namely environmental impacts, accidents and congestion. In contrast to the benefits, the costs of these effects of transport are generally not borne by the transport users. Therefore, these effects are labelled as external effects and the cost associated to them is called external cost (Van Essen, H. et al., 2008). There are five core categories of external cost: 1) Congestion and scarcity, 2) Accidents, 3) Air pollution, 4) Noise, and 5) Climate change (Van Essen, H. et al., 2008). The total external costs of transport in the EU, Norway and Switzerland in 2008 amount to more than €500 billion per year, or 4% of the total GDP, and these are expected to grow. About 77% of the costs are caused by passenger transport and 23% by freight. On top of these, the annual congestion cost of road transport amounts to between €146 and 243 billion (delay costs), which is 1 to 2% of the GDP (Van Essen, H. et al., 2011).
3. Shared economy: The sharing economy phenomenon relates to a general consumer behaviour trend generally known as instant gratification (Gansky, L., 2015).

Stewart et al. (2014) dealt with the future of rail industry towards 2050. The report identified a number of Megatrends, where energy and resources is amongst the most important. Economic growth may be limited by constraints on available resources and high and volatile prices; global consumption of resources will nearly triple to 140 billion tons per year by 2050.

Kautzsch et al. (2016) examined some of the Megatrends and gave examples of the impact of some of them on the auto industry. The Megatrends present a combination of technological leaps and upheavals in global society and the environment that will reshape economies, businesses and lifestyles. Particular emphasis was given to

Globalisation and its related trends such as the geographical distribution of production and activities, the competition at international scale and the international trade.

Ford (2012) focused on consumer attitudes in passenger transport in Europe. Economic pressure was identified as the most important Megatrend, which explains the impact of economic crisis on the transport industry.

The World Energy Council (2011) created two global transport scenarios: Freeway in which market laws define a pathway for open global competition, and Tollway where government interventions and common interests direct infrastructure and technology developments. These two scenarios deal with potential developments in transport fuels, technologies, and systems in the period up to 2050. Some of the driving forces elaborated in this study are the following: fiscal, demographic trends, urbanisation and megacities, geopolitics, global oil reserve and supply, environmental and health concerns, policies and regulations, lifestyle changes, fuel efficiencies and technological innovations.

The IATA (2017) report sets out the findings of a study exploring the forces shaping the future of aviation for the next 20 years. Geopolitical instability was identified as one of the key forces as one in four people on the planet live in fragile and conflict-affected areas. Cybersecurity concerns and regulation gaps in security and safety along with international regulation of emissions and noise pollution is another driver that affects the future of the airline sector.

New business models

Alegre et al. (2008) found that roughly one third of government gross capital formation in the old member states is investment in economic infrastructure, 80% of which is transport. As stated by Deloitte (2006), governments are increasingly turning to the private sector for financing, design, construction and operation of infrastructure projects. The search for alternative models is often justified and based on a belief that current financing systems are insufficient to meet development and maintenance needs. With this background, many governments have pursued the use of various ‘innovative’ alternative models, sometimes as part of a concerted policy focusing on infrastructure in general or given modes in particular, and often on a piecemeal basis. Once rare and limited to a handful of countries and infrastructure sectors, Public-Private Partnerships (PPPs) have emerged as one of the most important models governments use to close the infrastructure gap. PPPs take for example the form of Build-Operate-Transfer (BOT) contracts, Design-Build-Finance-Operate (DBFO) contracts or any variant of them, i.e. contracts where there is bundling of the different stages of the project and risks and responsibilities are transferred to the private sector to a greater extent than under traditional procurement (Iossa, 2015). As indicated in the EC White Paper (2011) there is a need to unlock the potential of private financing which will prerequisite an improved regulatory framework and innovative financial schemes. New financing instruments, for example the EU project bonds initiative, can support Private Public Partnerships (PPP) financing on a bigger scale (Iossa, E. et al., 2013).

The increasing role of PPPs

As stated above, Public Private Partnerships (PPPs) are a growing element of public sector procurement across Europe. Many scholars have analysed the advantages and disadvantages of these schemes. Some of the main advantages include acceleration of infrastructure provision, faster implementation, reduced whole life costs, improved quality of service, generation of additional revenues, enhanced public management, better incentives to perform (PWC 2005; Geest et al., 2011; Iossa et al., 2015).

The question of risk is fundamental in the consideration of PPPs. There are several risks categorisations in PPPs (EC 2003; Eurostat 2010; Iossa, 2011; World Bank 2011; US Department of Transportation 2012): Construction risk, Performance and availability risk, Residual value risk, Financial risk, Demand risk, Governance risk. Another categorisation, suggested by the European Investment Bank (2003), involves two determinants of risks: the social and the economic. The first one concerns public acceptance. Economic risks focus on the value for money criterion. For PPPs, the best way to avoid endless discussions about their pros and cons is to use widely agreed pre-defined cost-benefit tools comparing the PPP option with public and/or PPP alternatives. Transparent monitoring of PPP projects by public stakeholders is also essential.

With regards to the legal framework surrounding the PPPs, there is no specific EU legislation covering the formulation and operation of PPPs only, but EU public procurement rules including the Treaty on the Functioning of the EU, EU public procurement directives and relevant case law have currently been applied to PPPs. PPPs represent on method of public procurement, and as a typical example the main procurement procedure so-called 'competitive dialogue' covers some futures of PPPs. The EU has two procurement directives – the Public Sector Directive (2004/18/EC) and the Utilities Directive (2004/17/EC) (Son, 2012).

Summarising there are two major economic trends, globalisation and fiscal structure and developments. Table 2.3 below presents the main associated trends as identified in the literature.

Area	**Trend**	**Author**
Globalisation	Shortage of energy resources	Naniopoulos et al., 2015 Stewart et al., 2014 World Energy Council 2011
	Global regulation gaps	Iossa, 2011 IATA 2017 World Energy Council 2011
	(Re) distribution of income and wealth	World Energy Council 2011
	Economic & political conflicts (contrasting interests)	IATA 2017 World Energy Council 2011
	Higher competition & New Business Models	Naniopoulos et al., 2015 Iossa, 2015 Iossa, 2013 Kautzsch et al., 2016
	International trade	Kautzsch et al., 2016
Fiscal	Financial recession	Ford, 2012
	Market competition (also with regards to PPPs)	Geest et al., 2011 PWC 2005 Iossa et al., 2015 Kautzsch et al., 2016
	Geographic distribution of	Kautzsch et al., 2016

	production and activities	

Table 2.3: Economic trends

Source: Author

2.4.3 Policy trends

The EEA (2008) study outlines a vital need to increase coordination between all policies affecting the environment, such as transport policy and planning, while the future promotion of reforms to favour the attainment of sustainable mobility should be outlined (Colonna, 2009).

The polluter pays principle has a strong presence in EU policy, as indicated in the EU Treaty Article 191 paragraph 2:
'Union policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Union. It shall be based on the precautionary principle and on the principle that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay'.

The internalisation of external costs (externalities) is also integrated in the list of policy measures designated as smart pricing and taxation. The White Paper- Roadmap to a Single European Transport Area (EC 2011) explains the EU objectives for the internalisation of externalities.

According to Ricardo-AEA (2014) on a report commissioned by DG MOVE, the classification of the external costs of transport is as follows: congestion, accidents, noise, air pollution, climate change, other environmental impacts (costs of up- and downstream processes), infrastructure wear and tear for road and rail.

The external costs can be either social costs such as infrastructure, capital costs, congestion costs, accident costs, environmental costs or private (or internal costs), by the transport user, such as energy cost of vehicle use, travel time costs, taxes and charges.

Essen et al. (2012), in their report which was commission by DG MOVE of the EC, have identified the following pricing schemes: fuel taxes, vehicle taxes, infrastructure charges, insurance taxes, VAT exemptions, sea port dues and waste charges, fairway dues, airport and aviation charges. The same report highlights the importance of the harmonisation of transport pricing across the Member States, especially in fuel taxation and infrastructure charging.

The table below presents main pricing schemes per mode per country. As can be observed, pricing instrument is a very important policy tool that has been adopted by all countries.

Transport mode	**Pricing instrument**	**Country/ city**
Road	Fuel	EU.
Road	Infrastructure	AT, BE, BG, CZ, DK, FR, DK, GR, HU, IE, IT, LT, LV, NL, PL, PT,RO, SK, SI, ES, SE, UK.
Road	Insurance	AT, BE, BG, CY, DK, FI, FR, DE, GR, IE, IT, LU, MT, NL, PT, RO, SK, SI, ES, SE, UK.
Road	Ownership	AT, BE, BG, CY, CZ, DK, EE, FI, DE, GR, HU, IE, IT, LV, LT, LU, MT, NL, PL, PT, RO, SK, SI, ES, SE, UK.
Road	Registration	AT, BE, BG, CY, CZ, DK, FI, FR, GR, HU, IE, IT, LV, MT, NL, PL, PT, RO, SI, ES.
Road	Company car (as benefit in kind)	AT, BE, CZ, DK, EE, FI, DE, GR, IE, NL, PT, ES, SE, UK.
Road	Congestion charge	IT, MT, SE, UK.
Road	Company car tax	BE, FR, LV.
Road	Purchase premium	LU, SE, UK.
Road	Scrappage scheme	SI.
Rail	Infrastructure access charges	AT, BE, BG, CZ, DK, EE, FI, FR, DE, EI, HU, IE, IT, LV, LT, LU, NL, PL, PT, RO, SI, SK, ES, SE, UK.
Rail	Energy taxation	AT, BE, BG, CZ, DK, EE, FI, FR, DE, EI, HU, IE, IT, LV, LT, LU, NL, PL, PT, RO, SI, SK, ES, SE, UK.
Inland navigation	Fuel tax exemption	EU.
Inland navigation	Port dues	Krems, Antwerp, Gent, Liege, Vidin, Decin, Duisburg, Frankfurt am Main, Hannover, Mannheim, Lyon, Paris, Strasburg, Budapest, Mantova, Mertert, Amsterdam, Hengelo, Nijmegen, Rotterdam, Utrecht, Szczecin, Constantza, Bratislava, London.
Inland navigation	Fairway Dues	BE, DE, FR, LU, PO, RO.
Inland navigation	Waste water discharge	BE, DE, FR, LU, NL, CH.

Maritime shipping	Fuel taxes	EU.
Maritime shipping	Sea port dues and waste water discharge	Antwerp, Zeebrugge, Bourgas, Lemesos, Copenhagen-Malmo, Tallinn, Helsinki, Le Havre, Marseille, Bremen, Hamburg, Trieste, Riga, Klaipeda, Valletta, Amsterdam, Rotterdam, Gdansk, Sines, Constantza, Koper, Barcelona, Valencia, Gothenburg, Stockholm, Trelleborg, Grimsby & Immingham, London, Tees & Hartlepool.
Maritime shipping	Fairway Dues	FI, SE.
Aviation	Fuel taxes	EU.
Aviation	ETS	EU.

Table 2.4: Inventory of measures for internalising external costs

Source: adapted from Essen et al. (2012), An inventory of measures for internalising external costs in transport, report for DG MOVE-European Commission, page 119.

The EU has issued the Directive 2002/49/EC relating to the assessment and management of environmental noise stress on the strategic noise mapping. Member States must draw up action plans designed to manage, within their territories, noise issues and effects. Member States must also involve the public in the action plan development (CEC 2008). The vast majority of energy taxes are being levied on (mostly road) transport fuels (EC 2009). Policy measures envisaged in the White Paper are to (EC 2011 pages 19-27): 'establish a link between vehicle fuel taxation and environmental performance; fully internalise the cost of GHG emissions for all modes of transport in a coordinated and stepwise manner; assess the possibility of introducing VAT on all international passenger transport services inside the EU; promote a revision of company car taxation to eliminate distortions or, as a second best, to provide incentives for clean vehicles'. Europe's future is said to depend on cities resilient to climate change and this need will include assuring a resilient transport for the future of European urbanised areas (EEA 2012). On the other hand, transport adaptation to climate change will require specific policy instruments and investment in a low-carbon economy (CoR 2011).

The diverse structures of passenger car taxation in Europe were analysed by Kunert and Kuhfeld (2007). Taxes and fees related to the registration, ownership and use of cars are assessed differently across Europe, and their rates vary significantly.

Distinct from the previous ones, but still relevant, the new taxes on civil aviation many European countries have introduced in the last decade have a certain impact on the competing utilisation of air transport, especially on national routes.

Infrastructure projects include the European global navigation satellite systems (Galileo and EGNOS), which will complement the traditional networks and improve their exploitation (EC 2009). The Trans-European transport networks (TENs) policy has much increased the coordination in the planning of infrastructure projects by the Member States. The extension of the TENs to cover the new Member States, building on the investment already made prior to enlargement, has provided the blueprint for Structural and Cohesion Funds to gradually fill their infrastructure deficits. Significant changes in urban mobility require comprehensive actions that bring together land-use planning, road use and parking, transport pricing, infrastructure development, public transport policy and much more (EC 2011).

The EC in 2008 introduced a directive for traffic offences that covers the whole EU. This system for exchange of information, allows cross-border enforcement of sanctions. Although the traffic law varies in the member states, when an offence is committed with a vehicle registered in a different member state to the one where the offence is committed then a fine is sent to the home country of the offender.

Finally, the development of decentralised economic activities will require an efficient, flexible and intermodal transport system. The current situation in terms of accessibility in the EU suggests that there is a marked division between central and peripheral areas as regards their transport connectivity and costs as a result of geography and patterns of economic activity (Christidis and Ibañez, 2010).

Summarising, the two main areas of policies concern the institutional structures and policies and the transport relates policies. These are listed in Table 2.5.

Area	Trends	Authors
Institutional structures and policies	Cohesion policy	EC 2011
	Participation of citizens in decision making	CEC 2008
	Allocation of power (centralised or decentralised)	Christidis and Ibañez, 2010
Transport policies	Traffic law	EC 2008
	Internalisation of externalities (e.g. carbon taxes)	EC 2011 Ricardo-AEA, 2014
	Subsidies and incentives (e.g. scrapping schemes)	EC 2011
	Infrastructure investments	EC 2009 EC 2011
	Pricing (eg for parking and motorways)	EC 2011 Essen et al., 2012
	Charges (e.g. for congestion)	EC 2011 Essen et al., 2012 Kunert and Kuhfeld, 2007
	Governments' support of sustainable mobility schemes	Colonna, 2009 EEA 2008 EC 2011 CoR 2011
	Taxation of fuels	Essen et al., 2012 EC 2009 Kunert and Kuhfeld, 2007
	Vehicle taxation	Essen et al., 2012 Kunert and Kuhfeld, 2007

Table 2.5: Policy trends

Source: Author

2.4.4 Technological trends

The modernisation and digitalisation of transport services promises new efficiencies and comforts for modern urban travelers, international traders, passengers and public authorities by using technology to add value and improve transportation by offering increasingly accessible and comfortable shared-use mobility, matching supply and demand in real time, and building towards autonomous vehicle adoption for public and private actors. The intensive digital transformation of the global real economy has been observed by policy-makers, analysts and sectorial professionals for the last few decades, which opened opportunities for the creation of new business models, industrial processes, services and products.

Digital economy, in theory, is a knowledge-driven phenomenon, with a significant contribution to productivity rising when technology advances due to knowledge accumulation (Tapscott, 1995; Quah, 2003). Digital economy, in practice, has been empowered by exponentially growing computing power that leads to further developments of a broader range of digital products, applications and services, which are widely used by businesses and citizens, and thus this process establishes the foundations for the total digital transformation of the real sectors (OECD 2017). For this very reason, the European Union Digital Single Market Strategy adopted in May 2015 emphasises the need for building-up the proper environment for businesses and citizens in Europe to freely access the digital good markets, and creating a level playing field for digital networks, innovations and services to progress and increase the growth potential of the EU economy (EC 2017).

Transportation is one of the real economy's sectors experiencing huge digital transformation as a result of innovations such as Internet of Things (IoT), Big Data analytics, new business and operating models, artificial intelligence and robotics, super-performing computers and cloud systems. In future the traditional modes of transportation will become more diverse and simultaneously more connected – bicycles, public transport, pedestrians, smart trains and highly automated vehicles in the cities will play a major role and will need, on the technical side, a tailor-made database and traffic management approaches, as well as rules and safeguards responding to the risks and disruptions they pose. The latest concepts – Mobility as a Service (MaaS), E-Mobility, Traffic Management as a Service (TMaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) – use a combination of cutting-edge technologies to integrate with the existing infrastructure and offer new solutions to cope with the current economic, social and technological trends, however, they can also raise questions regarding data privacy and security, consumer and passenger protection, as well as fair and equal competition.

According to the EU funded research project OPTIMISM , trends and developments in the transport sector can be structured into the four technological fields: 1) vehicle technologies, 2) engine technologies, 3) material technologies, and 4) infrastructure/operating technologies (see Figure 2.4: OPTIMISM taxonomy of trends).

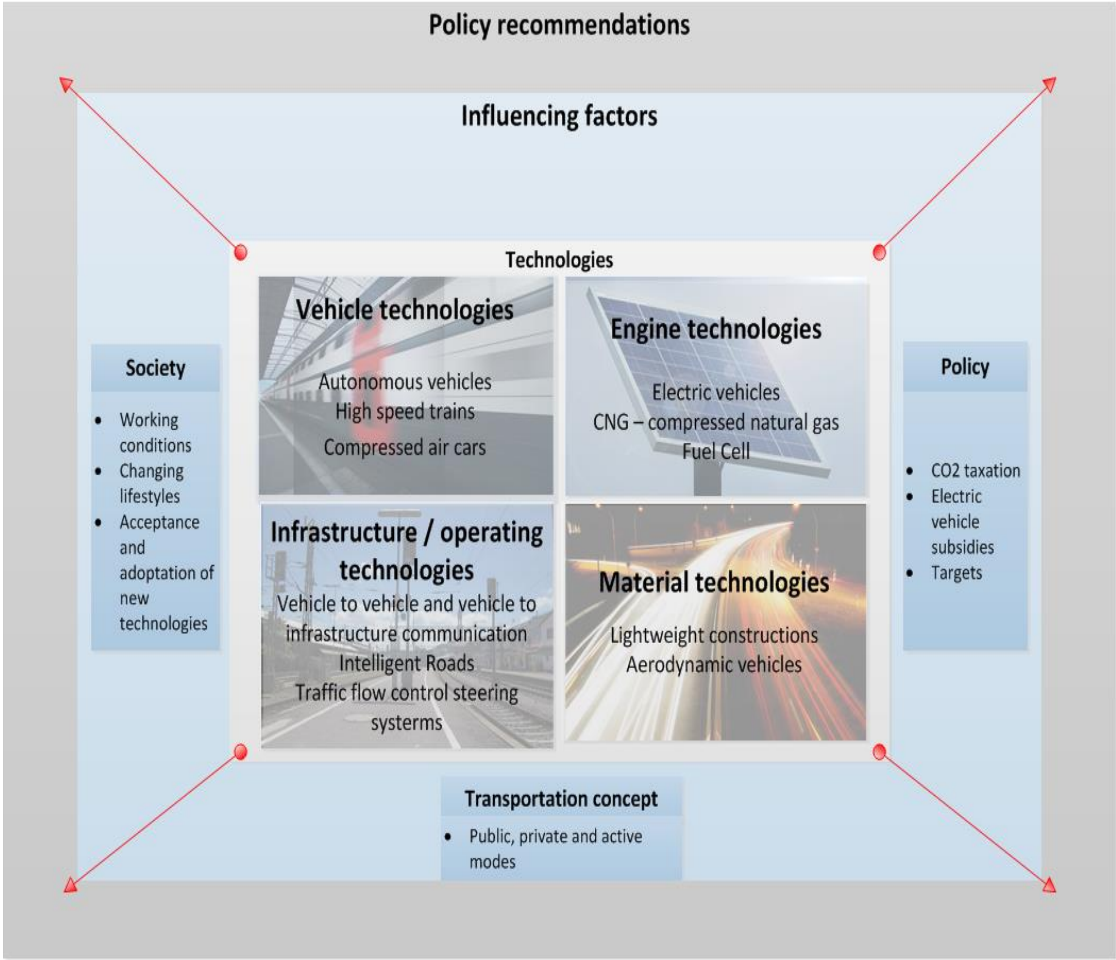

Figure 2.4: OPTIMISM taxonomy of trends

Source: adapted from OPTIMISM (Delle Site et al., 2012)

ITS builds on partnerships among all responsible public authorities and transport operators in order to foster a safe, efficient, affordable, integrated and environmentally friendly transport system. Thus ITS are a key enabler of the integration of different transport modes to provide door-to-door transport systems (EC 2001). At EU level, the crosscutting nature of ITS and their potential have determined their consideration as an integral part of the Common Transport Policy (EC 2010). ITS have been acknowledged as a key enabler to support major EU priorities as regards economic growth beyond 2020 (Wilfried, M., 2010).

According to a vision of road transport provided by ERTRAC (2009), by 2030 a highly integrated and service driven information society will emerge in which the mobility consumer takes part actively and continuously regardless of his/her location (home, work, commuting, leisure). Especially in the urban areas, where by then more than 80% of the European population is expected to be located, 'a wide variety of online services provided by advanced, cheap digital outlets, will bring on dramatic changes in consumer awareness, attitude and behaviour towards transport in general and personal mobility in particular'. One of the most frequent applications would be the ones that related to the availability of information where real time updates will become a norm. Passengers are expected to provide information, for example, on a traffic situation or tariff changes etc. The emergence of Big Data is also evident. 'Big Data technologies describe a new generation of technologies and architectures, designed to economically extract value from very large volumes of a wide variety of data, by enabling high-velocity capture, discovery and/or analysis' (J. Gantz and D. Reinsel, 2011, p 6). Mobility operators will be able to use the same information services, for example to optimise the efficiency of the network infrastructure, or to limit the environmental impact of mobility patterns, by offering travel incentives to specific consumer groups or to customers on preferred travel modes and routes, or even by implementing controls to speed limits. ICT is also expected to contribute to reduction of social exclusion because it will enable passengers to have the same access to information and cost-effective mobility options, comparable to those living in urban environments (ERTRAC 2009).

Transport technologies

In the field of vehicle technologies, one major trend that is observed is the development of autonomous vehicle systems. Although it is already technologically possible to let vehicles drive autonomously (without any intervention of a car driver), the introduction of autonomous driving will take, in practice, years (Delle Site et al., 2012). This is due to non-technical issues (e.g. consumer confidence and legal aspects) as well as difficulties involved in controlling a vehicle in unpredictable and challenging traffic conditions (especially in urban areas). According to Wadud et al. (2016), a complete integration of autonomous vehicles into the transport system does not even seem realistic before 2030. Several other reports even mention a timeframe up to 2050 before autonomous vehicles will be able to fully replace conventional vehicles (Tauber, 2016). Nevertheless, technological developments in this sector have put a lot of pressure on governments to make regulatory changes permitting on-road testing of autonomous vehicles (Schreurs and Steuwer, 2016).

Another trend in vehicle technologies that has developed rapidly over the past few years are drones. According to Deloitte (2018), passenger drones are expected to be electric quadcopter between destinations covering short to medium range distances (up to 65 miles). Drones were formerly mainly used in the military sector; however, they are now increasingly being used in private and commercial applications. According to a study of a leading global insurance company, 600,000 drones are currently in commercial use in the United States and about 1.9 million in private ownership. These numbers are expected to triple by 2020 (Dobie et al., 2016). In addition, numerous logistics companies are currently planning to use drones for the distribution of goods. Amazon, for example, supplied its first customer by drone in December 2016. However, the legal framework conditions for regular commercial operations are still insufficiently developed (Amazon, 2017).

In the field of engine technologies, one of the major developments that is currently influencing the industry is the electrification of vehicles. While the earlier generations of electric vehicles had a range of only a few kilometres, today electric cars can reach 300 kilometres (or more) with a single battery charge (Cobb, 2016). However, according to a study conducted by the UBS Group, the global production of cobalt and lithium would have to increase between twenty and thirty times to ensure a complete switch to electric cars. According to some studies, the production of batteries in particular is extremely damaging to the environment and has a severe impact on the overall environmental balance of electric vehicles. Romare and Dahllöf (2017) estimated in their latest study an emission of 150 to 200 kilograms CO2 per kWh battery capacity: the production of one single Tesla battery would, therefore, cause about 17.5 tons of CO2. Despite all these concerns and ambiguities, the market share of electric vehicles is increasing. Considering these developments, the share of electric vehicles could account for 25 to 40 percent of new vehicle registrations worldwide by 2030 (Arzt, 2017). Contrasting this though, a study conducted by Berkley et al. (2017) with regards to battery electric vehicle take up in Europe showed that despite the environmental burdens, the commitment by manufacturers has been relatively low with considerable variations across nations and regions.

Another important engine technology is hydrogen fuel cells. Fuel cells are used to convert hydrogen into electricity, which in turn drives an electric engine. According to Arena et al. (2017), increase of sales of fuel cell vehicles (FCV) are expected to be significant in the future, but only in the long term. Until then, there are still several constraints such as the missing infrastructure network or a lack in efficient solutions for hydrogen production to overcome. Nevertheless, the International Energy Agency (IEA) estimates an FCV market share of about 17% by 2050, with 35 million annual unit sales (Arena et al., 2017).

In terms of material technologies, one technology that is becoming increasingly popular is the additive manufacturing process, better known as 3D printing. Today, 3D printing is no longer only used for the production of prototypes, but is increasingly being used for mass production as well (Richter and Wischmann, 2016). In the automotive industry, manufacturing companies are using 3D printing for the production of individual components (Schroeder, 2015). Another technology that has entered dynamically the market and is being combined with 3D printing in production processes is lightweight construction. The idea behind the lightweight construction is to save raw materials and energy due to lower vehicle weights. A systematic use of lightweight construction in the transport sector has been observed for the first time in aircraft construction with the widespread processing of aluminium (IAI, 2016).

Infrastructure technologies

The growing number of electric vehicles on the roads requires the establishment of a well-connected and seamless charging infrastructure network. Tesla, for example, plans to build in Norway Europe's largest Supercharging station with 42 charging points (Lambert, 2017).

In the course of digitalisation and the advancing Smart City movement, Intelligent Transport Systems (ITS) are rapidly emerging. ITS-technologies optimise traffic flows and the use of infrastructure by intelligently managing and directing the different traffic components. Kantowitz and Le-Blanc (2006) distinguish three types of communication within ITS-technologies: Vehicle-to-Infrastructure (V2I), Infrastructure-to-Vehicle (I2V) and Vehicle-to-Vehicle (V2V). Practical applications for V2I and I2V technologies can be found in car park management, traffic management, usage-based cost accounting or navigation applications (Ruchatz, 2017).

With regards to V2V technology, Truck Platooning is gaining ground**:** here trucks are digitally connected with each other in such a way that they automatically move one after the other at a constant distance. This intends to relieve the drivers and save fuel by using slipstreams at reduced vehicle distances. Furthermore, Truck Platooning may induce significant road safety improvements: While a human driver has a reaction time of about one to two seconds, V2V communication can reduce the response time up to 0.2 seconds according to a study of the German vehicle manufacturer Daimler (Wilkens, 2017).

New mobility services

According to Hoppe et al. (2017), a major trend is the mobility as a service (MaaS): MaaS organises the entire transport chain for the mobility users. This includes the planning, booking and accounting of the trip in a mostly smartphone based system, integrating all types of traffic such as slow traffic, public transportation or sharing systems (Hoppe et al., 2017).

Some experts forecast that an utilisation rate of more than 50% of shared cars by the year 2030 is expected, mainly due to a large-scale adoption MaaS offers (Intelligent Transport, 2017). Although integrated platforms will play a major role in the mobility system of the future, there is some ambiguity and concerns about the ownership of (personal) data.

In the field of on-demand systems (transport services that can be ordered), the trend is becoming very popular. Especially, road-based systems (such as Uber) have already established themselves on a rather large scale penetrating the market of almost every country (Dvorsky, 2017). However, the extent of the impact the on-demand systems will have on the overall traffic volume within the transport system is still unclear and whether instead of a reduction, an increase might be induced (Reichel, 2018).

In recent years, the smart city has become a very popular concept. Although there are many definitions of smart cities, there are certain aspects that are linked with the concept of smart cities and these relate to the role of cities in the social and economic aspects of people worldwide, and in the huge impact on environmental sustainability (Mori and Christodoulou, 2012).

The first definition of a smart city was introduced in 2007 by Giffinger: 'the creation and connection of human capital, social capital and Information and Communication Technology (ICT) infrastructure in order to generate a greater and more sustainable economic development and a better quality of life'.

The European Union launched, in May 2010, the Digital agenda for Europe which aimed at improving Europe's economy by delivering sustainable economic and social benefits from a digital single market. The smart city in the digital agenda is understood as 'a place where the traditional networks and services are made more efficient through the use of digital and telecommunication technologies, for the benefit of its inhabitants and businesses'.

According to Giffinger et al. (2007), the holistic concept of Smart consists of six sub-areas Smart Economy, Smart People, Smart Governance, Smart Environment, Smart Living and Smart Mobility. In this context, Smart Mobility is defined as a 'modern form of mobility, which aims for more efficient traffic flows, emission reduction and cost-savings for the mobility users' (Giffinger et al., 2007, p12). Some solutions are based on implementing innovative and sustainable ways to provide mobility to people in cities, such as the development of public transport fuels that respect environment, supported by advanced technology and proactive behaviour of citizens (Neirotti, 2012; Van Audenhove et al., 2014).

A recent example of a mega size smart city project is the Neom in Saudi Arabia where it is expected that a 26,500 square kilometres large digital mega-industrial zone will be built in the middle of nowhere. This flagship project called Neom is to become a kind of separate state territory in which almost everything will be automated and IT-based including transportation. This includes for example electro mobility, autonomous road transportation and new multimodal mobility concepts such as passenger transport by drones. This futuristic zone is estimated to have an initial cost of up to 500 billion US dollars. The project is expected to be completed by 2025 (Shahine, A. et al., 2017).

Table 2.6 summarises the main trends in terms of technology. It is not focused on the actual technologies themselves as these change rapidly in short time and, therefore, they do not constitute a trend. The focus is on the driving factors behind the development of the individual technologies.

Areas	Trends	Authors
ICT	Diffusion and market up-take of ICT	OECD 2017 Neirotti, 2012 an Audenhove et al., 2014 Shahine, A. et al., 2017
	R&D spending	Schreurs and Steuwer, 2016 Lambert, 2017
	Innovation performance	OECD 2017
	Improved safety	Wilkens, 2017
	Improved traveller experience	Intelligent Transport 2017 Hoppe, 2017
Vehicle Technologies	R&D spending levels	Lambert, 2017
	Innovation performance	OPTIMISM 2012 Cobb, 2016
	Diffusion and uptake of technologies by market	Cobb, 2016 Arena et al., 2017 Dvorsky, 2017
	Improved safety	Wilkens, 2017

Table 2.6: Technological trends

Source: Author

2.4.5 Environmental trends

The EU has issued Directive 2002/49/EC relating to the assessment and management of environmental noise stress and strategic noise mapping. In this directive stress is placed upon the development (by Member States) of strategic noise maps showing the situation in terms of noise emissions. Furthermore, Member States must draw up action plans designed to manage, within their territories, noise issues and effects. Member States must also involve the public in the action plan development (CEC 2008).

The EU is well aware of the need to drastically reduce world greenhouse gas emissions, and consequently limit climate change. The EU aims at reducing emissions by 80-95% below 1990 levels by 2050. Commission analysis shows that while deeper cuts can be achieved in other sectors of the economy, a reduction of at least 60% of GHGs by 2050 with respect to 1990 is required from the transport sector, which is a significant and still growing source of GHGs. By 2030, the goal for transport will be to reduce GHG emissions to around 20% below their 2008 level. Given the substantial increase in transport emissions over the past two decades, this would still put them 8% above the 1990 level (EC 2011).

However, it has been pointed out that transport is the only sector in the EU in which greenhouse gas emissions continue to rise (Egenhofer, 2011). Therefore, unless this trend can be reversed, the EU will have little chance of reaching its objectives in the context of global obligations to reduce emissions between 80% and 95% by 2050 compared to 1990 levels. In this respect, a number of policies have the potential to reduce transport GHG emissions. Those targeting fuel economy and fuels arguably can act quickest but will not be sufficient to reach ambitious GHG reductions over the longer term (OECD/ITF 2009). As noted by Kunert and Kuhfeld (2007), the market value of future fuel savings may be small because of imperfections in the market for fuel economy. Therefore, additional instruments aimed at influencing the vehicle purchase decision may correct this distortion (Example: system of rebates for high fuel economy vehicles combined with fees levied on lower fuel economy vehicles – feebates).

Zachmann, G. et al. (2012) recognise that a consistent policy approach will be needed to allow a friendly decarbonisation growth and also to extend carbon pricing both in time and space. To ensure economic efficiency, the carbon price needs to be aligned across sectors, over time and across regions, and hence (Zachmann et al., 2012) argue that marginal abatement costs have to be aligned across sectors to minimise welfare losses, and emissions shall be reduced in those sectors in which lower costs are involved. Also, the price signal must have a long term component such that pollution rights will be scarce beyond 2020 to encourage low-carbon investments. Lastly, the price signal has to account for international spill-overs in such a way as to provide incentives for low carbon technologies to help in reducing emissions outside Europe as well.

Regarding other policy responses to resolving the infrastructure externality, Zito and Salvo (2011) concluded that direct subsidies or indirect finance through higher fossil fuel prices for fuelling stations using a given technology (e.g. hydrogen) will be very difficult to implement politically.

Technological innovation has the potential to deliver larger emission reductions on a much faster track than changes in travel and settlement patterns. A consistent finding of the study of the International Transport Forum (OECD/ITF 2009) was that many technology and fuel-related GHG reduction measures in the transport sector are available at relatively low cost or may even save money over time.

This ITF report (OECD/ITF 2009) identified other measures for reducing GHG emissions which might be adopted by policy-makers: road traffic management, demand management, mode shift (PT, cycling and walking) opportunities that help to reduce CO2 emissions in some cities depending on local and national circumstances.

The environmental trends can be summarised as follows (Table 2.7):

Area	**Trends**	**Authors**
Energy & emissions	Energy use levels	EC 2011 Kunert and Kuhfeld, 2007
	Renewable energy	OECD/ITF 2009 Kunert and Kuhfeld, 2007
	Energy prices	Zachmann et al., 2012 Zito and Salvo, 2011

Table 2.7: Environmental trends

Source: Author

2.5 Summary and conclusions of the chapter

Starting from the definition of ‘sustainable mobility’ and ‘Megatrends’, this chapter analysed the main Megatrends. A literature review-based methodology was applied and search on the term Megatrends in transport related and general foresight studies. Particular emphasis was given to the EC, ETPs and worldwide projects that have studied the Megatrends affecting transportation sector and roles of Megatrends in forward looking projects.

The table below summarises the main findings of the literature review

Political & Legal	Institutional structures and policies	Cohesion policy EU enlargement Participation of citizens in decision making Allocation of power (centralised or decentralised)
	Transport policies	Traffic law Internalisation of externalities (e.g. carbon taxes) Subsidies and incentives (e.g. scrapping schemes) Inadequate infrastructure investments Encouragement of public-private partnerships Opening of transport markets to competition Pricing (e.g. for parking and motorways) Charges (e.g. for congestion) Governments' support of sustainable mobility schemes Taxation of fuels Vehicle taxation
Economic	Globalisation	Shortage of energy resources Global regulation gaps (Re)distribution of income and wealth Economic & political conflicts (contrasting interests) International trade-Higher competition
	Fiscal	Financial recession Market competition Geographic distribution of production and activities
Social	Demographics	Migration Ageing- Fertility and birth rates
	Behaviour	Resistance to accept emerging technologies Environmental concerns Data Privacy Compliance with legislation
	Spatial Organisation	Urbanisation Development of Large Metropolitan cities Urban Sprawl
	Social Structures	Unemployment rate Unequal distribution of wealth Remote working Women’s increased role in the economy Working conditions and legislation
Technological	ICT	Diffusion and market up-take of ICT R&D spending Innovation performance Improved safety Improved traveller experience
	Vehicle technologies	R&D spending levels Innovation performance Diffusion and uptake of technologies by market

		Improved safety
Environmental	Energy & emissions	Energy use levels Renewable energy Energy prices

Table 2.8: Megatrends based on literature review

Source: Author

As Megatrends, together with socio-technical shifts in the transport industry, are expected to change the whole sector in a fundamental way, they should be further validated in order to estimate their impact on achieving sustainable mobility. The selection of the most important trends will be done with the involvement of experts through the Delphi Method. The prioritised Megatrends will then be further analysed using the Analytic Network Process methodology where their impact will be also determined.

CHAPTER 3

KEY POLICIES IN THE EU

Introduction

This chapter focuses on the description of the main key transport policies that are currently in place in the EU. The objective is to extract the parts that are relevant to the reinforcement of sustainable mobility. This is important when suggesting policy directions at chapter seven, because gaps might be identified if a particular direction is not in place or more emphasis and/or improvement can be suggested on the basis of the results of this research.

3.1 Policy framework and objectives

The European Commission adopted in July 2016 a low-emission mobility strategy. By 2050, greenhouse gas emissions from transport will need to be at least 60% lower than in1990 and be firmly on the path towards zero. The strategy integrates a broader set of measures to support Europe's transition to a low-carbon economy while its main pillars include the following:

- Further use of digital technologies, smart pricing and shift to lower emission transport modes
- Accelerating the deployment of low-emission alternative energy for transport (eg advanced biofuels, electricity, hydrogen and renewable synthetic fuels) and removing obstacles to the electrification of transport
- Shifting towards zero-emission vehicles

With regards to aviation, in 2016, the International Civil Aviation Organization (ICAO) agreed on a Resolution for a global market-based measure to address CO_2 emissions from international aviation as of 2021. This policy sets out the elements of the global scheme. The Carbon Offsetting and Reduction Scheme for International Aviation, aims at stabilising CO_2 emissions at 2020 levels by requiring airlines to offset the growth of their emissions after 2020. The scheme imposes the airlines to monitor emissions on all international routes and requires from them to offset emissions from routes included in the scheme by purchasing eligible emission units generated by projects that reduce emissions in other sectors (e.g. renewable energy).(EC, 2016)

On 17 April 2019, the European Parliament and the Council adopted the Regulation (EU) 2019/631 on setting CO2 emission performance standards for new passenger cars and for new light commercial vehicles (vans) in the EU for the period after 2020. The Regulation also includes a mechanism to incentivise the uptake of zero- and low-emission vehicles, in a technology-neutral way.

Historically, the European Union transport policy has been driven by the objective to meet certain challenges (EC, 2014). The congestion costs Europe around 1% of annual GDP – and freight and passenger transport alike are set to grow. Oil dependency; despite improvements in energy efficiency, transport still depends on oil for 96% of its energy needs. Oil will become scarcer in future, increasingly sourced from unstable parts of the world. By 2050, the price is projected to have more than double compared to 2005. Greenhouse gas emissions; by 2050, the EU must cut transport emissions by 60% compared with 1990 levels, if we are to limit global warming to an increase of just 2ºC. Infrastructure quality is uneven across the EU and lastly, competition**,** the EU's transport sector faces growing competition from fast-developing transport markets in other regions. To develop sustainable transport systems requires a massive infrastructure and R&D investment in the green technologies of the future (Bailey, 2010).

The development of regulations and legislation to facilitate the single European market began in the 1980s. Since then, legislation has focused on facilitating cross-border movements of goods and services (EC, 2014). In recent years, the evolution of technologies has created an intense need to focus on the digitalisation of transportation in order to ensure this is functioning as an integrated system. Naturally, this requires a continuous and laborious update of rules and regulations that can adapt the system to the new technology equilibrium. The main three pillars of this policy are: 1) digital transport; 2) promote multimodality via incentivising economic agents; 3) support the multimodal infrastructure and innovation in the context of the Connecting Europe Facility, Horizon2020, preparation for the next Multiannual Financial Framework (MFF) and the new framework programme for research and innovation (FP9); 4) protecting passengers rights, and 5) promoting active mobility integrated with other policy imperatives, especially in the context of urban and smart cities (DG Transport & Mobility 2018).

Smart, green and integrated transport is identified as a major aim of the Research and Innovation funding mechanism, known as the EU's Horizon 2020 (2014–2020) research programme.

The individual EU countries implement various measures to support the deployment of electric vehicles, such as subsidies and financial benefits, local incentives and infrastructure incentives. In countries where there are no incentives available i.e. Bulgaria, Estonia, Poland and Slovakia, there is a low propensity to buy electric cars (EAFO, 2017)

With regards to road charging schemes on European roads is not effectively applied in the EU. Eight EU countries apply distance-based charges (tolls) to private cars on (some) motorways. The charging systems vary in terms of network coverage, charge levels and other conditions which provides unclear incentives to users. In transport fuels rates, there are also substantial differences across the European countries. There is a general preferential treatment of diesel which is taxed less than petrol in almost all countries. (EC, 2018)

3.2 White Paper on Transport

The European Commission released in 2011 the White Paper on Transport entitled: Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system.

The Roadmap included 40 initiatives that would support the transport industry's competitive position, will increase mobility and remove obstacles in key areas. The policy introduced high standards especially for the greenhouse gas emissions for 2020 and 2050 (reduction by 60% by 2050). At the same time, the actions suggested are expected to reduce Europe's dependence on oil.

By 2050 the main key goals of the policies include:

- Decrease of conventionally fuelled cars in cities.

- 40% use of sustainable low carbon fuels in aviation; at least 40% cut in shipping emissions.
- A 50% shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport.
- All of which will contribute to a 60% cut in transport emissions by the middle of the century.

The initiatives launched cover the following areas:

An efficient and integrated mobility system

This includes the creation of a single European Transport Area (such as Single European Sky through SESAR[5] project). The promotion of quality jobs and working conditions such as a socially responsible transport sector is also an objective of the White Paper's initiatives. Enhanced security and safety which appear to be some of the important Megatrends especially with the wide use of ITS in transport are part of the strategy too along with the provision of a seamless door-to-door mobility

Technology and behaviour

The improvement of RTD and Innovation policy through better regulations and deployment strategies has also appeared as Megatrends because investment in RTD can bring new technological advances. Moreover, a behaviour change towards sustainable development and urban mobility plans can contribute to a shift towards sustainable mobility.

Infrastructure and smart funding

The improvement of transport infrastructure (TEN guidelines) is an essential component of the development of the transport sector. This goes in pair with coherent funding that can support the infrastructure development. Private sector engagement through the implementation of PPPs is gaining ground as a major trend and a new business model. Lastly, smart pricing and taxation are also part of the same strategy.

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[5] https://www.sesarju.eu/

International dimension: transport in the world

This includes opportunities for opening up third country markets in transport service.

3.3 Sustainable Urban Mobility Plans

The Sustainable Urban Mobility Plans programme is the most important topic in the Commission's Urban Mobility Package of policies (European Commission 2013). The definition of the Sustainable Urban Mobility Plan as introduced by the EC (2013, p 2) is 'a mechanism that aims at improving accessibility of urban areas and providing high-quality and sustainable mobility and transport to, through and within the urban area'. The concept reflects on the aim of developing a functioning city. The policies and measures defined in a Sustainable Urban Mobility Plan refer to all modes and forms of transport in the entire urban agglomeration, including public and private, passenger and freight, motorised and non-motorised, moving and parking.

More specifically, a Sustainable Urban Mobility Plan pursues an urban transport system which possess the following characteristics:

a) Is accessible and meets the basic mobility needs of all users;
b) Balances and responds to the diverse demands for mobility and transport services by citizens, businesses and industry;
c) Guides a balanced development and better integration of the different transport modes;
d) Meets the requirements of sustainability, balancing the need for economic viability, social equity, health and environmental quality; optimises efficiency and cost effectiveness;
e) Makes better use of urban space and of existing transport infrastructure and services; enhances the attractiveness of the urban environment, quality of life, and public health;
f) Improves traffic safety and security;
g) Reduces air and noise pollution, greenhouse gas emissions, and energy consumption;

h) Contributes to a better overall performance of the trans-European transport network and Europe's transport system as a whole.

Recognising the important role Sustainable Urban Mobility Plans can play, the European Commission proposed in its Action Plan on Urban Mobility of 2009 to promote their take-up by providing guidance material, promoting best practice exchange, and supporting educational activities for urban mobility professionals. In June 2010, the Council of the European Union stated its support for ‘the development of Sustainable Urban Mobility Plans for cities and metropolitan areas [...] and encourages the development of incentives, such as expert assistance and information exchange, for the creation of such plans’ (Council of the EU 2010).

The EC has introduced a number of measures that support member states in developing SUMPs to achieve better cities. The starting point for every city when developing a SUMP is the European Platform on Sustainable Urban Mobility Plans. The portal offers some tools that are required for the successful application of SUMPs by local planning authorities. Also, the interested parties can find relevant information, publications and success stories to use. In general, it constitutes a place for the exchange of knowledge, experiences and contacts through events conference, training courses and social media.

The ELTISplus[6] (2012) project underlined the obstacles for using integrated urban mobility approaches: car infrastructure orientation, resistance from established officials, lack of knowledge, lack of coordination and conservatism, perceived difficulty of public engagement, lack of perceived added value over conventional plans, lack of defined responsibilities and priorities. The EC DG Move (2013) grouped the barriers and performed a ranking exercise, in order of importance they appear to be: 1) lack of political will, 2) lack of knowledge of integrated urban mobility approaches and/or their benefits, 3) planning culture and tradition, 4) lack of funds for integrated planning.

[6] ELTISplus (2012) State of the art of SUMP in Europe

To overcome these barriers, the European Commission has developed a number of initiatives that support the adaption of SUMPS since the development of large metropolitan cities is a key Megatrend of the future. Firstly, the EC ssupports the exchange and capacity building on sustainable urban development through the European Regional Development Fund project such as the URBACT[7] programme which helps cities to adopt 'integrated solutions to common urban challenges, by networking, learning from one another's experiences, drawing lessons and identifying good practices to improve urban policies'. Also, the local authorities and networks can implement and pilot new urban mobility approaches in real-life conditions as part of the CIVITAS[8] 2020 project. Financial support is also available for urban mobility projects through European Structural and Investment Funds (ERDF), Horizon 2020 and Connecting Europe Facility, as well as other financial instruments.

3.4 Europe on the Move

Carlos Moedas, the Commissioner for Research Science and Innovation, in his speech in 2017, said that 'making transport greener and more efficient is a key challenge as we move towards a low-carbon economy. A coordinated research and innovation effort is crucial to tackle this challenge and promote the competitiveness of European industry. That is why this new strategy is so important'. The new strategy refers to the most recent (2018) set of transport policies, entitled 'Europe on the Move', which aims to promote the EC aim to move towards "clean, connected and competitive mobility". This latest policy includes the industrial policy strategy[9] (EC 2017) of September 2017 and completes the process initiated with the 2016 Low Emission Mobility Strategy[10] and the previous 'Europe on the Move' packages[11]. The set of initiatives under the new EU transport policy address the Megatrends of improved infrastructure, and improved regulations:

- New road safety policy framework for 2020-2030 introducing also two legislations on vehicle and pedestrian safety, and on infrastructure safety management**;**

[7] http://www.urbact.eu/
[8] http://www.civitas.eu/
[9] http://europa.eu/rapid/press-release_IP-17-3185_en.htm
[10] http://europa.eu/rapid/press-release_IP-16-2545_en.htm
[11] http://europa.eu/rapid/press-release_IP-17-4242_en.htm

- Measures to promote connected and automated mobility. This aims at making Europe a world leader for autonomous and safe mobility systems;
- Regulations and legislations on CO2 standards for trucks, on their aerodynamic, on tyre labelling and on a common methodology for fuels price comparison followed by a Strategic Action Plan for Batteries**.** Those measures reinforce the EU's objective of reducing greenhouse gas emissions from transport and meeting the Paris Agreement commitments;
- Two legislative initiatives establishing a digital environment for information exchange in transport**;**
- A legislative initiative to modernise permitting procedures for projects on the trans-European transport network (TEN-T).

Figure 3.1 below presents the main key policy actions and milestones over the last four years:

Figure 3.1: Mobility policy milestones

Source: adapted from European Commission, 2018, 'Factsheet Shaping the future of Mobility', Brussels

More specifically, the core of the European mobility strategy is focused on delivering 'the best low-emission, connected and automated mobility solutions, equipment and vehicles will be developed, offered and manufactured in Europe and there is in place the most modern infrastructure to support them' (EC, 2017, p2). To deliver sustainable mobility, the EC has put in place measures that provide safe, clean and connected & automated mobility.

The EC is investing is a number of embedded and non-embedded safety tools such as advanced emergency braking, lane-keeping assist system for cars or pedestrian and cyclists' detection systems for truck etc. Moreover, measures that support the Member States to recognise dangerous road sections are also adapted. According to the EC (2017), these measures are expected to save up to 10,500 lives and avoid close to 60,000 serious injuries over 2020-2030.

With regards to clean mobility, the EC is currently finalising the first CO2 emissions standards policy for heavy-duty vehicles. Investment is also being put into place for the design of more aerodynamic trucks and improvement of labelling for tyres. In addition, the Commission is developing an action plan for batteries that will aid the creation of a more competitive and sustainable battery ecosystem in Europe.

Lastly, the EC is heavily investing in technology research and development and large-scale cross border trials of automated vehicles with dedicated calls under Horizon 2020. Internet of Things Cars and fully autonomous vehicles are just few years away. The EC is putting forward a new strategy that looks at new ways of cooperation between road users, which could potentially have a huge impact on the mobility on the whole.

3.5 Summary and conclusions of the chapter

This chapter presented the main policy directions introduced by the European Commission in the area of sustainable mobility. EU sustainable mobility related targets and objectives were identified, especially with regards to CO2 emissions, from general legislation.

Europe on the Move has the ambition to accelerate the shift to clean and sustainable mobility. Sustainable mobility is at the heart of the H2020 programme where significant funds have been (and will be) invested in projects that develop sustainable mobility products or services.

Sustainable Urban Mobility Plans, the main instrument for underpinning sustainable mobility in urban areas, have been adopted by many cities. The EC is supporting the development of such plans with the provision of funding. However, it is the member states' obligation to implement them at national level and develop the necessary support environments for their local authorities.

CHAPTER 4

METHODOLOGY

Introduction

This chapter presents the research framework followed by analysing the passenger transport system with its components. The first step was desk research of related projects and publications relating to transport development and identifying the Megatrends. Sustainable mobility scenarios are then defined. Based on this framework, the relevant Megatrends, scenarios and relationships were determined as input to the Analytical Network Process method (ANP) using a series of questionnaires answered by transport experts. ANP is used in order to estimate the defined sustainable mobility scenarios. Estimation here means overviewing the different Megatrends' influence on the sustainable mobility scenarios. As a second step, the Megatrends were evaluated regarding their impact on the achievement of sustainable mobility using an expert participatory approach (questionnaires) and finally, potential scenarios were ranked by applying the ANP utilising a rich input from more than 100 experts who were involved through surveys throughout all the stages of the research. Figure 4. **1** below presents the methodological approach:

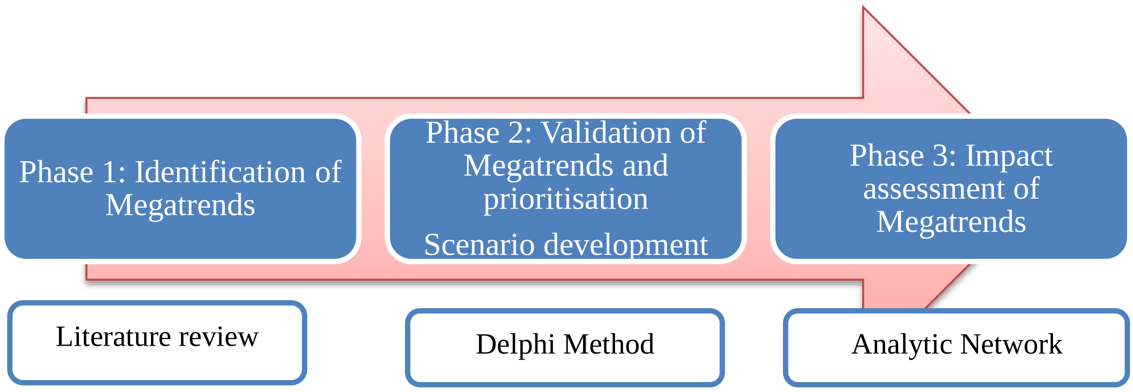

Figure 4. 1: Methodological approach

Source: Author

4.1 Foresight

Foresight was defined by Coates (1985) 'as the process by which the forces shaping the long-term future can be understood, and which should be taken into account in policy-making, planning and decision making' (Coates, 1985, p 30).

According to the Institute of Prospective Studies of the European Commission (2007), foresight can improve the quality of decision making, the impact of the decision making and the capability of the innovation system; foresight makes organisations and/or governments better able to react to changes.

There are three main stages involved in foresight (IPTS-EC, 2007; Foresight of Transport, 2004) have identified three main steps involved (Figure 4.2):

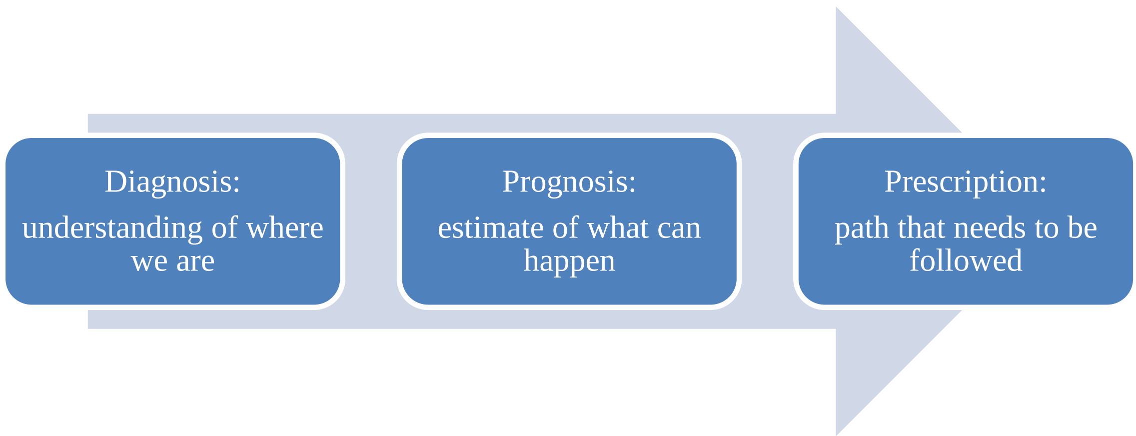

Figure 4.2: Foresight steps

Source: IPTS-EC, 2007

Foresight is, by its nature, a participatory discipline and the involvement of experts is a vital component (Georghiou, L., 2009). There are several methods that are used in foresight. Table 4.1 below summarises the main ones:

Methods	Tools		
Qualitative	Backcasting Conferences Essays Interviews Relevance Trees Role play/Acting Simulation Gaming	Brainstorming Workshops Expert Panels Literature Review (LR) Logic Charts Scenarios Science Fictioning	Citizens Panels Scenario Writing Genius Forecasting Morphological Analysis Scanning Surveys SWOT/PESTEL Wild Cards & Weak Signals (Wi-We) Stakeholder Analysis
Quantitative	Benchmarking Indicators Patent Analysis Delphi	Bibliometrics Time Series Analysis (TSA)	Modelling Trend Extrapolation Impact Polling/Voting Analysis Multi-criteria analysis
Creativity based	Genius forecasting	Essays	
Expertise-based	Expert panels Delphi	Roadmapping Relevance trees	Logic charts Morphological analysis
Interaction-based	Scenario workshops	Voting Polling	Citizen panels Stakeholder analysis
Evidence-based	Benchmarking Bibliometrics	Data mining Literature Review	

Table 4.1: Foresight tools

Source: Georghiou, L., 2008 and IPTS-EC 2007

However, a combination of more than one method can bring more accurate results. (Popper, 2008; Foresight Platform 2010[12]; UNDP 2014; For Learn 2007[13]). As indicated in the EU's Foresight Platform (2010) and Georghiou (2008), trend identification is a quantitative process with qualitative elements and the most frequent tools used are Delphi and Multi-criteria analysis. In this research, a combination of quantitative and qualitative approaches has been used.

[12] http://www.foresight-platform.eu/
[13] http://forlearn.jrc.ec.europa.eu/guide/

The foresight path that was followed involved, firstly, the identification of the landscape which includes the identification of Megatrends based on grey and scientific literature review including RoadMaps, White papers, etc. Then the foresight analysis included expertise-based tools such as Delphi and Analytic Network Process, a multi-criteria analysis (Figure 4.3**Figure 4.3**).

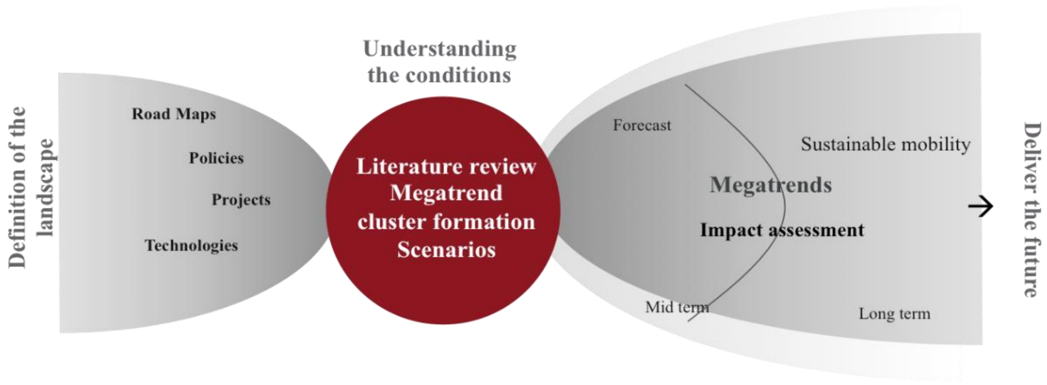

Figure 4.3: Foresight path

Source: Author

4.2 Panel of experts

Group decision making is a type of participatory process in which multiple individuals, acting collectively, consider and evaluate alternative courses of action and select from among the alternatives a solution or solutions (Van Knippenberg et al., 2004). The evaluation and decision making process is not attributable to any single individual. This is because all the individuals' inputs contribute to the outcome.

For the purpose of this research, a panel of experts was constructed. These experts constituted the potential responders for the four surveys. The experts on the panel were identified from personal contacts who participated in European research programmes in the area of transport and mobility in the past ten years.

The first group of potential respondents was identified as the policy makers who were responsible for analysing and implementing strategies for passenger mobility. The sample in this group comprised policy decision makers from the local, regional and national levels. In addition, representatives from the European Commission volunteered to participate in the surveys. The sample academics included lecturers, researchers and experts from various academic institutions throughout the EU, known as professionals in transport and passenger policy. The third group consisted of the transport industries that are more market oriented.

Please see Chapter 5.1 for detailed information on the identification of participants.

4.3 Overview of the methodological approach

This research employed a participatory method where transport experts were involved in providing their views on Megatrends that affect sustainable mobility. The two main methods used were Delphi and the Analytic Network Process. The Delphi technique, initially developed by Dalkey and Helmer (1963) at the Rand Corporation in the 1950s, has been a widely used and accepted method for achieving convergence of opinion concerning real-world knowledge derived from experts within given topic areas (Hsu et al., 2007). The Analytic Network Process (reference) is a multi-criteria method frequently used in complex decision making situations. In this research it was used to analyse further the most important trends identified in Delphi by exploring their impact in the achievement of sustainable mobility.

Phase 1 – Diagnosis: identification of Megatrends

The research started with a literature review on the main Megatrends. This provided input for the Delphi Questionnaire.

Phase 2 - Prognosis: foresight on Megatrends and scenarios

The next step involved the conduct of a Delphi investigation involving experts' opinions on the most important Megatrends that affect passenger mobility. The process that was followed is illustrated in Figure 4.4 below:

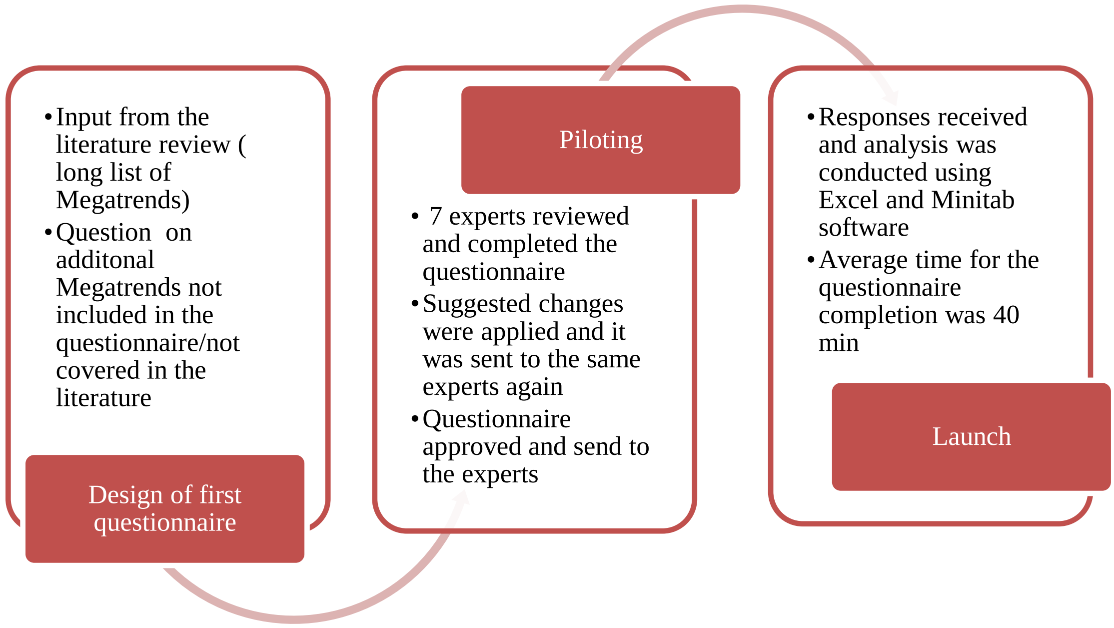

Figure 4.4: Methodology - Phase 2,1st questionnaire

Source: Author

Using the same pool of experts, a second questionnaire was sent along with the results of the analysis of the first one. The second questionnaire asked the experts to rank the Megatrends. The process that was followed is presented in Figure 4. 5 below.

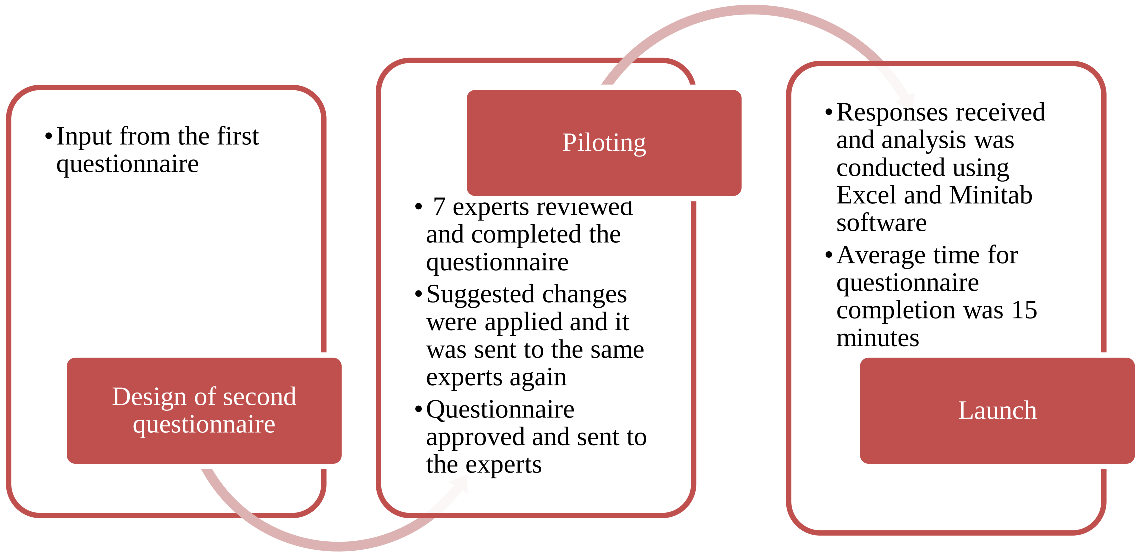

Figure 4. 5: Methodology - Phase 2, 2nd questionnaire

Source: Author

The details of the data collection process can be found at Chapter 5.

The last part of this phase included the development of three scenarios (more details can be found at Chapter 4.3). This process included a small workshop of 7 transport experts who brainstormed on possible future mobility scenarios. Figure 4.6 illustrates the steps involved.

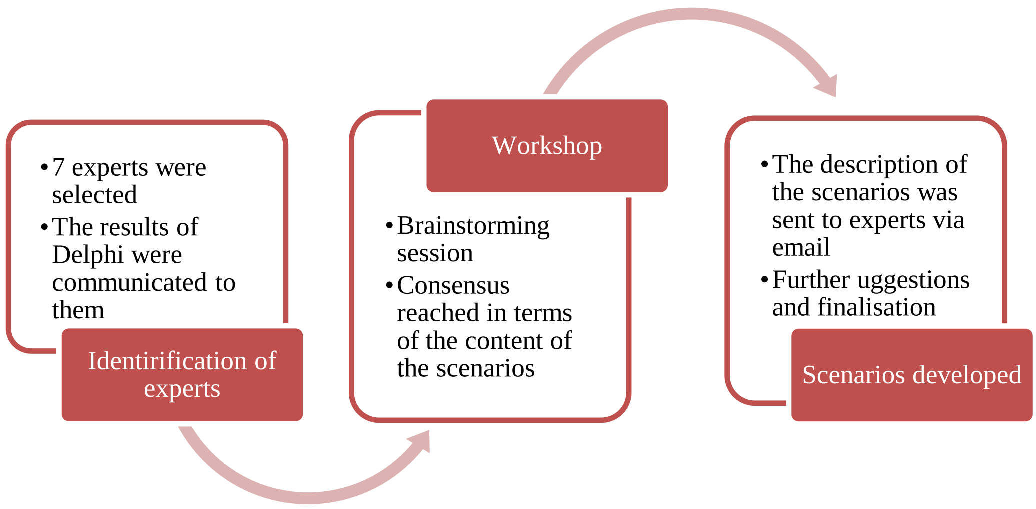

Figure 4.6: Methodology - scenario development

Source: Author

The last part of the second phase included the development of possible scenarios. The scenarios, following the principles of the ANP, explored the 'interactions' of the Megatrends (Chapter 4.3). The scenarios were developed during a workshop, which was attended by seven experts. The experts were selected from the same pool of experts as in the ANP and Delphi, based on certain criteria as described in Chapter 5.1.

Phase 3 - Prescription: Impact assessment of Megatrends to identify the right policy mix

The results on the priority ranking from the second round of Delphi were used to form the first ANP questionnaire. The aim of the first ANP questionnaire was to determine the relationships between the Megatrends (which Megatrends impact on each other). The process is described in Figure 4. 7 below:

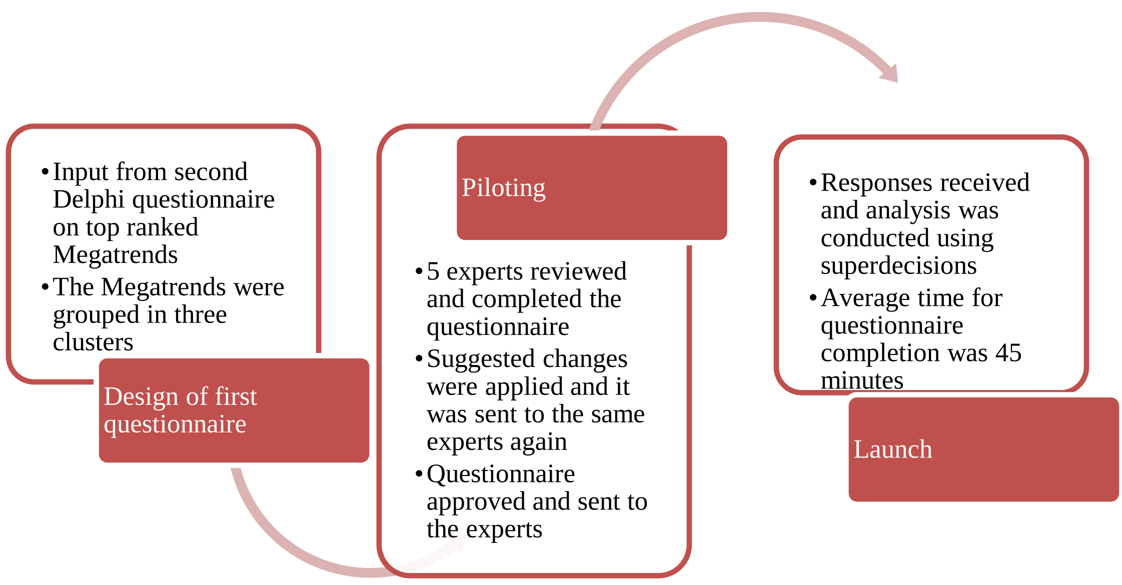

Figure 4. 7: Methodology - Phase 3, 1st questionnaire

Source: Author

The experts used in the ANP questionnaires were from the same pool of experts as in the Delphi Method. However, certain criteria were applied and this list was reduced to 80 participants. More details can be found in Chapter 5.1.

The second ANP questionnaire was then introduced. The aim was to weight the impact of a Megatrend versus another by conducting a sensitivity analysis, which tested how sensitive the Megatrends and scenarios are to certain changes. Based on the determined relationships between the Megatrends, the experts were asked to perform a pairwise comparison of the Megatrends and scenarios in order to indicate to what extend the selected trend was more important. For example 'ageing society' was compared with 'development of large metropolitan cities' where the experts indicated the relative importance, on a scale of one to nine, of the two Megatrends to each other. The analysis of the responses was carried out using the software package superdecisions (https://www.superdecisions.com/).

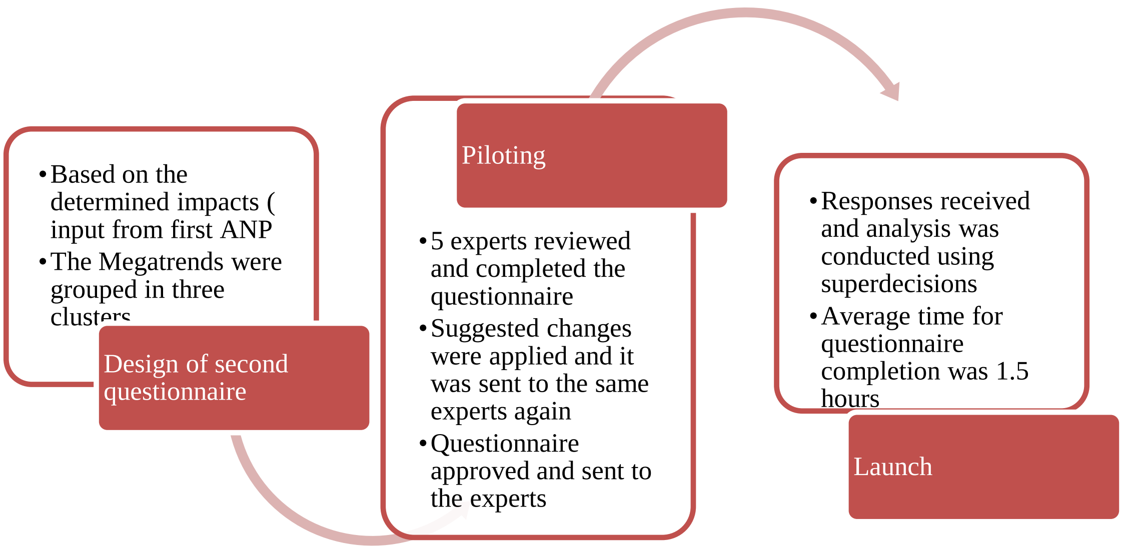

Figure 4. 8: Methodology - Phase 3, 2nd questionnaire

Source: Author

4.4 Delphi method

Delphi was used to deliver experts' opinions on the most important Megatrends affecting passenger mobility in the medium and long term. There are several reasons for choosing Delphi as a methodological tool. Delphi has been extensively used in forecasting and policy making (Rowe and Wright, 1999). It also allows the assembling of groups of experts from various geographical locations that can be approached by email and complete electronic questionnaires (Jay, 2016). Delphi methods have been proven very effective in case of topics that require multi-stakeholder engagement (Powell, C., 2003). In this research this was particularly useful as experts from policy, academia and industry participated. In addition, the experts were from different transport backgrounds in terms of specialisation (transport planning, ICT etc) but also transport mode (air, road etc). The responses from experts were anonymous. This results in a freedom that gives panel members considerable autonomy in presenting their opinions without fear of criticism (de Villiers et al., 2005).

There are several steps involved in the application and use of Delphi. However, Cyphert and Gant (1971), Brooks (1979), Ludwig (1997) and Custer et al. (1999) indicate that, in most cases, three main iterations are often sufficient to collect the information and reach a consensus. Here, the following iterations (steps) were involved:

1. First Expert Online Questionnaire: The main aim was to assess the key drivers and Megatrends with respect to mobility patterns that affect sustainable mobility. The questionnaire was based on a literature review (described in chapter 2) where the most frequently cited trends were used, however, the experts were also asked to identify any missing trends that were not found in the literature.
2. Communication of results and consultations: The experts received the results of the first round. Some of the experts requested further explanation of the results and details of the actual research. In this case, a consultation session with the relevant experts was held either via phone or skype.
3. Second Expert Online Questionnaire: During this stage the experts were asked to rank the factors that affect the Megatrends in terms of importance defined as potential impact on sustainable mobility.

The following basic characteristics of the Delphi technique were used (as described by Yousuf, 2007):

- Participant anonymity. The use of questionnaires allows the maintenance of anonymity.
- Controlled feedback from the interaction. The results of the previous stage are summarised and experts asked to revise their answers on the basis of how the other experts responded.
- Arithmetic mean. The average ranking of the groups' opinion has been used for determining the most favourable answer (trends).

Experts were asked to rate the importance of each factor in terms of its impact on passenger mobility on a five point Likert scale from one, 'Not at all important', to five, 'Extremely important'. Since only a selection of critical factors for each influential area was provided, experts were invited to suggest additional factors that they might consider critical and that were not already included in the list. The questionnaire was completed by 59 high calibre experts drawn from industry, academia, policy makers and also the European Commission. During the second round, the questionnaire was sent out to the same pool of experts. However, 37 returned the completed questionnaire.

4.5 Scenario design

The method that was used for the development of the scenarios was the systematic formalised narrative technique. The objective of the scenario building process was to define mid to long-term future scenarios (with the horizon 2035-2050) that would relate to the implementation of sustainable mobility.

The approach used was based on a number of assumptions (Mietzner and Reger, 2005):

- The future is not only a continuation of past relationships and dynamics, because it can also be shaped by human action (policy).
- Exploration of the future can inform the decisions of the present (policy advice).
- Uncertainty implies a variety of possible futures mapping a possibility space.

- Scenario building involves both rational analysis and subjective judgments and, consequently, requires participative and interactive methods, and is based on evidence (knowledge from literature/models), expertise (knowledge from experts) and creativity (for example: identification of wild cards, i.e. low likelihood high-impact events).

Once the scenario building approach was chosen, the scenario building process started with the definition of the conceptual framework, which defines the system for which possible future scenarios will be built.

The conceptual framework consists of four main blocks:

1. Key external factors, which relate to those variables which are not specific to the passenger transport system, but have impacts on it and contribute to shape its development;
2. Policy actions, which are the fundamental instrument, implemented at various geographical scales, to coordinate and steer the development of social and economic systems and naturally the development of transport systems;
3. Passenger transport system key characteristics, i.e. transport demand and supply factors, performances and mobility patterns;
4. Impacts on sustainable mobility.

After having defined the conceptual framework, the scenario building process proceeded with the following activities (Figure 4.9):

1. Identification of driving forces/key factors by using a structured literature review using key terms (key external factors, policy actions, transport demand factors and transport supply factors) (Method: literature review).
2. Selection of the main scenario variables, i.e. most important impacts that contribute to the achievement of sustainable mobility (Method: Delphi round 1).

3. Ranking/review of key factors according to their importance in terms of impact on passenger transport system and mobility patterns (Method: Delphi round 2).
4. Analysis of the links between key factors and their impact sustainable mobility (Method: questionnaire to identify the inter-relations).
5. Description of scenarios in terms of Megatrends relationship.

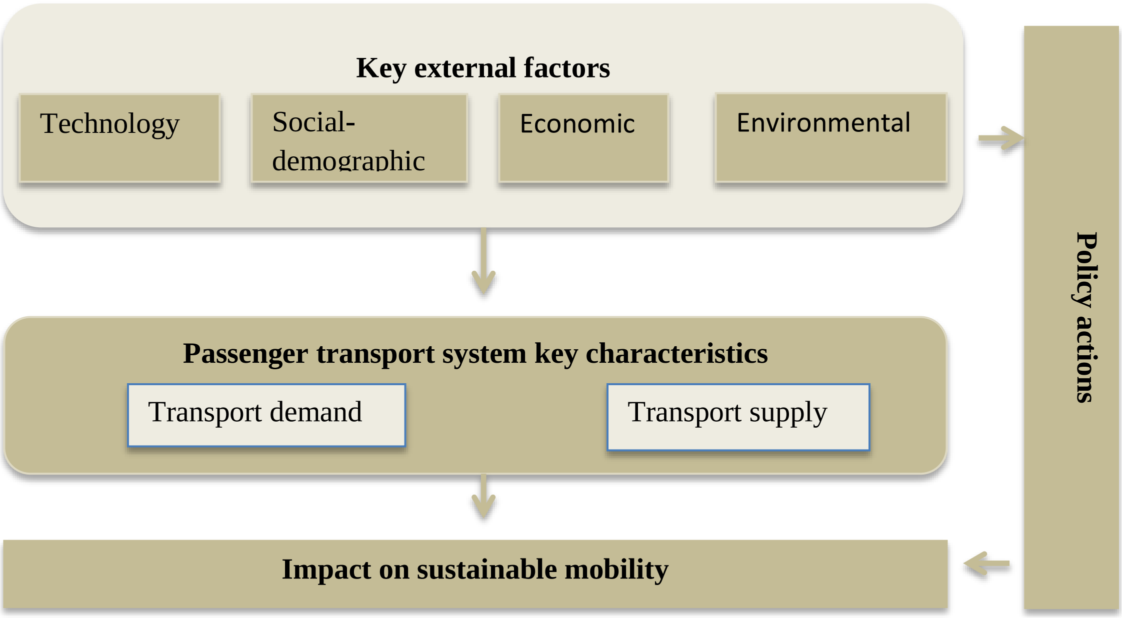

Figure 4.9: Scenario design approach

Source: Author

According to Rodrigue and Notteboom (2017), transport supply is defined as the capacity of transportation infrastructures and transport modes. Supply is expressed in terms of infrastructures (capacity), services (frequency) and networks (coverage). The number of passengers, volume (for liquids or containerised traffic), or mass (for freight) that can be transported per unit of time and space is commonly used to quantify transport supply. Transport demand reflects transport needs. Similar to transport supply, it is expressed in terms of numbers of people, volume, or weight per unit of time and space.

The factors that affect demand and provide supply depend on the key external factors. The effects of the changes of the exogenous trends on sustainable mobility or mobility in general is referred to as sensitivity (Litman, 2013). Sensitivities were tested in using the superdecisions software tool.

For the development of the actual content of the scenarios, a workshop was organised with seven experts. The experts had previously participated in the Delphi Method and were selected based on the following criteria:

- Background and experience on certain transport modes. Amongst all experts, all transport modes were represented.
- Balance between the three expert groups. Two policy makers, three academics and two from the industry.
- Knowledge of ANP. This was also particularly important as the content had to be relevant with the approach in order to be able to construct the ANP questionnaire.

The experts were explained the purpose of the research and the objectives of the scenario development. They were asked to think of possible sustainable mobility scenarios: what are the prerequisites for achieving sustainable mobility? The discussion concentrated on two major outputs: the number of scenarios and the content of the scenarios. Starting with the definition of the number of the scenarios, a voting process was going to be followed. However, this was not needed because all the experts suggested three scenarios. Once the number of scenarios was defined, a diagram was constructed on a white board where the experts were requested to add the content on posted it notes. Once the content was agreed, the posted it notes were removed and replaced by the description of the scenarios. The last part of the process was to give titles to the scenarios.

The process of the brainstorming is presented in Figure 4.10. On the left side are the requirements that had to be met. Regarding the ANP restrictions, it was discussed that the ANP questionnaires are long and complicated. The more scenarios are identified, the lengthier the questionnaires will be. This will cause two obstacles: 1. To recruit participants, and 2. To analyse the results. Also, in any case, more scenarios will not be adding value to the research because the descriptions suggested by the experts can fit into three scenarios. Regarding the sustainable mobility prerequisites, the experts indicated that the harmonisation of trends but also alignment of trends with policies that address them is the most important prerequisite in achieving sustainable mobility. Lastly, the impact of trends on each other and on policy development is important. The trends are interrelated and they impact on each other too. When the trends behave independently then it is impossible for the policy to apply the right measures and, therefore, sustainable mobility cannot be achieved.

During the brainstorming it was then decided (Figure 4.10, right column) that scenarios should be restricted to three to cover a positive, a neutral and a negative development. Also, the narrative of the scenarios focused on the harmonisation of trends and alignment of trends with policy. More specifically, the ideal scenario is a situation where Harmony exists and the policies are responding to the trends (impact of trends in policy formulation).

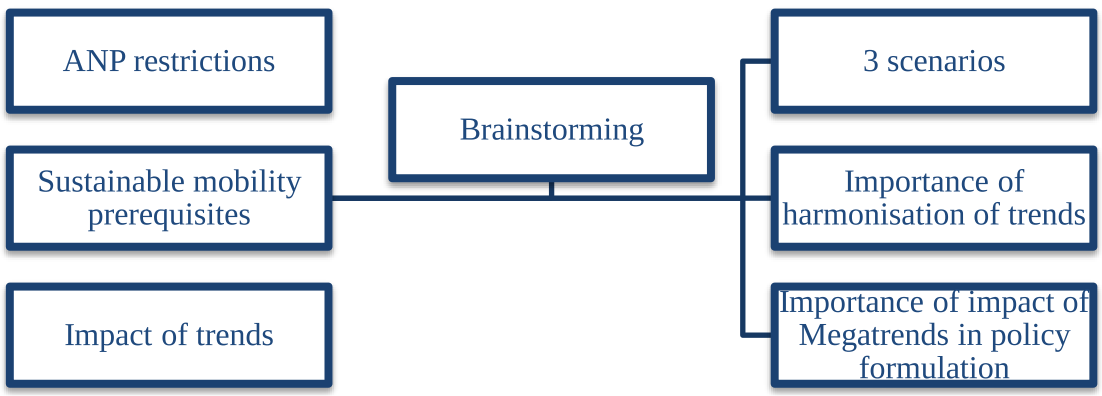

Figure 4.10: Brainstorming process

Source: Author

Therefore, the following three scenarios were defined:

(1) **S1 - Harmony** - a well-planned, harmonised scenario where sustainable mobility is achieved. The driving forces/external factors affect the policy formulation, which in turn employs directives that lead to sustainable development. The supply responds positively to the demand.

(2) **S2 - Inexhaustible** - everything is possible, so that there is uncertainty in achieving sustainable mobility due to the unpredictable 'sensitivities' of the trends. Harmonisation of trends exists but distortion of harmonisation is also possible and may impact the achievement of sustainable mobility.

(3) **S3 - Entropy** - disorder, leads to destruction, the collapse of the system. The trends behave independently of each other, so that sustainable mobility cannot be attained. The policies do not impact on sustainable mobility and the driving forces do not impact on one another. Sustainable mobility cannot be achieved.

4.6 Analytic Network Process (ANP)

4.6.1 Multi-criteria decision making

Multi-criteria decision-making aims to compile decisions based on judgments that 'compare different actions or solutions according to a variety of criteria and policies' (JRC 2007). Voulgaridou et al. (2009, p37) state that multiple criteria decision analysis (MCDA) concerns 'the approach of explicitly taking into account the pros and cons of a plurality of points of view, in other words to make a decision'. The results in MCDA are anticipated to stem from subjective opinions as indicators of preference, as well as the level of this preference.

Application of and the development of new MCD methods is growing very rapidly (DCLG 2009). In spite of the substantial number of MCD techniques, there is none that best fits all decision-making circumstances (Guitouni et al., 1998; Salminen et al., 1998). Although there are many MCDA approaches, the main features are simple: a set of alternatives (policies & scenarios), at least two criteria (trends) and one decision maker (experts/responders) (Voulgaridou et al., 2009).

Tsoutos (2009) identified four main reasons for using MCD methods. Firstly, they support input from multiple actors and at the same time allow to research the interest of the actors. Secondly, they are user-friendly and well-known methods, which have been tested and used for many years. There is a great variety of methods that can be chosen based on the specific contexts. Lastly, they allow inclusiveness of different perceptions and interests.

The steps involved in the model building of MCD tools are the following (Mateo, J. R., 2012): definition of the problem, assigning criteria weights, construction of the evaluation matrix, ranking the alternatives.

Velasquez et al. (2013) performed a review of the various MCD methods. The summary is presented in Table 4.2.

Method	Advantages	Disadvantages	Areas of Application
Multi-Attribute Utility Theory (MAUT)	Can take uncertainty into account, can incorporate preferences.	Needs a lot of input, preferences need to be precise.	Economics, finance, actuarial, water management, energy management, agriculture.
Analytic Network Process (ANP)/ Analytic Hierarchy Process (AHP)	Easy to use, scalable, hierarchy/network structure can easily adjust to fit many sized problems, not data intensive.	Problems due to interdependence between criteria and alternatives, can lead to inconsistencies between judgment and ranking criteria, rank reversal.	Performance-type problems, resource management, corporate policy and strategy, public policy, political strategy, and planning.
Case-Based Reasoning (CBR)	Not data intensive requires little maintenance, can improve over time, can adapt to changes in environment.	Sensitive to inconsistent data, requires many cases.	Businesses, vehicle insurance, medicine, and engineering design.
Data Envelopment Analysis (DEA)	Capable of handling multiple inputs and outputs,	Does not deal with imprecise data, assumes that all	Economics, medicine, utilities, road safety,

	efficiency can be analysed and quantified.	input and output are exactly known.	agriculture, retail, and business problems.
Fuzzy Set Theory	Allows for imprecise input, takes into account insufficient information.	Difficult to develop, can require numerous simulations before use.	Engineering, economics, environmental, social, medical, and management.
Simple Multi-Attribute Rating Technique (SMART)	Simple, allows for any type of weight assignment technique, less effort by decision makers.	Procedure may not be convenient considering the framework.	Environmental, construction, transportation and logistics, military, manufacturing and assembly problems.
Goal Programming (GP)	Capable of handling large-scale problems can produce infinite alternatives.	Ability to weight coefficients, typically needs to be used in combination with other MCDM methods to weight coefficients.	Production planning, scheduling, health care, portfolio selection, distribution systems, energy planning, water reservoir management, scheduling, wildlife management.
ELECTRE	Takes uncertainty and vagueness into account.	Its process and outcome can be difficult to explain in layman's terms; outranking causes the strengths and weaknesses of the alternatives to not be directly identified.	Energy, economics, environmental, water management, and transportation problems.
PROMETHEE	Easy to use; does not require assumption that criteria are proportionate.	Does not provide a clear method by which to assign weights.	Environmental, hydrology, water management, business and finance, chemistry, logistics and transportation, manufacturing and assembly, energy, agriculture.

Simple Additive Weighting (SAW)	Ability to compensate among criteria; intuitive to decision makers; calculation is simple does not require complex computer programmes.	Estimates revealed do not always reflect the real situation; result obtained may not be logical.	Water management, business, and financial management.
Technique for Order Preferences by Similarity to Ideal Solutions (TOPSIS)	Has a simple process; easy to use and programme; the number of steps remains the same regardless of the number of attributes.	Its use of Euclidean Distance does not consider the correlation of attributes; difficult to weight and keep consistency of judgment.	Supply chain management and logistics, engineering, manufacturing systems, business and marketing, environmental, human resources, and water resources management.

Table 4.2: Summary of MCD Methods

Source: Velasquez, M. and Hester, P. (2013). 'An Analysis of Multi-Criteria Decision Making Methods'. International Journal of Operations Research 10 (2), page 63.

4.6.2 Description of the ANP methodology

According to the founder of the ANP (Saaty, 2009), the model is based on 'the thinking man's rational way to combine logic to identify connection among attributes and judgments to derive priorities from causal explanation. Its questions revolve around what dominates what on the average or on the whole and how strongly it is expressed verbally and translated numerically with the use of the absolute fundamental scale'.

The Analytic Network Process is a generalisation of the Analytic Hierarchy Process. AHP is also a multi-criteria decision making method that decomposes a problem into a hierarchical structure of criteria and alternatives (Sharma et al., 2008). AHP can be used to solve problems where the decision criteria can be organised in a hierarchical way into sub-criteria (Tuzmen, 2011). The ANP on the other hand is more suitable to some complex interrelationships and clusters of alternatives (Yüksel and Dağdeviren, 2007).

The Analytic Network Process ANP (Saaty, 1996; Saaty, 2005) represents a decision making method which enables display of the interdependence and feedback between elements, analyse interaction between them as well as to synthesize their mutual influences through a network structure. This is a method that is used in order to determine priorities based on the relative relationship between elements, which is a natural procedure for the human mind (Saaty, 2009). The ANP model combines advanced decision techniques and expert knowledge. Therefore, it is a method for involving various stakeholders, decision-makers, whose influence and power are either known or assumed (Saaty, 2009).

An ANP network represents a combination of graphic outline of the problem by mapping elements and relationships between them. Relationships between the elements are the result of combination of mathematical relations and mimic of human reasoning in the decision process. Saaty's fundamental priority scale is used to determine relative weights of each element in network by using pairwise comparison, for example comparing the importance of ageing society with large metropolitan cities. In Saaty's 1–9 scale, 1 indicates equal importance, 3 indicates moderate importance, 5 indicates strong importance, 7 indicates very strong importance, and 9 indicates extreme importance. Even numbered values fall in between importance levels (More about the scale can be found in Chapter 4.6.3).

The fundamental scale of values to represent the intensities of judgments is shown in Table 3. 'This scale has been derived through stimulus response theory and validated for effectiveness, not only in many applications by a number of people, but also through theoretical justification of what scale one must use in the comparison of homogeneous elements' (Saaty and Vargas, 2013).

An interesting observation that has emerged from research in psychology 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'.

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 more thorough than by assigning numbers more or less arbitrarily trough guessing.

In ANP, there is a pairwise comparison of elements, in this research a comparison of Megatrends. So, Megatrends are measured against each other and they are given a score of 1-9, which shows the relative importance of Megatrends (Table 4.3).

However, there are many situations where elements are equal or almost equal in measurement and the comparison must be made not to determine how many times one is larger than the other, but by what fraction it is larger than the other. In other words, there are comparisons to be made between 1 and 2, and what we want is to estimate verbally the values such as 1.1, 1.2,…, 1.9.

Intensity of importance	Explanation
1	Equal importance
2	Slight
3	Moderate
4	Moderate plus
5	Strong importance
6	Strong plus
7	Very strong
8	Very, very strong
9	Extreme importance
1.1–1.9	When activities are very close a decimal is added to 1 to show their difference as appropriate

Table 4.3: The ANP scale of numbers

Source: adapted from Saaty, T. L. and Vargas, L. (2013).

4.6.3 How the ANP works

The ANP allows the involvement and quantification of all relevant factors in the decision-making process, as well as all the identification of the existing influences between decision criteria and alternatives (Jharkharia et al., 2007).

The procedure of the ANP application consists of two main phases (Saaty, 2001):

Phase 1: The decomposition of the problem. In this phase the problem is decomposed into its main components/elements. The components/elements are grouped into clusters setting the hierarchy of the criteria, which controls the interactions in the network.

Phase 2: Paired comparison and prioritisation. In this phase, the influences/impacts of the elements within the clusters and the clusters themselves are identified.
In terms of relation, it can be:

- 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

An example of the question that precedes the selection of relationship in general is: What is the relationship between element A and element B with regards to the achievement of sustainable mobility?

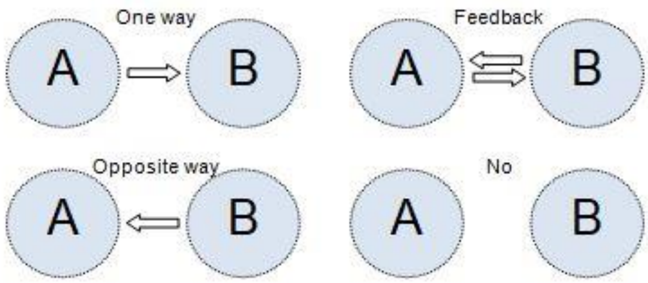

Figure 4.11: Relationship of elements
Source: Author

Furthermore, the pairs of elements that have influence on each other provides the basis of the questionnaire. The questions refer to the impact of the elements, which is the central concept of the ANP. An example of such question is: What is the importance of element A compared to element B with regards to the achievement of sustainable mobility?

In this research, the two phases were applied as follows:

Phase 1: Here, the main research question that drove the first stage was: what are the main trends affecting sustainable mobility?

During that phase the results on the most predominant trends, identified in the literature review, were further prioritised using the Delphi method. In the two round surveys, the experts ranked the most important trends that affect mobility. This was first in the ANP model, which enabled the elaboration of the factors included in the three clusters (environment - economy - society) as defined by the experts. In this first phase, the influences of the trends were not yet identified. Figure 4.12 represents the steps involved in this phase and the main result.

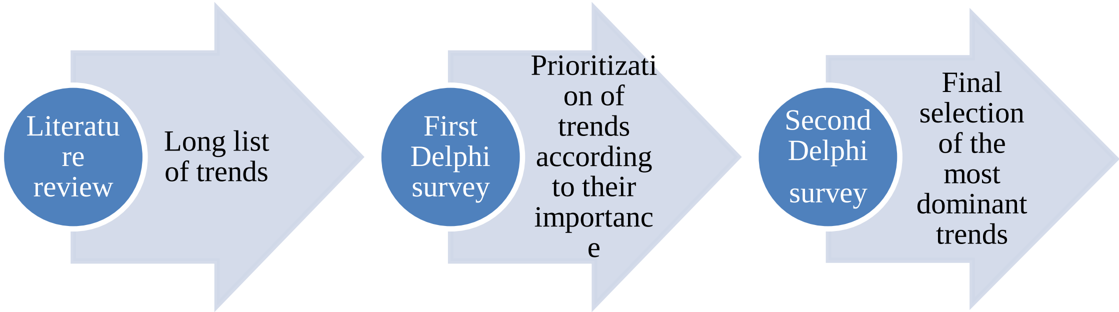

Figure 4.12: Steps in Phase 1 of the ANP

Source: Author

Phase 2: The elements in the clusters were identified in Phase 1 applying the Delphi method. They are clustered according to their characteristics following the same classification which was used in the Delphi questionnaire, as suggested by the experts. The objective of this phase was not only to generate clusters but to identify the relationships between the elements within and between the clusters. This was again performed by a survey questionnaire where the experts were asked to indicate the influence paths of each of the clusters and trends. A map of influences/impacts was finally developed (See Figure 6. 1). The questionnaire can be found in Annex 5.1.

An ANP model was then constructed in order to take into account the complexity of the decision problem and the elements involved. The table below presents the elements of the ANP model according to the literature review, validated by experts through the use of Delphi. The network is made up of sub-nets with different clusters and elements. (Table 4.4)

Clusters	Elements (Trends)
Environment	Charges Infrastructure investment Renewable energy Sustainable development
Economy	Financial recession International trade Pricing Taxation
Society	Ageing society Large Metropolitan Cities Urbanisation Unemployment

Table 4.4: Elements of the ANP clusters

Source: Author

After the formulation of clusters and the identification of the interrelationship of trends, the questionnaire was constructed based on a series of pairwise comparisons. The questionnaires were prepared and evaluated by the experts. The questions in these questionnaires are structured according to the relationships.

The ratio scale used is one to nine where one means that the elements are equally important and nine means that the different of influence of the two elements is significantly important. An example of a question is illustrated in Figure 4.13:

CLUSTER SOCIAL FACTORS

Which of the following Megatrends affects the most Scenario1-Harmony?						
	Large metropolitan cities	Unemployment	Urbanisation	Unemployment	Urbanisation	Urbanisation
Ageing society	2					
Ageing society		3				
Ageing society			-2			
Large metropolitan cities				-2		
Large metropolitan cities					-2	
Unemployment						2

Figure 4.13: Example of an ANP questionnaire

Source: Author

Positive real number rating (0, 1, 2, 3, 4, 5, 6, 7, 8, 9) is given when the element on the row is judged to have higher preference than the one in the column. Negative real number rating (-1,-2,-3,-4,-5,-6,-7,-8,-9) is given when the element on the row is judged to have lower preference than the one in the column. For example, in the above, ageing society is slightly more important than large metropolitan cities regarding the alternative Scenario 1 (the score given is 2). Ageing society is slightly less important than urbanisation regarding the alternative Scenario 1 (the score given is -2).

With regards to the analysis of the questionnaire answers, apart from the identification of the most predominant trends in terms of their importance in the achievement of sustainable mobility, a sensitivity analysis was also conducted (See more on Chapter 6.3.5). This was the last step of the ANP analysis, to observe the change in the achievement of sustainable mobility in case of priority changing in trends. This is important in order to determine the impact of the changes and identify the elements (policies in this research) that would affect the application of sustainable mobility the most.

4.6.4 Review of Analytical Network Process applications

The ANP can be a very useful tool in decision-making sciences and strategic directions (Saaty, T., 1996, 2005; Saaty, T. and Brady, C., 2009; Saaty, T. and Brady, C., 2009; Saaty, T. and Vargas, L., 2013). Whitaker (2007) conducted a study on validation examples of the ANP method, which revealed that this method is a useful tool for analysing several levels of networks to enable informed strategic decisions.

Given that the ANP can consider the interrelationships among elements in a problem setting as well as human way of thinking in a process of elements evaluation (Saaty, T. L., 2009) – pairwise estimation of importance, the use of the ANP method for selecting and ranking has increased substantially in recent years both in the areas of transportation but also foresight. 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. In particular, there were 76 articles of the manufacturing industry, 26 for environmental management and agriculture, 19 for general decision, 15 for power and energy industry, 15 for transportation industry, 11 for construction industry and 10 for healthcare.

Ossadnik et al. (2015) performed a study of the rising importance of AHP/ANP in the literature. The summary of the results is presented in Figure 4.14:

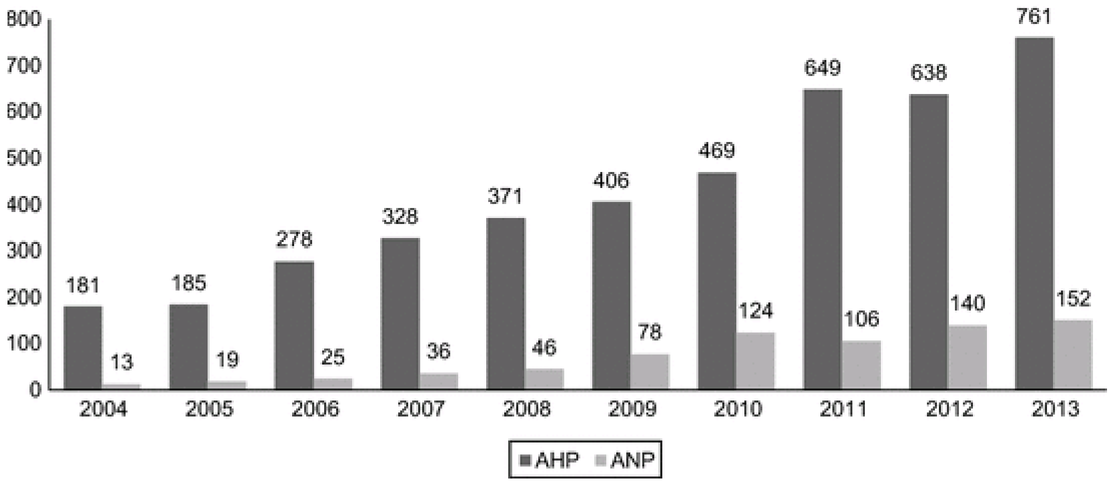

Figure 4.14: Number of AHP and ANP publications by year (bibliometric analysis)

Source: Ossadnik, W., Schinke, S. and Kaspar, R. (2016). 'Group Aggregation Techniques for Analytic Hierarchy Process and Analytic Network Process: A Comparative Analysis', page 425.

Voulgaridou et al. (2009) conducted a review of the ANP usage in the field of sales forecasting. They concluded that ANP was more frequently as an input to strategy selection than other dimensions of sales forecasting.

With regards to transportation, Tsai and Su (2005) completed a research on political risk assessment process on designing ports. In particular they 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 Shanghai. This system approach consists of political measures analysis and assessment processes using the three methods of Delphi, ANP/AHP and Ward’s clustering (Tsai and Su, 2009). Ward's clustering is a hierarchical clustering procedure, normally used when there is a small amount of data (Ward, 1963).

Chang et al. (2007) applied the ANP method in combination with fuzzy explain Delphi and zero-one goal programming to evaluate regeneration scenarios for the railway industry. Zero-one goal programming (Dantzig, 1958) is a mathematical programming approach that can evaluate multiple goals and criteria. ZOGP assign optimal values to a set of variables in the problems where there are multiple and conflicting goals, and measured in priority exists among the goals (Liao, 2009). 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.

Tudela et al. (2006) evaluated urban transport investments. Cost-benefit (CBA) and multi-criteria analysis were applied to derive results on what aspects decision makers should consider when making investments (economic or non-economic). The AHP was used as a complementary method to provide weights to the elements identified by the cost-benefit analysis. The results revealed that non-monetary aspects such as public perceptions should be taken into consideration when designing urban transport investment plans.

Caliskan (2006) developed a decision support approach based on experts' experience to review and evaluate transportation investments. The methodology was built around the concept of Cognitive Maps and AHP. The Cognitive Map is a signed 'digraph including the way individuals, groups, and experts realise and understand a problem as well as the bilaterally connected elements' (Lee et al., 1992). The Cognitive Map process is based on a chain of interviews held with transportation experts to identify investment criteria. There are three phases involved in this process: 1. The experts are asked to determine the variables; 2. The experts then determine their importance, and 3. A matrix for pairwise comparison is developed. The AHP model was then applied to determine the most suitable investment scenario.

Ulutas (2009) utilised the Data Envelopment Analysis (DEA) in combination with 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.

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 (1999) adopted the ANP for selecting a strategy for managing logistical chains while Wu and Lee (2007) integrated the ANP for selection knowledge management strategies.

Table 4.5 presents the areas of ANP application based on the abovementioned indicative list of applications.

Area of application	Year	Author	Technique(s) used
Management of logistical chains	1999	Meade and Sarkis	ANP
Transportation and policy	2005	Tsai, M. and Su, C. H.	Delphi, ANP/AHP Ward's clustering
Urban transport investments	2006	Tudela, A., Akiki, N. and Cisternas, R.	Cost-Benefit & AHP
Transport investments	2006	Caliskan, N.	Cognitive Maps and AHP
Knowledge management	2007	Wu and Lee	ANP
Railway industry scenario appraisal	2009	Chang, Y., Wey, W. and Tseng, H.	Zero-one goal programming, ANP
Sales and forecasting	2009	Voulgaridou, D.; Kirytopoulos, L.; Leopoulos, V.	ANP
Performance of airports	2009	Ulutas, B.	DEA & ANP
Airline industry strategic decision	2012	Sevkli, M., Oztekin, A., Uysal, O., Torlak, G., Turkyilmaz, A. and Delen, D.	ANP & SWOT

Table 4.5: ANP applications

Source: Author

Concluding, the applications of ANP have grown over the last years. It has been used in a number of industries including transportation, mainly to forecast sales, regeneration scenarios for the rail industry and performance of airports. In terms of transport policy development, it has been used to assess political risks on designing ports. In this research, it has been used as a foresight tool that can support policy decisions in the area of sustainable transport, thus broadening the scope of the ANP applications.

4.6.5 Advantages and limitations of the Analytical Network Process

The power of the Analytic Network Process (ANP) lies in its use of ratio scales to capture the elements' interactions, which makes the method very useful in a scenario analysis process where the elements involved interrelate and affect each other (Saaty, R., 2016). The ANP represents a network structure, which is closely aligned with scenario development where many elements are included within each of the scenarios/networks. Although the method allows for interdependence, it does include independence too; this provides the benefit of being able to prioritise groups or clusters, therefore, ANP ‘can support a complex, networked decision-making with various intangible criteria’ (Tsai et al., 2010, p. 3884). The ANP has the capacity to prioritise and explore the interdependences of clusters of elements; therefore, it is a suitable method for complex decisions and scenario evaluation (Velasquez, 2013).

Another advantage of the method relates to foresight and lies with the reliability of predictions made with ANP. Niemira et al. (2003) and Saaty et al. (2013) performed a forecasting study where ANP supplied the underpinning method to further develop a method to forecast a financial-crisis possibility. Micovic (2012) used it to forecast automobile sales and Lee et al. (2006) for technology foresight. Lastly, Ozorhon (2006) forecasted the performance of international construction joint ventures. The above-mentioned authors have indicated that the ANP has provided a very reliable ‘judgmental forecasting structure’ to evaluate the options and scenarios in a consistent manner.

In all Multi-Criteria methods an important aspect is the weights typology of coefficients of importance and substitution rates (Munda et al., 2005). The weights in ANP represent the gain with respect to one variable allowing compensate loss (tradeoffs) with respect to another (Stewart, N., 2002; Munda, G., 2005; Polatidis et al., 2006; Munda, 2008). This refers to the pareto efficiency theory where multi objective optimization is achieved by allocating a score to a criterion that makes it better off while at least one other criterion becomes worse off (Barr, 2012). This has significant importance in the evaluation of scenarios and design of policies because the elements within the scenarios along with the policies to reach the optimum effect are interrelated. In the ANP method, the scaling of the criteria and the weights are connected and dependent on one another and as a result if one changes, the other has to change consequently (Belton, V. and Stewart, N., 2002; Rowley et al., 2012; De Montis et al., 2000). Therefore, the soundness of the ANP use in this respect, relates with the aggregation procedure, which refers to the data aggregation that is performed by obtaining the geometric mean values (see more in Chapter 6.3).

Dyer (1990) criticised ANP outlining as the major disadvantage the subjective rankings by the experts involved in the process. On the contrary, Saaty (1990) provides a different perspective on the issue arguing 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 heavily relies on experience and knowledge of the experts and this can be turned into a drawback if the experts do not possess the necessary understanding on the subject Therefore, it is of imperative importance to select a mixture of experts with the necessary knowledge on the issue examined.

Furthermore, since it involves complex models and networks, ANP questionnaires, which rely on pairwise comparisons, are often very long which may reduce the experts' willingness to participate (Keeney et al., 1977; Polatidis et al., 2006; Munda, G, 2008; Antunes et al., 2012; Giner-Santojia et al., 2012). The same problem appears in the number of alternatives to be assessed where they are normally too high or they are heterogeneous. The solution to this problem, according to Saaty et al. (2011), is to apply ratings evaluation or grouping alternatives into homogeneous groups when constructing the questionnaires.

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 scenarios is a multi-criteria decision problem.
- There are interdependencies 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 experts to carefully reflect on their selected priorities.

- The method allows consideration of qualitative criteria.
- Participation of experienced participants has been possible to achieve, therefore, the prerequisite of the collective knowledge of experts has been fulfilled.

The application of ANP methodology in this research has been based on the following principles:

The trends landscape: definition of the main trends

As indicated by Whitaker (2007), a prerequisite of the successful application of ANP is the thorough understanding of the issue. Therefore, a systematic approach was used to gather and analyse the trends and Megatrends affecting mobility. Literature review combined with expert knowledge, using the Delphi method for the selection of the most important/prioritisation, was applied.

Learning framework: adaptation of the model

Selecting strategies for acquiring sustainable mobility is a multi-criteria decision problem. The learning framework refers to the development of input elements (criteria) for the elaboration of the scenarios. The ANP model receives as input the values of critical factors (trends) associated with sustainable mobility. The impact of the factors (trends) is predicted with the use of a scale of estimations that are given by the experts.

Value capture mechanism: achieving optimisation

Achieving the relative importance of some criteria and measures by simple weighting method is difficult. Capturing the value from the responders' answers is a critical step in the process. This has been achieved by: 1. Using the experience of (the right) experts. 2. Providing a framework for evaluation that measures relationships between interconnected factors to perform pairwise comparisons. Transport is a complex system that depends on multiple factors, due to the complexity of the system any intervention must be based on thorough consideration and analysis of the interactions of the factors (EC 2009). The structure of the ANP model has not come from the numbers that are generated, but rather from a map of relationships that has been designed (see Chapter 6.3.2).

4.7 Summary and conclusions of the chapter

This chapter presents the methodology that has been followed in this research. Starting from a literature review, a long list of Megatrends was identified. The questionnaire of the Delphi method, which followed, was based on the Megatrends identified in the literature and was conducted in two rounds where the experts ranked the Megatrends based on their impact on mobility. The twelve most predominant trends were validated and their impact on sustainable mobility was measured using the Analytic Network Process. At the same time, three scenarios were developed with the assistance of seven experts. The scenarios were also assessed using the ANP describing the possible connections between trends and their impact on policies. This method offered insights on the interactions between the trends and their relevant impacts.

CHAPTER 5

DATA COLLECTION

Introduction

Chapter five describes the data collection process. Once the literature was analysed and the EU policies reviewed, the desired mix of experts, according to the selection criteria given in this chapter, was identified. The experts contributed in the Delphi questionnaire but also in the Analytic Network Process methodology.

In total, four questionnaires were launched (two for Delphi and two for the ANP). The expert involvement process is described along with the design of the questionnaire approach.

The panel of experts was constructed from contacts that were made during the researcher's participation in Pan-European collaborative research programmes. This included experts from all transport modes and from almost all European countries.

5.1 Identification of participants

The participation of experts in the identification of key Megatrends and their assessment of their impact on sustainable mobility is a core element of this research work. Their selection was based on criteria aligned with the aim and objectives of the research. Considering the importance of 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 sustainable mobility, recognition of Megatrends, political imperatives and transport advances.

The identification process started with the development of a panel of experts (around 100 names). As the focus of this thesis is of particular interest for the European Commission, Project Officers from the two main Directorates General (DG) of the European Commission were contacted in order to participate in the surveys: DG Move and DG Research. Also the department of the EC that deals with foresight, the Joint Research Centre-Institute of Prospective Studies, was also contacted. The experience of the researcher in previous research projects funded by the European Regional Development Programmes[14] has assisted in the developing of a further list of potential participants, which consisted of regional, local and national policy makers from European countries. The responses of the participants did not represent official opinions of the EC, but rather their individual opinions. All the responses were provided anonymously.

The initial list of experts was enriched with fifty more potential participants that were identified through an intensive search on TRIMIS[15], which is the transport projects database of the European Commission and includes national and European funded projects. After having selected key projects that had relevant aim with this research, their coordinators were contacted. This resulted in an enriched long list of 150 names representing key experts from academia, industry and policy making.

In addition to the criteria for selection of individuals, it was important to ensure that

[14] ERDF, European Structural Funds named as 'INTERREG projects' aim to promote the knowledge exchange between authorities of different countries and regions.
[15] https://trimis.ec.europa.eu/

the panel as a whole satisfied a number of criteria; the panel should provide:

- Coverage of all transport modes.
- Coverage of different sources of expertise (Engineering, Economics, Planning …).
- Coverage of different type of organisation (public and private, Research/University, Industry, Public Authorities, Transport Operators …).
- Coverage of as many EU countries as possible.

Figure 5.1 presents the participant identification process:

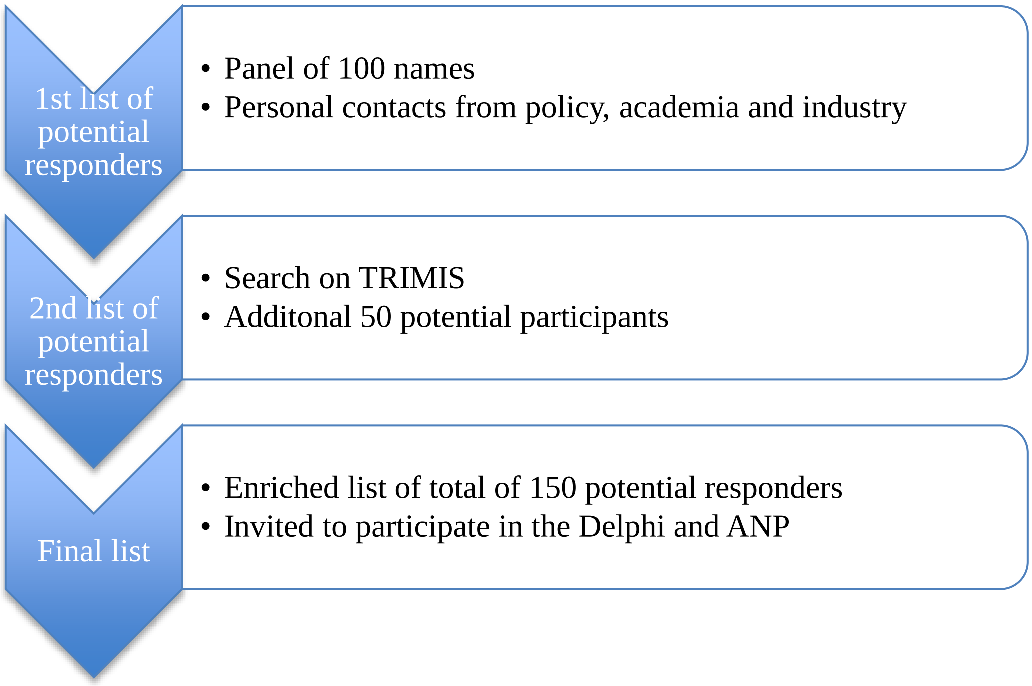

Figure 5.1: Participant identification process

Source: Author

5.1.1 Participants of Delphi questionnaires

Figure 5.2 illustrates in blue colour the countries that were represented in the two rounds of the Delphi questionnaire, which aimed at identifying the most prominent trends based on experts' opinions. A total of 17 European countries were represented.

Figure 5.2: Map of responders of Delphi questionnaire

Source: Author

The list of participants for the first Delphi questionnaire by country by expertise is presented in Table 5.1:

Country	**Number of participants**	**Transport mode experience**	**Number of participants**	**Specific research experience**	**Number of participants**
Austria	1	Air	19	Modelling	15
Belgium	3	Water	7	Engineering	14
Croatia	4	All	7	Transport planning	19
Czech Republic	3	Surface	26	Social sciences in transport	11
France	1				
Germany	4				
Greece	4				
Italy	6				
Netherlands	5				
Norway	1				
Portugal	4				
Romania	1				
Serbia	7				
Spain	8				
Sweden	1				
Switzerland	2				
UK	4				

Table 5.1: list of participants for the first Delphi questionnaire

Source: Author

The list of participants for the second Delphi questionnaire by country by expertise is presented in Table 5.2:

Country	**Number of participants**	**Transport mode experience**	**Number of participants**	**Specific research experience**	**Number of participants**
Austria	1	Surface	23	Modelling	7
Croatia	2	Water	6	Engineering	7
France	1	Air	1	Transport planning	14
Germany	2	All	7	Social sciences in transport	9
Greece	9				
Italy	3				
Netherlands	2				
Serbia	6				
Spain	4				
Sweden	1				
Switzerland	2				
UK	4				

Table 5.2: list of participants for the second Delphi questionnaire

Source: Author

5.1.2 Participants in the ANP questionnaires

Again, as the aim of this study is the provision of policy directions for Europe, the representation of 21 European countries was very important. The long list included representatives of all countries. Figure 5.3 illustrates in blue colour the countries that were finally represented in the ANP data collection process.

Figure 5.3: Map of ANP participants

Source: Author

The list of participants for the questionnaires by country by expertise is presented in Table 5.3

Participant background	**Number of participants**	**Countries**	**Number of participants**
Policy-makers	20	Greece	12
Academia	29	Serbia	8
Industry	27	Austria	1
		United Kingdom	4
		Czech Republic	3
		Italy	7
		Montenegro	3
		Romania	3
		UK	7
		Belgium	4
		Bulgaria	1
		Cyprus	1
		Denmark	1
		France	3
		Germany	3
		Ireland	1
		Latvia	1
		Poland	4
		Portugal	3
		Slovakia	1
		Slovenia	2
		Spain	2
		Switzerland	1

Table 5.3: list of participants for the first ANP questionnaire

Source: Author

5. 2 Data collection processes

During the Delphi process, at the first stage, the responders were approached via email. The response rate was 40%, 40 participants contributed to the survey in the first two weeks. In order to achieve a higher number, the survey remained open for a further week. During that time, a reminder email was sent to all the names on the long list along with personalised emails to some key contacts. As the survey was totally anonymous, there was no way of identifying the names of the participants based on their answers. After the second round of emails, 19 more questionnaires were received. This increased the response rate to 59%.

For the ANP, the involvement process was slightly different as this questionnaire was longer and more complicated and required a more in-depth knowledge of the subject matter, but also an understanding of how the ANP questionnaire was structured. The enriched list (150 names) was used initially for approaching the potential participants. From that list, the most relevant participants were identified to ensure a fair representation of industry and academia and, more importantly, policy makers. From that list, around 80 potential respondents were chosen. They were contacted via email and were given 4 weeks to complete the questionnaire and return it online. Again, it was completely anonymous. After having received the ANP email, some of the responders returned it asking for further clarifications and explanations. These were provided in written form (email) but also through phone calls when required by the participants. However, as the questionnaires were completed anonymously, it was not possible to identify the participants from their responses. During that time apart from the individual calls and emails, a webinar/presentation on providing instructions on the questionnaire was also organised over skype for those who requested further assistance. A dummy questionnaire was completed, explaining at the same time the logic behind the process.

The ANP included the launch of two questionnaires: One for the evaluation of relationships between the elements (trends) within the clusters and one for the evaluation of the impact of trends on sustainable mobility. During the first questionnaire, 20 responses were received. During the second questionnaire, 56 responses were received; a total of 70% response rate. According to Saldivar, G. (2012) online surveys usual average response rate is in the range of 30%, therefore, this is considered a good response rate, as the experts needed 1 hour to fully complete the questionnaire. Despite the fact that the questionnaire was lengthy and time consuming, the experts expressed their eagerness to receive the final outcomes of the research because they found the approach very thorough and reliable for obtaining well thought results.

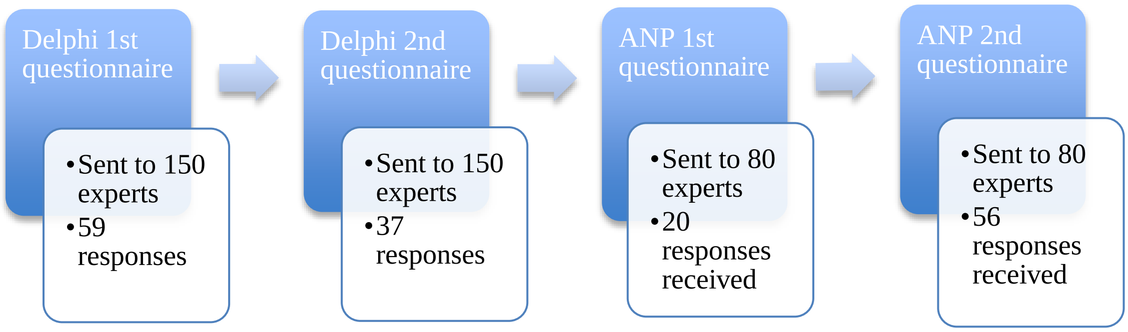

Figure 5.4: Data collection process

Source: Author

5.3 Questionnaire design

In total there were four questionnaires: two for the Delphi and two for the ANP. The design process was slightly different for each and reflected the complexity of the ANP.

Delphi questionnaire

The design of the questionnaire was driven by the research question: 'what are the current Megatrends affecting the transport system?' The list of trends and Megatrends included in the questionnaire were initially derived from the literature review. The participants were invited to suggest additional trends that were not included in the questionnaire.

A consent form was provided on the first page of the questionnaire, which participants had to sign in order to proceed with completing the questionnaire. A participant information sheet was also provided about the research, objectives and aim, and instructions for the participants. The main body of the questionnaire focused on the importance of trends belonging into 11 groups of factors. Finally, the end part was about the participants' background in terms of country, transport mode experience and transport field.

The first draft questionnaire was pre-tested on seven experts. They were from three different countries (UK, Belgium and Greece) and represented different transport modes. Three of them were from academia, two policy makers and two from the industry. Finally, two of them (academia) were very experienced in questionnaire design, having initiated their own online software for questionnaire development and, at the same time, were experts in transport.

After having received the feedback from the piloting, the questionnaire was improved and some questions rephrased.

The questionnaires can be found in ANNEX D- DELPHI QUESTIONNAIRES.

ANP questionnaires

The first ANP questionnaire was aimed at defining the relationships between the trends and the clusters (groups) of trends. This was a long but easy to complete questionnaire. The first page was a consent form and some explanations about the aim of the research. The main body of the questionnaire was focused on the relationship definition while a graph was provided too in order to enable participants to better understand how the 'relationship map' will be eventually built based on their answers. Lastly, information on their countries and the group they belong to (industry-academia-policy making) was asked at the end of the questionnaire form. The piloting of the ANP questionnaire was an essential part of the process as it requires a deeper understanding of the method and, therefore, it is important to make sure this has a very effective and clear structure. The questionnaire was pre-tested on seven participants including an expert on ANP who provided feedback in terms of the robustness of the tool and the technicalities that had to be followed in order to ensure that the required inputs for the next step of the ANP would be obtained. The other six were from industry, academia and two policy makers who gave some general feedback in terms of structure, layout and clarity of the questions. The changes made to the questionnaire as a result of the pre-test feedback included altering the order of the questions and clarifications in the email invitation about the ANP method.

So, to summarise, the first questionnaire provided input in terms of relationship of trends. After having analysed the results, the trends that appeared to have a relationship were used in the second round of ANP in order to determine the extent of their impact. The relationship can be: One-way (→ or ←) arrows determine the impact of a trend over another. Two-way arrows define the mutual impact of the trends on each other (←→).

An example of a question during the first ANP questionnaire can be found in Figure 5.5.

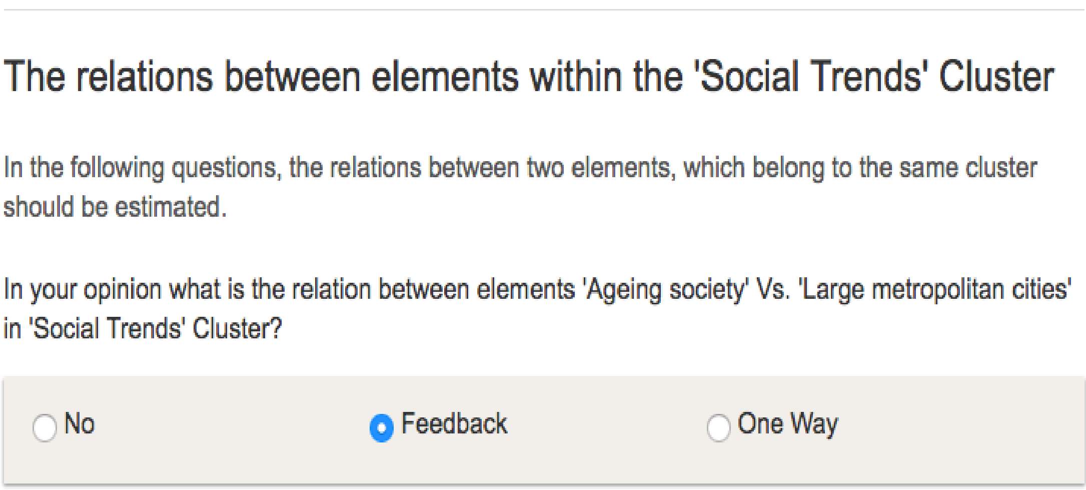

Figure 5.5: Example of a question in the first ANP questionnaire

Source: Author

The experts were asked to define the impact of all the main Megatrends (as identified in the Delphi). In the above example, the expert indicated that Ageing society and Large metropolitan cities impact (affect) each other. That means, that a change in the policy that relates to Ageing Society will affect the development of the Large metropolitan cities Megatrend. During the second questionnaire, these two Megatrends are compared with each other and the experts are asked to evaluate which one is more important in achieving sustainable mobility and to what extent.

The second questionnaire was challenging both in terms of design but also attracting participants. The ANP matrix that had to be developed was not supported by most of the online questionnaire development tools. Therefore, Microsoft Excel was finally used. The layout and structure of the questionnaire underwent three piloting rounds until reaching the final form. The same seven experts who piloted the first ANP questionnaire were asked to also test the second. The changes that were made were the following:

- Added an introductory page that included definition of the main terms used in the questionnaire, information about the three scenarios that were going to be tested and explanations on the scale of estimation.
- Added a page with an example of a completed set of questions.
- Blocking (with black colour) the cells that were not supposed to be used and highlighted the ones that had to be completed by the experts.

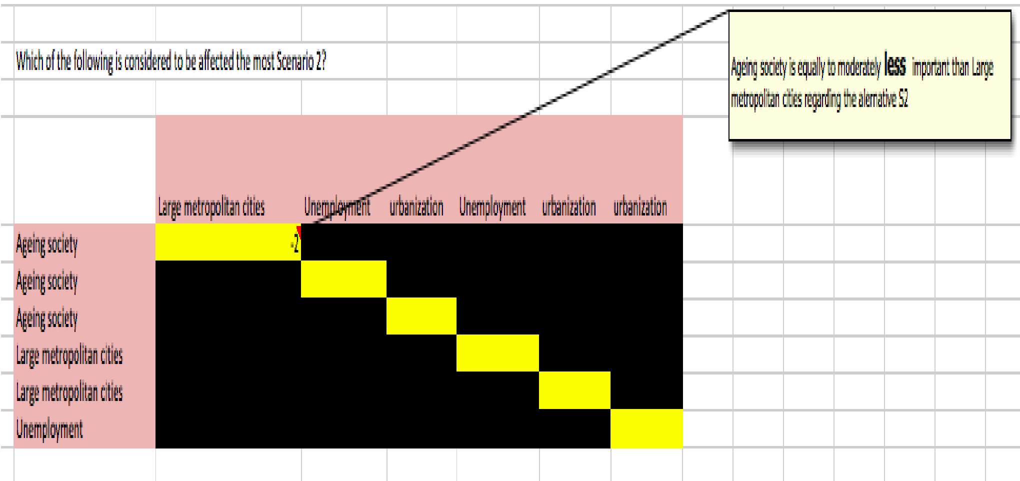

Figure 5.6: Example of a question of the second ANP questionnaire

Source: Author

As showed in Figure 5.6, the participants were asked to indicate which of the two trends (pairwise comparison) is more important in achieving sustainable mobility and to what extent. The scale of importance was from 1 to 10 with 1 meaning very little and 10 very important. When the entry (Megatrend) on the row was more important, then a minus (-) had to be entered. So, with regards to the example above, the Ageing Society is less important than Large Metropolitan Cities.

The questionnaires can be found in ANNEX E- ANP QUESTIONNAIRES

5.4 Summary and conclusions of the chapter

This chapter presented the identification process of participants along with the data collection process and the design of the questionnaires. The participants were identified based on criteria that related to their expertise and country so as to achieve participation of all expert groups (policy makers, academics and industry), but also to have as many countries as possible represented. The previous involvement of the researcher in multi-country research projects enabled the development of a long list of potential candidates. This was further enriched by adding names of coordinators of research projects that were identified through CORDIS and TRIMIS. The participation of 59 experts in the Delphi and 56 in ANP was finally achieved while a total of 21 countries were represented.

Finally, for the design of the questionnaires both for Delphi and ANP, seven experts were again involved in the piloting process. The questionnaires underwent two round of changes before being launched to the potential participants.

CHAPTER 6

ANALYSIS OF RESULTS

Introduction

The aim of chapter six is to present the analysis of the results from both the Delphi process and the Analytic Network Process. The previous chapters described the main Megatrends found in the literature review along with the Methodology and data collection process that was used. This chapter describes how this data was processed, analysed and condensed in a functional way so as to address the research questions and allow for conclusions and recommendations. The diagram below presents the process that was followed, the objectives of each step and the tools used.

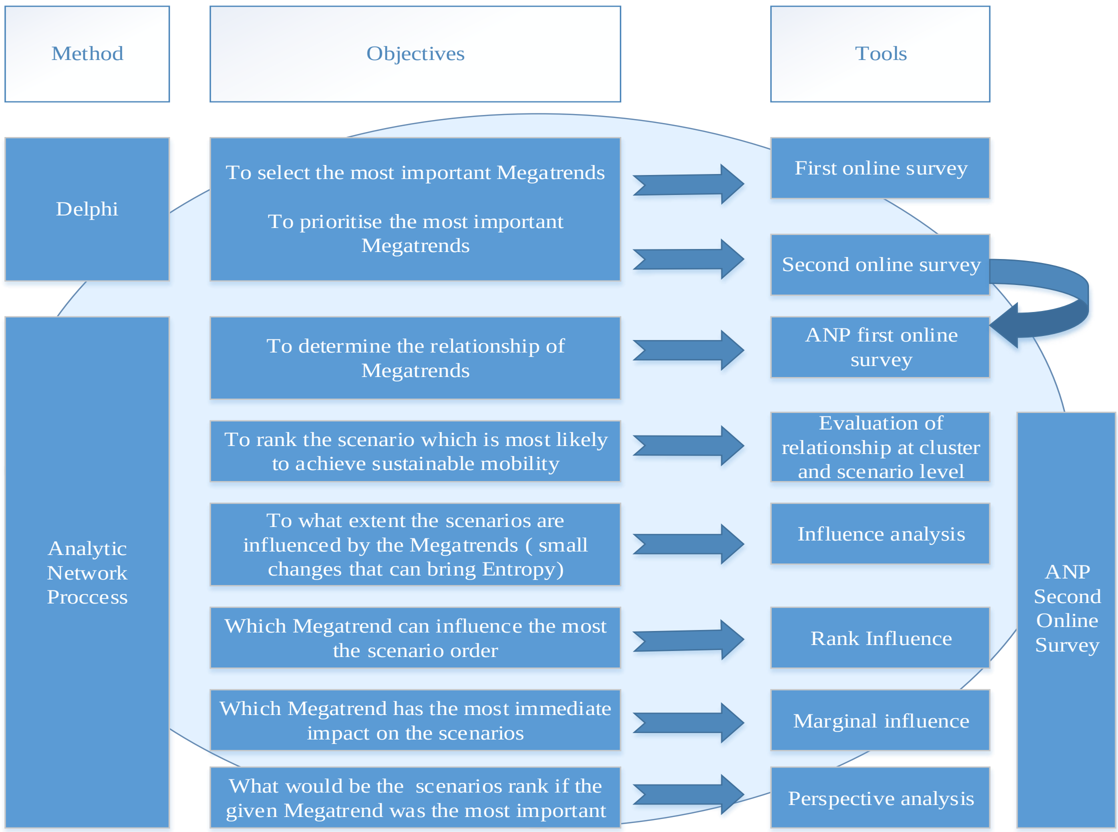

Figure 6.1: Analysis map

Source: Author

6.1. Results from the Delphi (first round)

The objective of the first expert online questionnaire was to collect expert opinions on:

1) the relative importance of critical factors in terms of their impact on passenger mobility; and
2) identify factors that were not found in the literature review.

The experts were asked to evaluate the most important Megatrend on a range of 1 (little importance) to 5 (great importance). If they did not have an opinion they were asked to tick ‘0’ on the relevant box of the questionnaire. The scale that has been used to rate the importance is the following (Table 6.1):

Not at all important	1
Slightly important	2
Moderately important	3
Very Important	4
Extremely important	5
No opinion	0

Table 6.1: Delphi rating scale

Source: Author

The first question examined the importance of the demographic factors. The answers of the participants are summarised in the Table 6.2. The score that was given (one to five) is presented in the horizontal line. The individual demographic factors are on the first column. The figures of the cells represent the number of answers given for each factor for each score. So, for example, migration is very important (score four) for 21 experts.

The average score is the sum of the answers given for each score divided by how many numbers are being averaged. So, for example for migration the average has been calculated as below:

Standard deviation, also presented in the table below, is a measure that indicates to what extent the data lie apart. In other words, how much the data is spread out and whether the scores are close to the average. Standard Deviation (SD) is zero, when all data values are the same so there is no variation whatsoever. Therefore, small SD represents data where the results are very close in value to the average.

Demographics										
	Responders per score (1 to 5)									
Trends	**1**	**2**	**3**	**4**	**5**	**0**	**Empty cells**	**Total**	**Average score**	**SD**
Migration	0	8	16	21	12	1	1	59	3.5	1
Ageing society	1	0	6	26	25	0	1	59	4.3	0.79
Fertility and birth rates	1	7	20	19	8	2	2	59	3.4	1.14

Table 6.2: Delphi results_Demographics

Source: Author

Demographics have been rated on average as being very important to extremely important. The factor that has been chosen by the most experts is the ageing society with average score 4.3 and low standard deviation (0.79) (Table 6.2).

Behaviour										
	Responders per score (1 to 5)									
Trends	**1**	**2**	**3**	**4**	**5**	**0**	**Empty Cells**	**Total**	**Average score**	**SD**
Resistance to accept emerging technologies	5	18	15	12	8	0	1	59	3	1.19
Environmental concern	1	11	18	15	13	0	1	59	3.48	1
Data privacy	11	13	15	12	4	2	2	59	2.63	1.3
Compliance with the legislation	4	11	17	14	6	6	1	59	2.8	1.43

Table 6.3: Delphi results_behaviour

Source: Author

Behaviour has been characterised mainly as moderately to very important (Table 6.3). The factor that received the highest score with the lowest deviation is the environmental concern.

Spatial organisation										
	Responders per score (1 to 5)									
Score	**1**	**2**	**3**	**4**	**5**	**0**	**Empty Cells**	**Total**	**Average score**	**SD**
Urbanisation	0	1	7	24	25	1	1	59	4.2	0.93
Development of large metropolitan areas	0	1	5	26	25	1	1	59	4.41	0.9
Urban sprawl	0	3	12	17	23	3	1	59	3.87	1.28

Table 6.4: Delphi results_spatial organisation

Source: Author

In terms of spatial organisation (Table 6.4), almost all factors received high values, especially the development of large metropolitan areas and urbanisation. However, the differences in the experts' preferences are relatively small and that deems the importance of spatial organisation on the whole in mobility.

Economy										
Trends	Responders per score (1 to 5)						Empty Cells	Total	Average score	SD
	1	2	3	4	5	0				
Financial recession	0	4	11	20	22	1	1	59	3.98	1
Market competition	1	7	21	20	8	1	1	59	3.4	1
Geographic distribution of production and activities	1	5	14	20	18	0	1	59	3.84	1

Table 6.5: Delphi results_economy

Source: Author

The standard deviation in the Economy seems to receive the same value (1). However, as most important factor, the experts rated the financial recession, again with very small difference from the market competition and geographic distribution of production and activities (Table 6.5).

Social Structures										
Trends	Responders per score (1 to 5)						Empty Cells	Total	Average score	SD
	1	2	3	4	5	0				
Unemployment rate	0	5	16	23	14	0	1	59	3.8	0.9
Unequal distribution of wealth	2	8	12	17	14	5	1	59	3.31	1.5
Flexible working	0	3	18	27	9	1	1	59	3.67	0.92
Women's increased role in the economy	4	10	22	13	9	0	1	59	3.22	1.25
Working conditions and legislation	4	14	19	15	5	1	1	59	3	1.13

Table 6.6: Delphi results_social structures

Source: Author

The highest score for the Social Structures has been allocated to unemployment rate, which also received high consent level (deviation 0.9). Flexible working comes second but with a very small variation from the unemployment rate (Table 6.6).

Globalization										
Trends	**Responders per score (1 to 5)**						**Empty Cells**	**Total**	**Average score**	**SD**
	1	**2**	**3**	**4**	**5**	**0**				
Shortage of energy resources	0	9	13	15	20	1	1	59	3.74	1.19
Global regulation gaps	3	12	14	13	6	10	1	59	2.6	1.57
Distribution of income and wealth	3	12	13	20	7	3	1	59	3.12	1.31
Economic & political conflicts	2	14	10	20	6	6	1	59	2.93	1.44
International trade	0	6	15	19	17	1	1	59	3.75	1
Higher competition	2	12	13	18	10	2	2	59	3.28	1.27

Table 6.7: Delphi results_globalisation

Source: Author

Globalisation seems to be a trend that has received higher deviation in terms of experts' opinions about the most important factor, if compared with the rest of the Megatrends so far (Table 6.7). The most important factor though with relatively low deviation (1) is the international trade. Shortage of energy resources is also very important with a small difference from international trade.

Environment										
Trends	**Responders per score (1 to 5)**						**Empty Cells**	**Total**	**Average score**	**SD**
	1	**2**	**3**	**4**	**5**	**0**				
Energy levels	0	4	9	27	14	3	2	59	3.73	1.21
Sustainable development	0	2	15	25	15	1	1	59	3.86	0.96
Renewable energy options	0	5	16	25	11	0	2	59	3.73	0.87
Energy prices	0	0	12	18	26	2	1	59	4.1	1.1

Table 6.8: Delphi results_environment

Source: Author

The importance of the environment (Table 6.8), on the whole, was rated overall as extremely important. The specific factor that received the highest score was the sustainable development while second were energy levels and renewable energy options.

Institutional structures and policies										
Trends	Responders per score (1 to 5)						Empty Cells	Total	Average score	SD
	1	2	3	4	5	0				
Cohesion policy	2	10	17	19	5	5	1	59	3	1.33
EU enlargement	4	12	25	9	6	2	1	59	2.91	1.17
Participation of citizens in decision making	4	19	12	9	11	2	2	59	2.96	1.37
Allocation of power	3	15	19	9	8	4	1	59	2.86	1.34

Table 6.9: Delphi results_institutional structures and policies
Source: Author

The institutional structures and policies were overall rated on average as moderately important (Table 6.9).

Transport policies										
Trends	Responders per score (1 to 5)						Empty Cells	Total	Average score	SD
	1	2	3	4	5	0				
Traffic law	3	7	16	22	8	1	2	59	3.38	1.14
Internalisation of externalities	0	11	8	25	13	1	1	59	3.63	1.13
Subsidies and incentives	1	6	20	16	9	5	2	59	3.19	1.36
Inadequate infrastructure investments	0	4	13	20	21	0	1	59	4	0.93
Encouragement of public-private partnerships	4	15	20	12	5	1	2	59	2.93	1.13
Opening of transport markets to	4	9	20	18	6	1	1	59	3.17	1.14

competition									
Pricing	0	2	15	21	19	0	2	59	4	0.86
Charges (e.g. for congestion)	0	1	9	22	25	1	1	59	4.17	0.95
Governments' support of sustainable mobility schemes	0	5	20	20	12	1	1	59	3.62	1
Taxation of fuels	0	3	10	27	17	1	1	59	3.94	0.98
Vehicle taxation	1	6	19	17	15	0	1	59	3.67	1

Table 6.10: Delphi results_ policies

Source: Author

A number of transport policies related factors received high values (Table 6.10). Amongst them are the inadequate infrastructure investments, pricing and charges. The factor that received the greatest attention is the charges as the score is the highest and the standard deviation low.

Information and Communication Technologies										
	Responders per score (1 to 5)						**Empty**		**Average**	
Trends	**1**	**2**	**3**	**4**	**5**	**0**	**Cells**	**Total**	**score**	**SD**
Diffusion and market up-take of ICT	3	7	14	23	8	3	1	59	3.29	1.29
R&D spending	3	9	15	17	13	1	1	59	3.43	1.24
Innovation performance	3	7	11	22	11	3	2	59	3.38	1.36
Improved safety	3	9	17	19	7	2	2	59	3.21	1.22
Improved traveler experience	2	6	15	20	14	1	1	59	3.6	1.16

Table 6.11: Delphi results_ICT

Source: Author

For the ICT there was not any factor that really stands out as they all received similar scores (Table 6.11)

Vehicle technologies										
	Responders per score (1 to 5)						Empty		Average	
Trends	**1**	**2**	**3**	**4**	**5**	**0**	**Cells**	**Total**	**score**	**SD**
R&D spending levels	2	8	14	20	13	1	1	59	3.53	1.18
Innovation performance	2	4	15	15	19	3	1	59	3.62	1.37
Diffusion and uptake of technologies by market	2	10	15	21	10	0	1	59	3.46	1
Improved safety	3	6	20	21	7	1	1	59	3.34	1.1

Table 6.12: Delphi results_vehicle technologies

Source: Author

Similarly as in the ICT, the opinions of the experts on vehicle technologies are given the same importance almost equally between the various factors (Table 6.12).

New factors

The experts were also asked to suggest factors that according to their opinion are important but they have not been included in the questionnaire. In Table 6.13 are the new factors that have been put forward:

Demographics	Behaviour	Spatial organisation	Economy	Social Structures	Transport policies	ICT
Pandemics like Ebola	Status, cost-awareness	Lack of local/regional economic development	Changes in Supply Chain	Retirement age	Congestion rate in urban areas	E-commerce
Expatriation	Shifting cultural values of vehicle ownership and social perceptio	Land use mix (urban planning)	Transport infrastructure and affordability of housing			Automatic driving

	ns of public transport					
Attitude toward living standards	Resistance to change existing mobility routines	Densification	Purchasing power and domestic production			
Increasing share of single person households vs large families	Vandalism, playing behaviour	Infrastructure, geographical situation & conditions	Business activity; employment and incomes			
Number of residents, employees and visitors	Cultural issues, education & training		Re-materialisation of economic activity, overall structure of economy			
Livability of cities	Social significance of different modes of transport					
Concentration of populations in urban vs rural areas						

Table 6.13: Delphi results_new factors

Source: Author

The majority of the above-mentioned factors that have been suggested by the experts already belong to the categories included in the two rounds of the questionnaires. For example the concentration of population in urban areas has already appeared in the study as ‘urbanisation’. The results of the second questionnaire were sent to all the members of the panel (150 contacts) along with the list of new factors/trends. They were asked to confirm that these would need to be included in the next phase (ANP), as they constitute important trends that affect mobility. The vast majority indicated that these were already indeed included in the questionnaire. Therefore, in essence, there were no new factors to be further considered.

Profile of the responders

The experts were asked to self-define their expertise. Their answers fell into four greater categories, however, it is possible that some of them might belong in more than one categories or the understanding of the disciplines was different depending on their countries.

The four categories are: engineers, planners, modellers, and social scientists. As seen on Figure 6.2, the expertise of the participants was almost equally distributed in the four main transport disciplines.

Specific research experience	Number of participants
Modelling	15
Engineering	14
Transport planning	19
Social sciences in transport	11

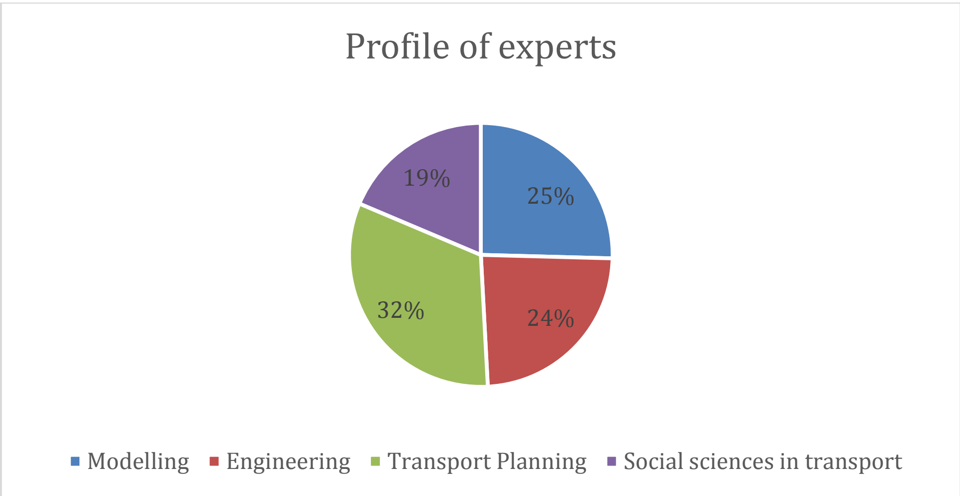

Figure 6.2: Profile of experts in the 1st Delphi survey

Source: Author

With regards to the transport mode expertise of the participants, the majority of them were experts in the surface transportation as seen on Figure 6.3.

Transport mode experience	Number of participants
Air	7
Water	7
All	19
Surface	26

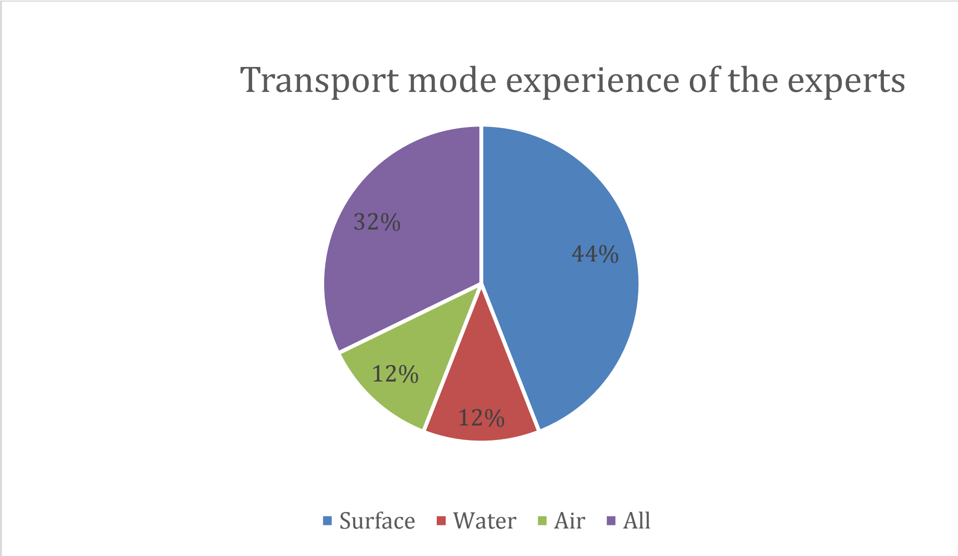

Figure 6.3: Experts transport mode experience in the 1st Delphi survey

Source: Author

Summary

The first online questionnaire has permitted to rank key factors affecting passenger transport system according to their importance. Table 6.14 presents the twelve most important factors with the lowest deviation levels, as identified by the experts (in random order):

Trends	Factors	Score	Standard Deviation
Demographics	Ageing society	4.3	0.79
Spatial Organisation	Development of large metropolitan areas Urbanisation	4.41 4.2	0.9 0.93
Economy	Financial recession	3.98	1
Social Structure	Unemployment rate	3.8	0.9
Globalisation	International Trade	3.75	1
Environment	Sustainable Development Renewable energy options	3.86 3.73	0.96 0.87
Transport policies	Charges (e.g. for congestion)	4.17	0.95

	Inadequate infrastructure investments Taxation of fuels Pricing	4 3.94 4	0.93 0.98 0.86

Table 6.14: Summary of findings of the 1st Delphi survey

Source: Author

6.2. Results from the Delphi (second round)

During the second round of the questionnaire, the experts were asked to rank the above-mentioned trends identified in the first round. The most predominant trend was the large metropolitan cities followed by urbanisation.

With regards to the profile of the participants, the majority of the experts were from the surface transportation domain as seen on Figure 6.4.

Transport mode experience	Number of participants
Surface	23
Water	6
Air	1
All	7

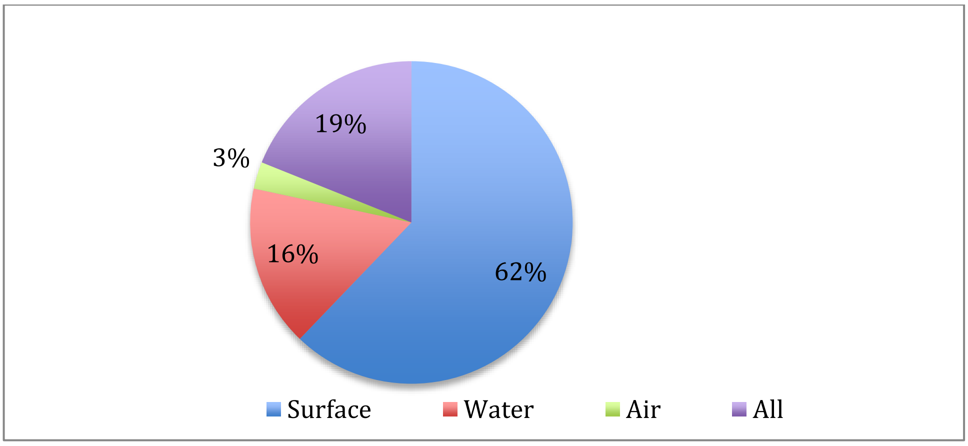

Figure 6.4: Experts transport mode experience in the 2nd Delphi survey

Source: Author

With regards to their transport research expertise, the majority of the experts were transport planners (Figure 6.5).

Specific research experience	Number of participants
Modelling	7
Engineering	7
Transport planning	14
Social sciences in transport	9

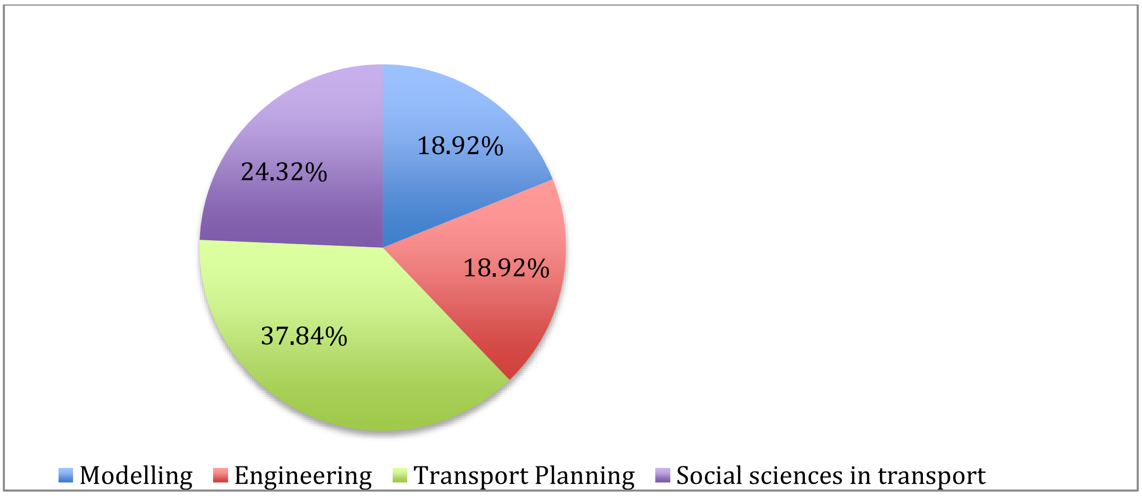

Figure 6.5: Experts transport research experience in the 2nd Delphi survey

Source: Author

Table 6.15 presents a summary of the findings, a total of 37 experts participated in the second round. The trends are represented in the first column while the ranking on the second line (from 1st to 12th). The arithmetic 'mean' represents the central tendency of the data in question. In this particular table, since the question relates to ranking the mean with a closer to first value is considered predominant. Therefore, according the majority of the experts the predominant factor that affects sustainable mobility is the development of large metropolitan areas.

Megatrends	Number of responders – Ranking (1st to 12th)												Mean	Responses Total
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**		
Ageing society	4	4	7	1	4	4	4	4	2	1	0	2	2.5	37
Development of large metropolitan areas	10	10	3	1	1	3	3	1	1	0	4	0	1.9	37
Urbanisation	6	7	2	5	2	5	1	2	2	1	2	2	2.3	37
Financial recession	2	2	2	7	7	3	0	3	2	5	3	1	2.9	37
Unemployment rate	2	2	2	2	3	6	3	3	4	3	1	6	3.4	37
International Trade	1	1	3	2	1	0	2	2	4	1	7	13	4.3	37
Sustainable Development	2	1	4	2	6	3	4	2	4	5	4	0	3.2	37
Renewable energy options	0	0	1	7	5	2	3	3	2	5	5	3	3.5	36
Charges (e.g. for congestion)	1	4	2	3	1	1	7	6	4	3	2	3	3.3	37
Inadequate infrastructure investments	2	2	3	5	1	3	5	5	6	4	0	1	3.1	37
Taxation of fuels	2	3	6	3	0	3	4	1	4	5	4	2	3.2	37
Pricing	5	1	2	1	6	4	4	4	1	2	4	3	3.1	37

Table 6.15: Importance of factors (1 most important, 12 less important)

Source: Author

6.2.1 Non parametric analysis

In order to investigate if there are differences in the (research & transport mode) experience of the responders with regards to the selection of key Megatrends a series of Kruskal-Wallis tests were performed. The Kruskal-Wallis H test (or the so called one-way ANOVA on ranks) is a nonparametric test that is used to determine if there are statistically significant differences between two or more groups of an independent variable on a continuous or ordinal dependent variable (Leaerd Statistics 2018*)*.

To conduct the Kruskal-Wallis test, there are certain assumptions that this research has met. These included independence of the observations, so there were different participants answering the questions and each of the participants belonged to one group. Also there were more than two groups of participants (transport modes and transport expertise). Lastly, in KW test the scale must be ordinal which is what has been used in this research (five point Likert scale).

Testing the hypotheses

The null hypothesis of the Kruskal-Wallis test is that all k distribution functions are equal. The alternative hypothesis is that at least one of the populations tends to yield larger values than at least one of the other populations. The test statistic used in this test is called the H statistic. The hypotheses for the test are:

- H_0: population medians are equal.
- H_1: population medians are not equal.

To determine whether any of the differences between the medians are statistically significant, the p-value to the significance level is compared in order to assess the null hypothesis.

Explanations of the values

- The z-value indicates how the average rank for each group compares to the average rank of all values.
- The N value is the total number of observations in each group which should be > 5 for a K-W test.

- The Median is the middle point of the data set. Meaning that this midpoint value is where half of the observations are above the value and half of the observations are below the value.
- Average rank is the average of the ranks for all observations within each sample. The software used in this analysis, Minitab, used the average rank to calculate the H statistic (the test statistic for the Kruskal-Wallis test). To calculate the average rank, Minitab ranks the combined samples. Minitab assigns the smallest observation a rank of 1, the second smallest observation a rank of 2, and so on. If two or more observations are tied, Minitab assigns the average rank to each tied observation. Minitab calculates the average rank for each sample (Support Minitab 2017).
- The degrees of freedom (DF) are the number of groups in the data minus 1. Under the null hypothesis, chi-square distribution estimates the distribution of the test statistic, with the specified degrees of freedom. Minitab used the chi-square distribution to estimate the p-value for this test.
- The P-value is a probability that measures the evidence against the null hypothesis. Lower probabilities provide stronger evidence against the null hypothesis.

It can be observed in the results (tables) in Annex 3 that the p-values of the test are higher than the level (0.05). Therefore, we do not reject the null hypothesis and conclude that the p-values indicate that the overall ranking median of one group is not statistically different from the others. That practically means that the answers that were provided were similar regardless of the background experience and the transport mode expertise of the experts.

The tables of results can be found in ANNEX C- KRUSKAL WALLIS TEST

6.3 Results from the ANP network

6.3.1 Introduction

The specific scientific objectives in this thesis are grouped into three thematic areas each with supporting objectives. One of them is to conduct Megatrends analysis with subcategories: (1) to assess the Megatrends priorities by a group of experts through the application of Analytical Network Process methodology, and (2) to measure the impact of Megatrends on the achievement of sustainable mobility.

The research questions that this thesis seeks to answer for these thematic areas are:

1. What are the most predominant Megatrends that effect sustainable mobility?
2. What is the impact of the most predominant Megatrends on the achievement of sustainable passenger mobility?
3. What is the interrelationship of the Megatrends?
4. How sensitive are the sustainable mobility scenarios' priorities to the changes in the Megatrends' importance?

As described in previous chapters, the use of the ANP is proposed because it offers a useful representation of the complex interactions, interdependencies and feedback relationships among the different components of complex problems such as the achievement of sustainable mobility. The problem was modelled as a structure or network system composed of different elements (Megatrends and scenarios) grouped in clusters and connected to each other by influences among them.

Once the model was constructed, the online ANP questionnaire was filled in with the aim of determining the relative importance for each scenario with regards to all identified Megatrends. This approach is to recognise how much each Megatrend influences the achievement of sustainable mobility, which is represented with a given scenario.

A timeframe of one month was provided for the collection of responses to the questionnaire and 56 responses were received. The responders belong to three groups of experts, from academia, policy-makers and industry.

6.3.2 Determination of relationship between Megatrends

As described in Chapter 5, in order to reach a geographical spread sample of participants, an online questionnaire was used for the determination of relationships between the Megatrends. Having tested the various versions of the questionnaire, the right 'matrix' for the answers was created. That included a set of questions that were not too lengthy but at the same time self-explanatory. The answers included three types of relationship (one way, feedback and does not have relationship) as per the ANP definition.

The responses were gathered by sending a general email to all high calibre experts from the academia, industry and passenger transport policy area. Twenty responses were received for the determination of the relationship between the elements. The responders participated anonymously and there were no means of identifying their identity. The following map of clusters and Megatrends interrelationships was constructed based on the results of the questionnaire (Figure 6. 1):

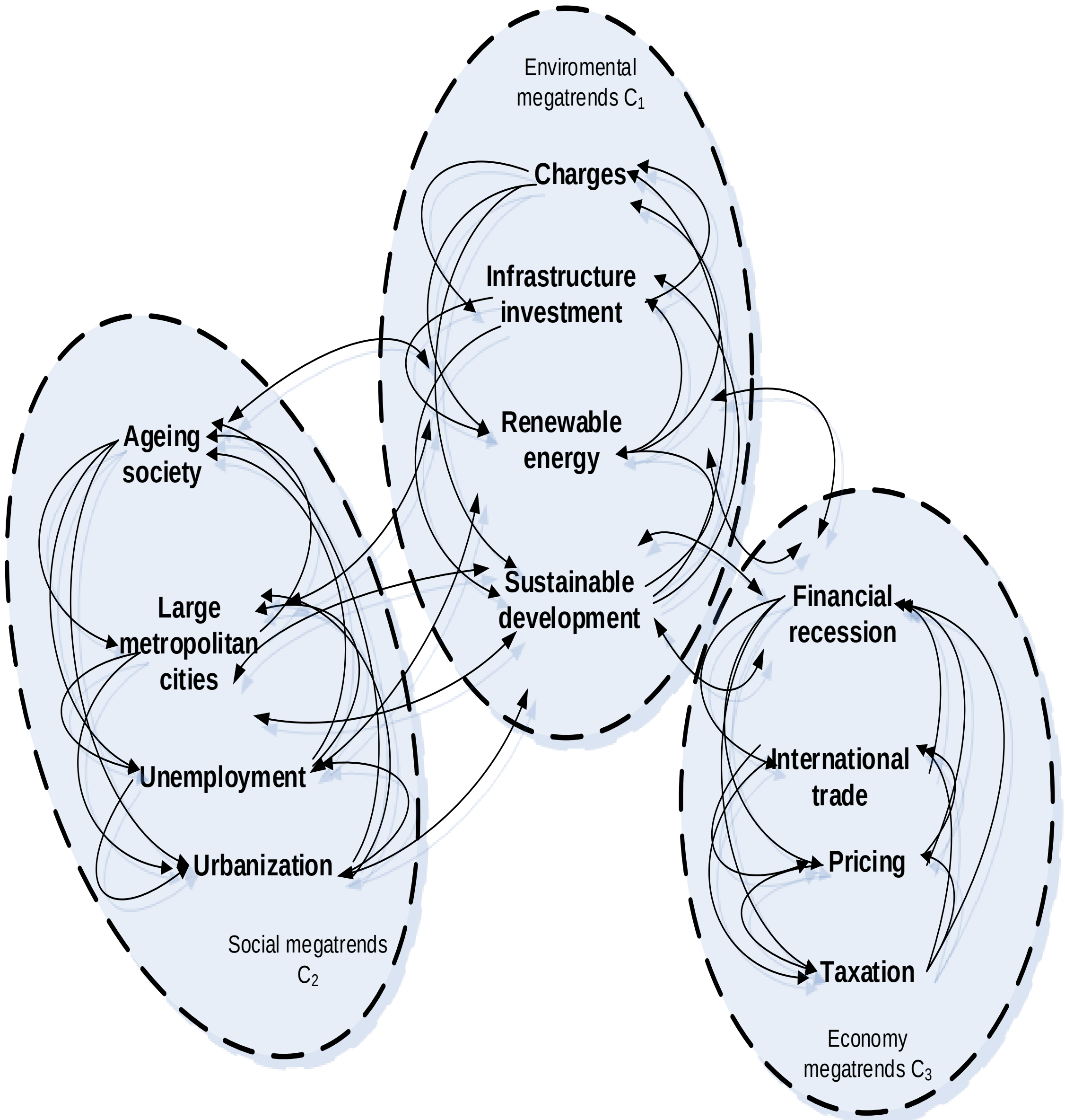

Figure 6. 1: ANP relationship map of clusters and elements

Source: Author

To observe the groups' different interests, an analysis of responses by groups was carried out. In the first questionnaire there were two main groups of questions: (1) definition of the relationships between the Megatrends in the clusters and (2) between clusters themselves (Figure 6. 1). The arrows on the above figure represent the relationship of the Megatrends and clusters and they form the basis for the next phase of the ANP where the extention of the relationship (impact) will be determined.

In order to present the ANP results in a structured manner, three different steps were carried out. These are:

1. The priorities of Megatrends have been analysed and compared both for the groups and the aggregated one.
2. The weights of the clusters have also been analysed for the separate groups and for the aggregated.
3. The ranking of the analysed scenarios has been obtained, which is the final aim of the whole evaluation process.

The results that were obtained for each Megatrend and for each group of experts include a large number of tables and images, which represents an abundant amount of information (Annex 1 and 2). The following chapters present the analysis of the results for the aggregated group and the most important sections in the validation of Megatrends and the measurement of the Megatrends impact (e.g. represented by stability and sensitivity analysis).

Since three groups of experts filled in questionnaires, three categories of results were delivered. Each one shows the relative importance according to the group's judgments. Aggregation of the groups' judgements was performed in order to obtain global judgments for all the experts, a limit supermatrix was calculated showing the consolidated preferences of all experts. That practically means, the total of all groups of responders (and not by category academia-policy making-industry).

6.3.3 Analysis of results at Megatrends level

Table 6.1. is a simplified presentation of the supermatrix, and resulted outcomes. It can be observed that the most relevant Megatrend for the aggregated group is the infrastructure investment. The second one is the financial recession. In order of importance, the order is as follows: sustainable development, renewable energy, taxation and large metropolitan cities.

With regards to Table 6.1, the higher the number the more important the trend. So, for example, as can be seen for the aggregated group, after the most important Megatrends of infrastructure investment (0.1107), financial recession (0.1079), sustainable development (0.1033) and renewable energy (0.1031), follows a group of Megatrends formed by charges, taxation and large metropolitan cities with the importance 0.0841, 0.0831 and 0.0748. The least important Megatrends are the international trade, unemployment, ageing society and urbanisation that have an importance of less of 0.0550. In general, as introduced, Megatrends that belong to the cluster of social Megatrends are evaluated as less important in having an affect in the achievement of sustainable passenger mobility.

Clusters	**Megatrends**	**Aggregation scores**
Cluster 1 - Economy Megatrends	Financial recession	0.1079
	Taxation	0.0831
	Pricing	0.668
	International Trade	0.0548
Cluster 2 - Environmental Megatrends	Infrastructure Investment	0.1107
	Sustainable Development	0.1033
	Renewable energy	0.1031
	Charges	0.0841
Cluster 3 - Social Megatrends	Large metropolitan cities	0.0748
	Unemployment	0.0476
	Ageing society	0.0422
	Urbanisation	0.0415

Table 6.1: ANP results for Megatrends

Source: Author

A graphical representation of the results presented in the table above, can be seen in Figure 6. 2

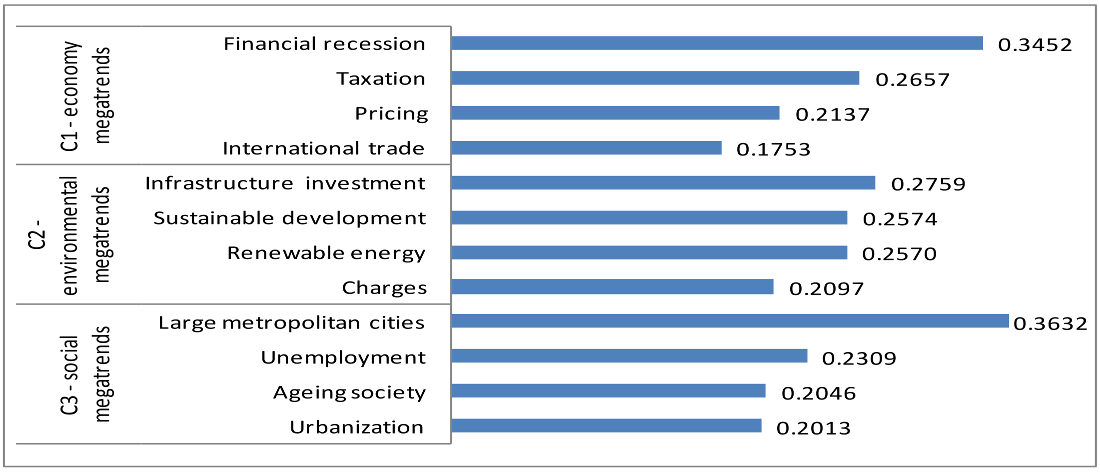

Figure 6. 2: Results for Megatrends_ aggregation

Source: Author

As conclusion on the assessment of Megatrends, it can be noted that sustainable passenger mobility has specific characteristics that have been connected with the environmental aspects, according to the experts as showed in the figure above where the trends within the cluster of environment received highest scores (Figure 6. **2**). This can be the reason that the experts have given higher scores to the elements within the environmental Megatrends cluster.

6.3.4 Analysis at cluster and scenario level

The weighting of the clusters provides some important insights into the overall perspective and underlying respondents' perceptions of the Megatrends in economy, environment and social groups of Megatrends. In other words, that principal respondents' conception of how Megatrends influence sustainable mobility. The main results, as demonstrated in Table 6.2, show that respondents from all groups have the same consistent evaluation for all the three clusters and that the differences of priorities are minimal. This was also revealed in the Kruskal Wallis test (Chapter 6.2.1). Such results indicate the very high reliability of aggregated results.

group of respondents	Clusters		
	C1- economy megatrends	C2- environmental megatrends	C3-social megatrends
Aggregation	0.3475	0.3629	0.2089
Policy-makers	0.3129	0.3546	0.2594
Industry	0.3143	0.3381	0.2649
Academy	0.3246	0.3355	0.2606

Table 6.2: Cluster priorities

Source: Author

The overall preference for each scenario with regards to all the considered Megatrends has also been obtained. The higher the preference, the more influential the scenario is. Table 6.3 shows the value of the priority in respect to the best-ranked element in the group (Ideal), the normalised priority as a share of the element in relation to all elements in the group (Normalised by cluster), and the Score (priorities obtained in limit supermatrix).

Elements (Scenarios and Megatrends)	Ranking	Ideals	Normalized By Cluster	Score
Scenarios				
S1-Harmony	1	1.0000	0.4998	0.0400
S2-Inexhaustible	2	0.5419	0.2709	0.0217
S3-Entropy	3	0.4588	0.2293	0.0184
Economy Megatrends				
Financial recession	1	1.0000	0.3453	0.1079
Taxation	2	0.7695	0.2657	0.0831
Pricing	3	0.6191	0.2138	0.0668
International trade	4	0.5079	0.1754	0.0548
Environment Megatrends				
Infrastructure investments	1	1.0000	0.2759	0.1107
Sustainable development	2	0.9330	0.2574	0.1033
Renewable energy	3	0.9314	0.2570	0.1031
Charges	4	0.7601	0.2097	0.0841
Social Megatrends				
Large metropolitan cities	1	1.0000	0.3632	0.0748
Unemployment	2	0.6358	0.2309	0.0476
Ageing society	3	0.5635	0.2046	0.0422
Urbanisation	4	0.5542	0.2013	0.0415

Table 6.3: Ranking of trends and scenarios

Source: Author

According to the table above, S1-Harmony has been significantly more valued than the other two scenarios for each of the groups. In conjunction with the clusters of Megatrends, it is also evident from the scores received that the cluster of environmental Megatrends appears to be the most important in achieving S1-Harmony.

An analysis of the results per expert group was also possible; Figure 6.3 illustrates that the ranking order for the three scenarios is the same for the three different groups too.

	Scenarios		
	S1-Harmony	**S2-Inexaustible**	**S3-Entropy**
Aggregation	0.0400	0.0217	0.0184
Policy makers	0.0407	0.0226	0.0193
Industry	0.0425	0.0213	0.0187
Academia	0.0381	0.0235	0.0170

Table 6.4: Scores of priorities for the scenarios

Source: Author

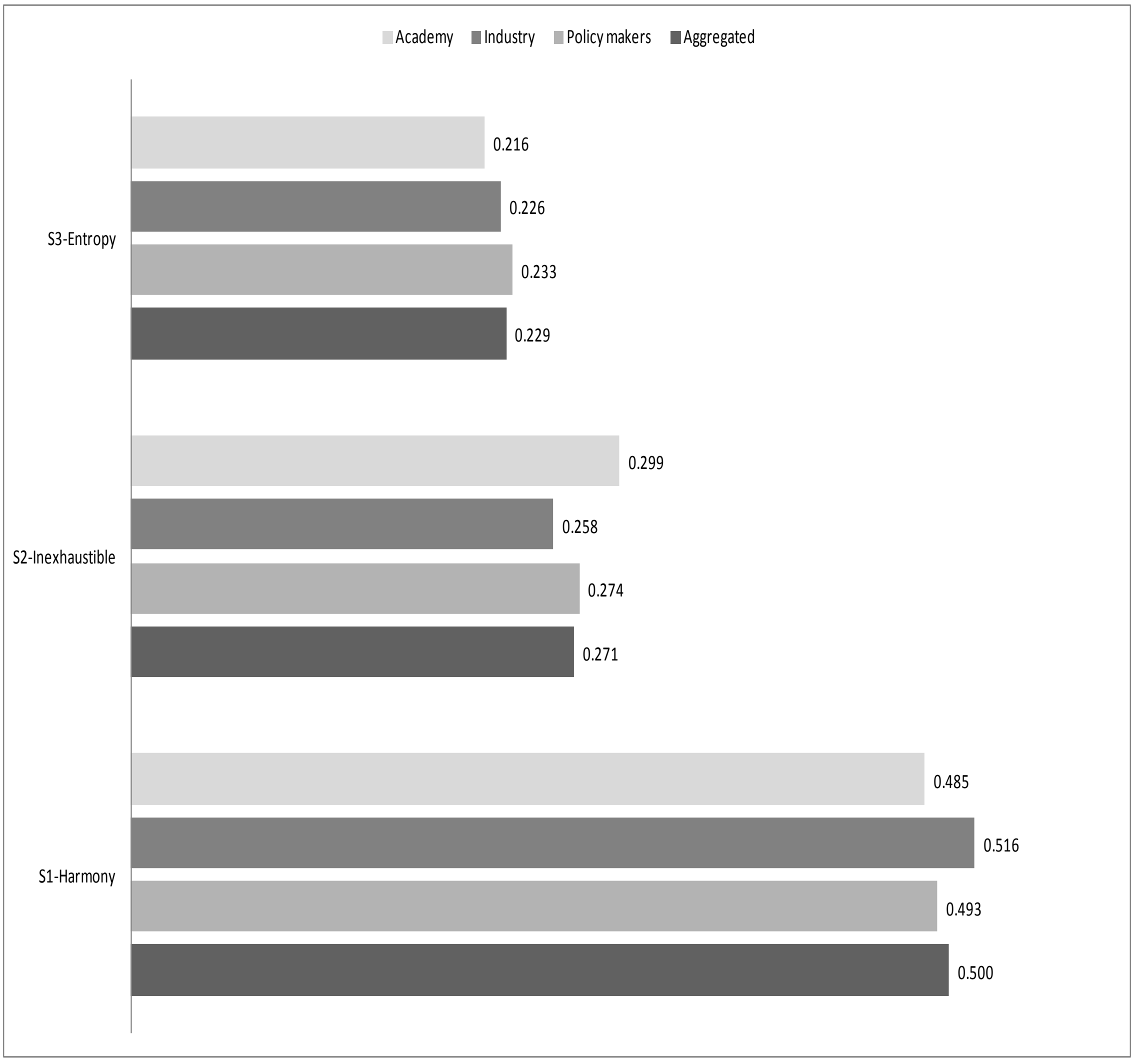

Figure 6.3: Results for the scenarios

Source: Author

To conclude, the main outcome of the analysis at cluster level with regards to scenarios is that S1-Harmony has been evaluated by all experts as the most likely to support the achievement of sustainable mobility. As in all foresight studies though, a disruptive change of circumstances, might lead to different results. The external environment (politics, technological development, social changes etc) affects the opinions of the individual experts. At the same time, the high ranking (second after S1) of the Inexhaustible scenario can be explained by the experts' awareness that in a globalised world it is difficult to strike a balance because of the openness of the system as the risk of an unpredictable is very high.

6.3.5 ANP sensitivity analysis

Sensitivity analysis is a technique with the main purpose to test the robustness of the results of a model in the presence of uncertainty/changes and to better understand the relationships between input and output variables.

To conduct sensitivity analysis it is important to know the following differences between the standard what-if-analysis and the sensitivity analysis for network models such as ANP. What-if analysis is a technique that is used to determine how the output of a model (numerical or otherwise) can be linked to different sources of inputs. What-if analysis also identifies errors in the model through unexpected relationships between inputs and outputs. It is mainly used to simplify the model by fixing the model inputs that have no effect on the output, as well as to identify and remove redundant parts of the model structure. It can be used if the inputs are independent.

Therefore, to receive meaningful results from a what-if-analysis, there should be independence between the input elements.

The idea of ANP Row Sensitivity is to choose the node[16] (the column of the supermatrix) and a row (the node's whose priority we are changing) and adjust its weight both globally and prior to the limit matrix calculation. This is accomplished by changing not just the weight of the node with respect to a single node, but with respect to all nodes connecting to it. To perserve the ANP structure, a single parameter is used that varies between zero and one. With changing that single parameter, all of the entries in the given row of the supermatrix would be changed. After that the limit supermatrix is calculated.

To answer the question of how sensitive the sustainable mobility scenarios priorities are to the changes of the Megatrends importance, the sensitivity analysis is conducted to understand how the priorities of the sustainable mobility scenarios responding/react to the changes of Megatrends influence. In other words, the aim of the sensitivity

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[16] Node is the term used in an ANP model to name an element in a network. In the same literature, the term element, criterion, factor is also used. Here is the Megatrend.

analysis in the ANP model is to predict how the different influences among the Megatrends affect on the priority of sustainable mobility scenarios.

The sensitivity analysis has been performed in four means in order to conduct a thorough analysis of the impact of Megatrends by validating the results through the following tests:

1. Identify the Megatrends that require the least change to induce a rank change of the sustainable mobility scenarios (rank influence).
2. Identify the Megatrends where small changes give rise to the largest change in scores of the sustainable mobility scenarios (marginal influence).
3. To change the Megatrend weights, each in turn, by a fixed amount and calculate the change in sustainable mobility scenarios scores or rankings (simply Influence).
4. To respond to the question of what would be the sustainable mobility scenarios rank if the given Megatrend was the most important (perspective analysis)?

6.3.6 Node sensitivity

Sensitivity analysis is used to identify the impact of changing the importance of one Megatrend to the sustainable mobility scenarios; the direct impact of Megatrend (line charts). The sensitivity analysis registers the points of the sustainable mobility scenarios ranking change with the change of the Megatrends priorities (dots in cross-check of two lines).

Numerical size of the change of each entry is controlled by the parameter value (p). The starting point for the changes begins with weighted supermatrix. The parameter value is set to 0.5 (p=0.5) at the starting point and limited supermatrix was being calculated.

An example of the sensitivity of the sustainable mobility scenarios with respect to taxation Megatrend is given in Figure 6.4. The sensitivity of the sustainable mobility scenarios with respect to all Megatrends per groups as well as the sensitivity of the significant Megatrends with respect to other Megatrends per groups is provided in ANNEX B – NODE SENSITIVITIES (GRAPHS)

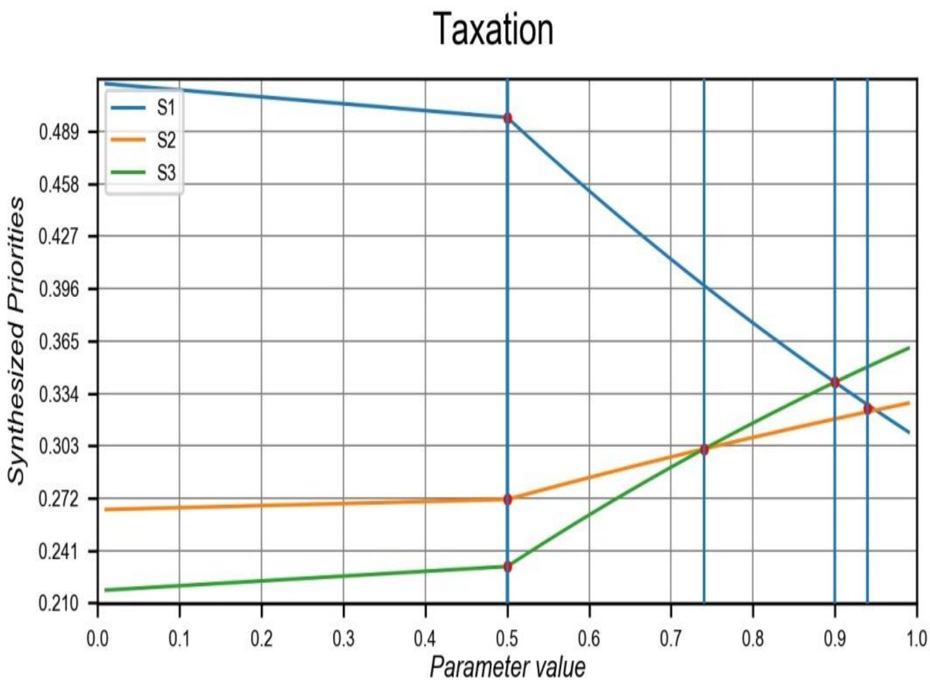

Figure 6.4: Resulting graph for taxation Megatrend

Source: Author

Figure 6.4 illustrates graphically the modifications of the normalised scores of the sustainable mobility scenarios (synthesised priorities) with the change of priority of taxation Megatrend. The normalised scores of the sustainable mobility scenarios are displayed with the coloured lines.

The numerical size of the change of each Megatrend is controlled by the parameter value (p). Parameter value varies from 0 to 1. From p0 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 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).

As can be seen in Figure 6.4, changes of taxation Megatrend importance is most reflected in the change of the S1 Harmony scenario and S3 Entropy scenario. In the first case, it can be noted that the impact of the Megatrend is direct and quickly leads to a change in the S3-Entropy scenario rank and it becomes the first ranked. In the case of S1 Harmony scenario, the impact of the Megatrend is such that it loses its position and falls to the last position from the first place.

The sensitivity analysis (in the form of Node sensitivity) points outs the significance of the stability of the first ranking S1-Harmony scenario. Namely, the first-ranked scenario does not change its rank in the case of small changes of the Megatrends importance. The S1-Harmony scenario changes only when Megatrends change the value of $p \geq 0.9$ (which is significant and less probable changes) except for the unemployment Megatrend, where S3-Entropy is pushed into the first place when it changes the value from 0.5 to 0.8 (Figure 6. 5).

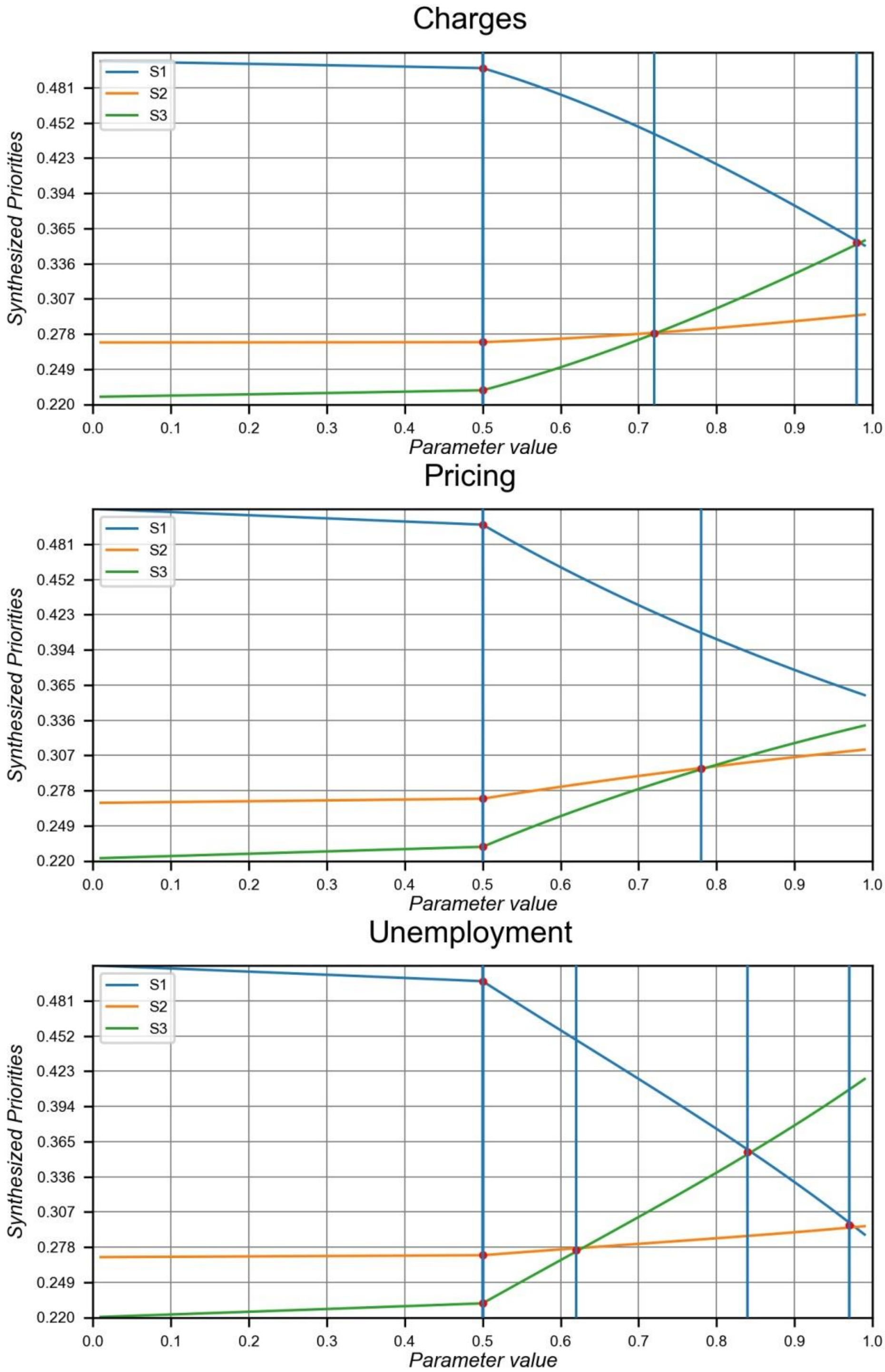

Figure 6. 5: Resulting graphs for charges, pricing and unemployment

Source: Author

6.3.7 Influence analysis

The influence analysis is performed by identifying the most influential elements. From a mathematical perspective, the most influential elements are the ones whose normalised synthesised priority vectors in p = 0.9 have the biggest distances (d_i) from normalised synthesised priority vectors in p = 0.5. After having defined the global priorities by raising every element priority from parameter value (p) of 0.5 to 0.9, the new preferences order of the sustainable mobility scenarios was introduced.

Table 6.5 shows the most influential Megatrends for the different groups of experts and the aggregated one. The resulting data can be found in Annex 1.

Aggregation		
Megatrend	**Influence order**	**Scenario order**
Sustainable Development	3	S1>S2>S3
Taxation	2	S3>S1>S2
Charges	4	S1>S3>S2
Unemployment	1	S3>S1>S2

Table 6.5: The most influential Megatrends

Source: Author

At the Table 6.5 above, the more influential Megatrends can be seen with regards to the scenario ranking. The Megatrends are found on the first column while the second column reveals the ranking of Megatrends. For example, for the aggregated results, the most influential Megatrend is the one that received the first place at the Megatrend influence order and that is the unemployment. The third column presents the order of the scenarios in case that the specific Megatrend is not addressed. In the same example, S3-Entropy comes into place when unemployment rates increase and there is no policy solution implemented for that.

So, it can be noticed (Table 6.5) that the order of importance of the Megatrends in defining the order of scenarios is unemployment, taxation, sustainable development and charges.

The scenarios order is changed even by the slightest changing in the value of the Megatrend unemployment importance. Athough the priority of the Megatrends sustainable development and charges has been changed, the S1-Harmony scenario remains in the first place and the S3-Entropy and S2-Inexhaustible scenarios change the rank/order. In the case of the Megatrends unemployment and taxation, they bring up S3-Entropy scenario.

The results per stakeholder/ expert group can be found at Annex A 2 Influence analysis

6.3.8 Rank Influence

Rank influence calculates how much the rank of a given Megatrend must change to cause a change in the rankings of the scenarios. From a mathematical perspective that is to say how much the change in the parameter value (*p*) is needed to change the ranking of the scenarios. The conclusion is that the smaller the change needed, the bigger rank influence that Megatrend has. Table 6.6 shows the Megatrends that have the smallest change that influences the ranking of scenarios. The all resulting data can be found in Annex 1. Again unemployment is the first in the influence order. However, taxation and charges can cause S3-Entropy scenario.

Aggregation		
Megatrend	**Megatrend influcence order**	**Scenario order changing**
Pricing	4	S2>S3>S1
Taxation	3	S3>S2>S1
Charges	2	S3>S2>S1
Unemployment	1	S1>S2>S3

Table 6.6: The top influencers

Source: Author

The results per stakeholder/expert group can be found at Annex A.3 Rank Influence analysis

6.3.9 Marginal influence

With node sensitivity, influence analysis and rank influence, it is not clear what Megatrends have the most immediate impact on the sustainable mobility scenarios scores. Marginal influence calculates derivatives of the sustainable mobility scenarios scores with respect to parameter value (*p*). It means that marginal influence calculates which scenarios are the most sensitive to small changes in Megatrends priorities or which node first causes a change in the ranking of scenarios.

For example, if the scale ratio for the parameter value (*p*) is equal to 0.01 the changes in the priorities of the Megatrends can be calculated every 0.01 value from *p*=0.5 to *p*=1.0. If the changes in priorities are the same in every parameter value from *p*=0.5 to p=1.0, the marginal influence of the Megatrend per alternative will be the same at any value from p=0.5 to p=1.0. If the changes in priorities are not the same over the values of p=0.5 to p=1.0, the marginal influence of the Megatrend per scenario will be taken at the parameter value (p) where the derivative of the scenario score with respect to parameter value (p) is the biggest. The overall marginal influence of one element is equal to the sum of marginal influences of one Megatrend per scenario.

The resulting data can be found in Annex 1. The most marginally influential Megatrends are again unemployment, taxation, pricing, and charges. According to the experts' judgments, these four Megatrends can result to S3-Entropy scenario (the derivative for the S3-Entropy scenario is positive for each and negative for S1-Harmony and S2-Inexhaustible scenario).

It is worth noting that the Megatrend unemployment, is the most marginally influential. Charges Megatrend is the fourth most marginally influential Megatrend by the judgment of all groups (Table 6.7).

Aggregation		
Megatrend	**Megatrend influence order**	**Scenarios priority**
Pricing	3	S3 ↑
Taxation	2	S3 ↑
Charges	4	S3 ↓
Unemployment	1	S3 ↑

Table 6.7: The most marginally influential Megatrends

Source: Author

This analysis draws attention to which Megatrends need to be considered the most when drafting policies since small mistakes can lead to major disturbances among scenarios ranking. In other words, the unemployment Megatrend needs to be taken into consideration when developing sustainable mobility policies because it can prevent the application (achievement) of that.

The results per stakeholder/expert group can be found at Annex A. 4 Marginal influence analysis

6.3.10 Perspective Analysis

The last aspect of the sensitivity analysis is the perspective analysis. Perspective analysis evaluates what would the resulting scenario scores be if a given Megatrend was the most important. The most important element is determined when the parameter value (p) is equal to 1.0 for the given Megatrend. In this analysis, distances (d) are calculated too, but with one major difference than in the influence analysis: the parameter value (p) is set to be 1.0. This is, also, the main difference between a most influenced element and most important element in the ANP Sensitivity Analysis. The resulting data can be found in Annex 1.

It can be observed (Table 6.8 and Figure 6. 6) that the top four Megatrends are taxation, charges, sustainable development and unemployment (highlighted in blue colour in the table below).

Looking at the changes of the scenarios order, the unemployment Megatrend brings up an S3-Entropy scenario (light red line in Figure 6. 6) and down the others, and the sustainable development Megatrend keeps the S1-Harmony scenario dominance (green line in Figure 6. 6).

		Scenario ranking		
Megatrends	**Distance (d)**	**S1-Harmony**	**S2-Inexaustible**	**S3-Entroy**
Financial recession	0.1075	1	2	3
International trade	0.0872	1	2	3
Pricing	0.1826	1	3	2
Taxation	0.2403	3	2	1
Charges	0.2003	2	3	1
Infrastructure investments	0.0491	1	2	3
Renewable energy	0.1558	1	2	3
Sustainable development	0.2337	1	2	3
Ageing society	0.1224	1	2	3
Large metropolitan cities	0.1699	1	2	3
Unemployment	0.2898	3	2	1
Urbanisation	0.0263	1	2	3

Table 6.8: The top four changers

Source: Author

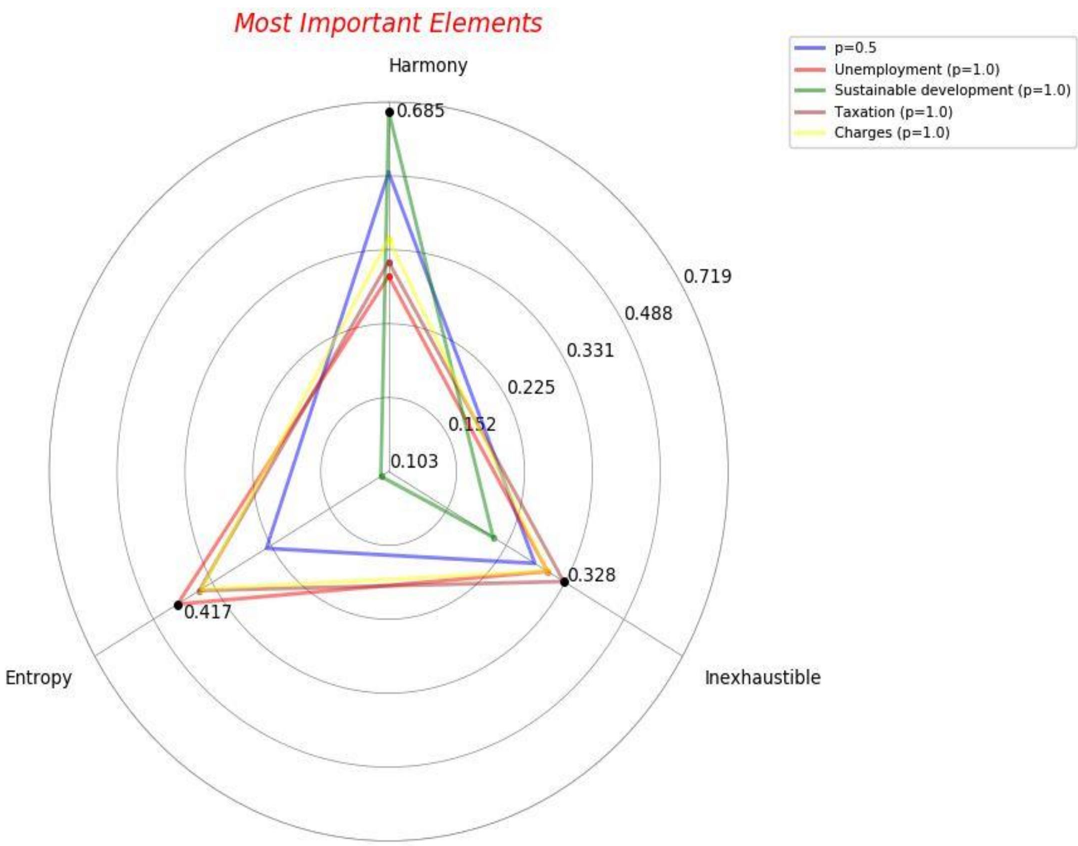

Figure 6. 6: Ranking scenarios vs perspective important Megatrends

Source: Author

The in-depth sensitivity analysis and observation of the individual impacts of Megatrends has showed that the greatest impact on the stability of the scenarios order have the following Megatrends: unemployment, taxation, pricing, sustainable development and charges.

The results per stakeholder/expert group can be found at Annex A.5 Perspective analysis

6.4 Summary and conclusions of the chapter

In this chapter the results of the Delphi and ANP application have been provided. This included the evaluation of scenarios for sustainable mobility in transport. Using the ANP model, the global concept of influences was broken down into twelve factors/trends that were previously identified in Delphi, evaluating different aspects that together enabled to define a preference/ranking. The preference measured the greater or lesser influence of Megatrends on the ranking of scenarios for sustainable passenger mobility. Delphi has showed that the priorities that have been given by the experts on the Megatrends do not have major differences. Also, the opinions of experts seem to be similar regardless of their transport mode expertise and transport research experience. However, the most important ones appeared to be the following, which were further analysed using the ANP:

Development of large metropolitan areas	Ageing society	Unemployment rate
Financial recession	Urbanisation	International Trade
Sustainable Development	Renewable energy options	Charges (e.g. for congestion)
Infrastructure investments	Taxation	Pricing

The ANP analysis has revealed that Scenario 1–Harmony is the one that is most likely to achieve sustainable mobility. Similarly as in the Delphi, the opinions of experts were similar regardless of their background (industry-academia-policy making) and lastly, the most influential Megatrends are: charges, taxation, unemployment, sustainable development, pricing.

CHAPTER 7

DISCUSSION

Introduction

Chapter 7 summarises the results of the research conducted. This includes the outcomes in relations with the research questions and conclusions along with primary contributions. Policy directions are suggested both in terms of the top ranked Megatrends but also on creating a macro-environment that would foster sustainable mobility.

7.1 Key findings in response to the research questions

This research aimed to identify the Megatrends that affect the achievement of sustainable mobility by applying a participatory foresight methodology and propose some generic policy directions based on research findings. Figure 7.1 represents a summary of the approach and the research questions:

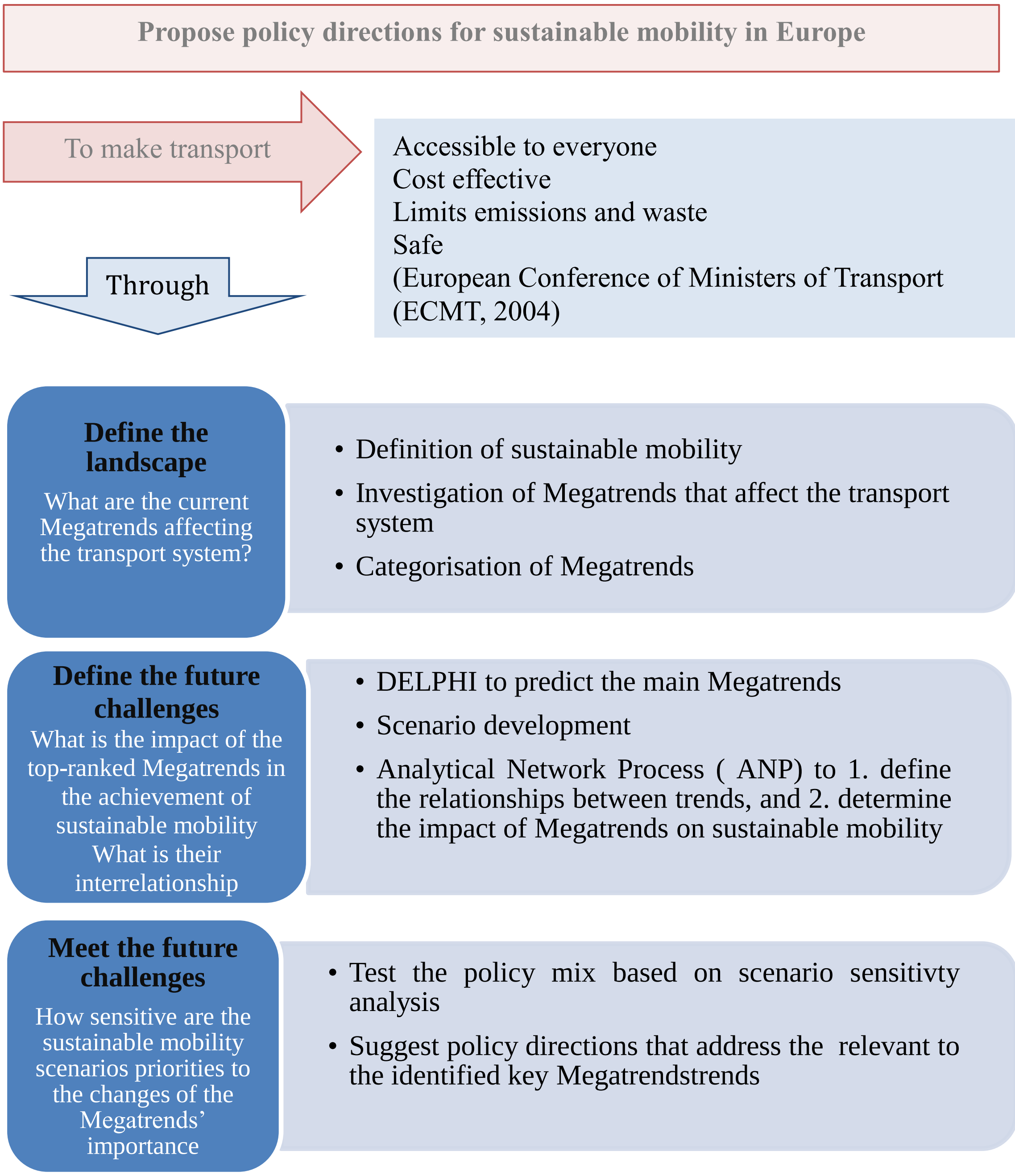

Figure 7.1: Research approach and questions

Source: Author

The three scenarios that were developed with the support of experts, focused on the interrelationship of Megatrends but also the link of Megatrends to the policy. The experts, during the ANP process, identified the scenario that is more likely to support the achievement of sustainable mobility and the Megatrends that affect its application. The three scenarios are presented in Table7.1:

Scenario 1: Harmony	Scenario 2: Inexhaustible	Scenario 3: Entropy
• The trends are harmonised and lead to the achievement of sustainable mobility, i.e movement, habits and behaviour of passengers contribute to reducing the negative effects of transport on society, economy and environment.	• Everything is possible, so that there is uncertainty. Harmonisation of trends exists but distortion of harmonisation is also possible and may impact the achievement of sustainable mobility.	• Disorder, leads to destruction, the collapse of the system. Trends exist independently of each other, so that sustainable mobility cannot be attained.

Table7.1: Scenarios

Source: Author

The sections below (7.1.1 to 7.1.5) provide some answers to the research questions.

7.1.1 What are the current Megatrends affecting the transport system?

The analysis of results at the Megatrends level revealed that the four most important in order of importance are infrastructure investment, financial recession, sustainable development, renewable energy, taxation and large metropolitan cities. Among the three clusters of Megatrends, social, environmental and economic, the environmental cluster is perceived as the Megatrend in achieving sustainable mobility. This reflects the clear connection between environmental protection and sustainability. From a policy development perspective then, addressing these four Megatrends is a core element in building a sustainable mobility system. Suggestions on how these Megatrends can be addressed are given in section 7.3. These Megatrends, however, impact on the application of sustainable mobility at different levels. Therefore, the next research question and relevant findings reflect on the extent of the impact.

7.1.2 What is the impact of the top-ranked Megatrends in the achievement of sustainable mobility?

Although the Megatrends in 7.1.1. were given high score by the experts, this does not imply that their impact in achievement of sustainable mobility is crucial too. To assess the magnitude of the impact, a sensitivity analysis was performed. The results demonstrated that the impact of Megatrends in the achievement of sustainable mobility is as follows:

The sensitive Megatrends (Node sensitivity/Influence analysis)

The most sensitive Megatrends, as perceived by the experts in the ANP, are unemployment and taxation. Especially in the case of unemployment, it is considered as a major factor for leading in destruction, which means a complete collapse of the system where sustainable development cannot be achieved (Scenario 3-Entropy). This poses certain risks and emphasises the importance of building the necessary conditions, especially on the macro-evironment, to deal with unemployment but also to reinforce sustainability as the main driving force of the economy.

Accelerators of sustainable mobility (Perspective analysis)

During the first part of the ANP analysis, it was evident that experts believed that sustainable mobility could be achieved if Scenario 1-Harmony is dominant. So, it is of great importance to create the necessary conditions that would enable the implementation of this scenario. During the perspective analysis, it has been demonstrated that there are four Megatrends that affect the scenario order: unemployment, taxation, pricing, sustainable development and charges. However, unemployment and sustainable development were the most crucial in accelerating the application of sustainable mobility. Unemployment might create constrains while sustainable development as main policy direction would support sustainable mobility.

7.1.3 What is the interrelationship of the Megatrends?

The experts of all three groups, during the ANP process, declared that the Scenario 1-Harmony is the most preferable scenario to occur in order to achieve sustainable mobility. Here Megatrends do affect the policy formulation, which, through the necessary policy measures, can lead to sustainable mobility. Also, the Megatrends impact on each other; therefore, the policy measures that need to be undertaken should encompass all the important Megatrends. Guidelines for all the Megatrends that were identified as important during the ANP, are presented in Chapter 7.3.

7.1.4 How sensitive are the sustainable mobility scenarios priorities to the changes of the Megatrends' importance?

The experts stated that again unemployment is an important Megatrend in achieving sustainable mobility. If not enough attention is given on that particular factor, it will lead to significant changes in the scenario order, with the outcome that sustainability cannot be met. Other important Megatrends that were considered as sensitive to changes are taxation, pricing, and charges. It can be observed that all of them are related to monetary measures.

7.1.5 Consensus between the experts

The three expert groups that were consulted during this research project were from academia, policy making and industry; all of them shared similar opinions with regards to the most influential Megatrends affecting sustainable mobility. This was further validated during the ANP analysis where, in the majority of cases, the experts gave similar answers regardless of their background.

This shared vision about the achievement of sustainable mobility implies that efforts can be applied in one common direction. Since the interests and the visions of the experts are shared, a stronger and more efficient collaboration between the three stakeholder groups should also be possible. As noted in the literature review, increasing the use of PPPs is one of the trends in the development of an efficient transport system. Given the common interests of governments (policy making) and industry, these types of collaborations are expected to play an even a more significant role in the future. For that reason, it is of imperative importance to develop the necessary framework conditions (legal framework, risk sharing schemes, etc) to enable them to succeed.

7.2 Policy directions at macro-level: setting the scene

The aim of this research is to propose strategies for achieving sustainable mobility. The directions put forward aim to address the Megatrends identified at the outset of this research as described above and they derive from literature review of the suggested schemes. Continuously changing conditions require on-going revision of strategies so as to reflect emerging needs and challenges. There is no best practice or a single strategy that fits all purposes. However, at the European level, it is of imperative importance to ensure that targets are set and support measures implemented in order to safeguard cross EU cohesion and social acceptability.

According to Harris (2001), the sustainability perspective suggests that fundamental and proactive government policies are required to achieve socially and ecologically sound development. Of course, due to the unique characteristics of the market economies in different countries, sustainable development needs to be further steered through the use of micro-economic policies, but within the overall framework of macro-economic policy.

7.2.1 Citizen participation in policy design

The Delphi methodology, but also the ANP, confirmed that the experts and stakeholders of the transport system share a similar vision not only about the future Megatrends but also with regards to the most preferable scenario. This shows they are aiming at a similar goal with similar interests. Therefore, it is important to involve all stakeholders including users in the policy development.

Today's economy is driven by extended relationships, wider geographical outreach and an increasing importance of human capital. However, many organisations still work in silos and fail to cross-fertilise others; they do not perceive themselves as part of a complex interconnected ecosystem. In order to enable stakeholders to learn from each other and build a common pool of knowledge, resulting in decisions that are most valuable to the system, dynamic and shared tools and methods are needed.

The development and continual improvement of policies to encourage sustainable mobility must include citizens in the process. The reason is not simply to respond to users' needs, but also to contribute to identifying ways of changing habits and established patterns of transport behaviour. According to Umpfenbach (2014), individuals' actions (at work or at leisure) are the prime causes of good or harmful environmental outcomes, including transportation. Therefore, it is important to involve users in the policy making process so as to recognise their motivations in the context of policy objectives. Adopting an environment-conscious approach will have a positive effect on sustainable mobility.

Traditionally, industry lobby groups, such as the European Technology Platforms[17], and academia are consulted in the policy design process. However, in recent years, the EC has been investing in finding ways of directly integrating citizens' and users' needs into policy-making processes. This is evidenced by the increased funds made available for citizens' involvement calls under the H2020 Transport programme. A proven method, used by CIPTEC[18] project for example, is the use of crowdsourcing campaigns and co-creation workshops. Crowdsourcing refers to an open call that invites users to suggest, comment and advise through a web platform. Co-creation refers to collective creativity action where stakeholders come together to jointly be involved in the development of a new artefact, in this case policy intervention. Such methods can stimulate the interest of the public and achieve a greater impact for the measures in question as the users had a major involvement in the design of actions, as the ones who designed them will follow them.

7.2.2 Harmonisation of policies

The research showed that there are two types of 'harmonisations' that are evident in the process of achieving sustainable development. The first one concerns the 'harmony' in

[17] ACARE, ERRAC, WATERBORNE, ERTRAC, ESTP
[18] www.ciptec.eu

sharing the same views between the stakeholder groups with regards to Megatrends and scenarios. The second relates to the 'Harmony Scenario' choice, which was ranked as the most efficient in achieving sustainable mobility. Experts from different backgrounds and places in Europe support the argument that the Megatrends are very much interrelated and have a direct impact on policy measures. From a policy development perspective, the harmonisation of opinions and trends, translates to a need in harmonising the rules and regulations that would support the further implementation of measures or even technologies that can support sustainable mobility.

Two of the most representative examples of gaps in policies in the legislation are safety and security standards, especially for autonomous vehicles and harmonisation of regulations in PPPs where there is a lack of coherent framework. Public procurement is the regulation that frames the implementation of PPPs where currently there is no European wide directive that guides the successful implementation of PPPs.

The EC, recognising the importance of Europe's planned transition towards zero-emission mobility, has adopted a new regulatory framework that includes actions on clean technologies that are implemented through emission standards and deployment of low carbon fuels (EC 2017)[19]. Safety and security standards are also part of the same regulatory regime. However, there are gaps in regulations and a lack of harmonisation in some areas. As an example, even in the case of a complete implementation of autonomous vehicles within national transport systems, people will still desire to travel abroad. This will require trans-European harmonisation and standardisation for autonomous vehicle systems in order to make cross-border traffic possible. In the course of the development of autonomous vehicle systems, future R&D activities, therefore, need to increasingly address questions of transnational system harmonisation in order to enhance the EU's strategic goal towards a European multimodal transport information, management and payment system. Whilst the rapid development of AVs brings this need into sharp relief, the need for coherent and cohesive cross-EU action is common to all transport developments and modes.

[19] European Commission, 2017, DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL - on the promotion of the use of energy from renewable sources (recast), Brussels

Harmonisation also needs to be achieved in terms of regulations used to promote the use of technologies and business models aimed at supporting sustainable mobility developments. For example, there is no specific homogenised EU legislation that covers the formulation and operation of PPPs. There are only EU public procurement rules, notably the Treaty on the Functioning of the EU and EU public procurement directives. The main PPP procurement procedure, the so-called 'competitive dialogue', covers some features of PPPs. The EU has two procurement directives to support the implementation of PPPs – the Public Sector Directive (2004/18/EC) and the Utilities Directive (2004/17/EC) (Son, S., 2012). However, these are not comprehensive.

The three main policy directions that should be introduced in order to support the implementation of PPPs are the introduction of homogenised rules for implementation in national procurement procedures, the introduction of common PPPs contractual models in Member States and the introduction of common rules in dispute resolution systems.

Apart from PPPs, homogenisation is required in the deployment regulations amongst the member states. Deployment regulations refer to the implementation stage of PPP projects and frame the conditions that enable the partnership to realise the project in a transparent manner. This includes a range of interventions containing the introduction of common standards to ensure interoperability and intellectual property rights.

7.2.3 Research and Development

Research and development play a key role in the future of the transport system and the focus on sustainable mobility. In recent years, through the implementation of the H2020 programme, there has been a stronger emphasis from the EC's side to invest in the application of the behavioural science concepts to transport planning, for example in the promotion of MaaS.

RTD and innovation policy should promote systemic transformation, which is adaptable to the changing challenges as some Megatrends are more amenable to change than others. The focus should be on research management including the definition of 'hot' topics, proposing procedures and assessment, eligible institutions, funding schemes etc. This implies continuous foresight activities that would keep policy makers informed about high potential topics and would reinforce further investment in them through RTD grants. High potential topics are the technologies or transport concepts, such as MaaS, that could effectively tackle major challenges. This could promote research with the highest innovation potential – going beyond the mainstream and allowing for disruptive innovation supporting system transformation. This can include, for example, providing open innovation spaces, institutions and initiatives.

There is a need to develop new methods and approaches to put sustainability into practice. Solutions that balance the economic, environmental and social interests of different stakeholder groups need negotiation. Thus, further research is needed on how sustainability in a balanced sense, in terms of reaching equilibrium between the interests of society, policy makers and industry, could be ensured. In addition to practical solutions and applied research there is still need for more theoretical research coupled with a normative discussion. The desire for practical solutions should not replace basic knowledge, a normative discourse on sustainability and the discussion of how to bridge theory and practice – which could best be ensured in research combining both theory and practice.

Enabling bottom up research would promote the emergence of disruptive, unexpected and innovative solutions. Risk capital needs to be allocated for science and research to accommodate the risks of failing when investing in very new and innovative solutions. Bottom-up ideas on solutions, but also on the problems to be addressed, would increase the potential for identifying successful solutions – which today is limited by top-down strategies for research and the recent scientific system neglecting and excluding approaches outside mainstream thinking.

7.2.5 Economic policy

Unemployment, which is ranked as the most influential Megatrend by the majority of the experts, can be tackled through effective socio-economic policies. The pricing and fiscal structure could encourage sustainable mobility, particularly for transport and land-use planning integration. Policies for housing and real estate, for example, can encourage decisions about where to live in order to reduce congestion and sprawl.

Disruptive technologies are changing markets. The new trends and developments offer a huge potential for the development of new markets and the change of existing structures. For example, the entrance of new players in the transport market such as Google. On the other hand, they also raise a number of questions, in particular as regards the impact on the labour force, both sectorial and in general.

In the automotive sector in particular, the predicted increase in the number of electric vehicles and increased demand for the raw materials required for battery production can lead to further exploitation and overuse of natural resources. It is, therefore, important to proactively manage these critical raw materials and find ways, through future R&D activities, to re-use raw materials within means of transportation. In addition, further procedures need to be developed to ensure the sustainable disposal of non-recyclable materials. Circular economy policies and strategies must, therefore, be increasingly applied in the transport industry. For example, incentives for producers should be developed along with information campaigns on the sustainable use of scarce resources. Second-life usage of batteries from EVs in applications for stationary energy storage and elsewhere will need to become more widespread. Carbon fibre shortage will require recycling solutions to be developed, and the same need will apply to many other increasingly scarce resources.

In order to ensure the transition from fossil to renewable energy sources, new large-scale solutions for energy production from renewable sources will have to be found. Future policies will need to increasingly develop strategies and incentive systems for the production, storage and consumption of electricity from renewables and make appropriate adjustments, for example to grid capacity. In addition, efforts must be made to increase energy efficiency within means of transportation (e.g. improved energy density in batteries from electric vehicles), which can be achieved through technological advances, but also via modified construction methods and new and more efficient materials for example aerodynamic optimisation and lightweight construction.

7.3 Policy directions for the top ranked Megatrends

The Analytical Network Process in combination with the Delphi technique revealed six main top ranked Megatrends. Top Ranked indicates Megatrends that, according to the experts, need to be addressed more efficiently through the introduction or improvement of policies in order to achieve sustainable mobility as described in Section 7.1. The suggestions on policy directions on how to efficiently address them are described below (sections 7.3.1 to 7.3.7).

7.3.1 Charges

The associated external costs of increased mobility such as congestion, noise, accident risks and air pollution, have been a major concern for decision makers and a number of policies have already developed to deal more effectively with these costs. Charges can help address time loss due to congestion, local pollution, noise and contribution to climate change caused by emissions of GHGs, pavement costs and road damage, increase in accident risks, extra-fuel consumption and decrease in quality of life, whilst also being a source of public revenue. Sometimes they are differentiated by vehicle type, while electric vehicles are often exempted. However, although they can be a very effective tool, they are at the same time politically challenging and complex to implement. Some cities that have implemented congestion charges include Stockholm, London and Singapore.

Charging schemes aimed at promoting sustainable mobility are listed here. However, a combination of more than one can also be proven efficient depending on the individual characteristics of the cities:

- Road Tolls: This refers to fees for the use of the road network. They can be used to fund construction of roads.
- Value Charging: Value is the estimated value of the usage of the road to the driver/user. These are variable charging schemes for use of the road network where the level of price differs depending on the time of the day, month or year. These schemes aim to decrease traffic during rush hours. And even out traffic flows through time.

- High Occupancy Tolls: These allow private vehicles to use the lanes that are reserved for public transport on payment of a toll.
- Travel distance based charging: These charges are proportional to the distance travelled.
- Zonal schemes: The charges, usually daily fees, are applied to vehicles within a single perimeter.

As charges constitute an important element in ensuring sustainable mobility, EU policies should be focused in the following directions, having always as a basic direction the polluter pays principle:

- Provision of financial support to conduct feasibility studies for the adoption and application of the optimal charging scheme depending on the individual features and needs of the cities.
- Provision of financial support to investigate acceptability of the schemes, governance and cost-benefit analysis of the impacts.
- Education and information provision. This measure includes campaigns that would inform the public about the benefits of the schemes.
- Introduction of guidelines or legislation about the governance issues that enable cities to implement the schemes in accordance to their objectives.

These policy recommendations aim at overcoming the barriers that many cities faced when implementing charging schemes. For example, in Slovakia there has been no legal basis to introduce congestion charging. In other countries and cities too, even when the legislation is there, the charging is very difficult to implement; several schemes have been initiated but never actually became reality (New York, Edinburgh, and Manchester).

7.3.2 Taxation

At the moment each of the EU Member States has a different set of policies towards the taxation of transport. The bases of national taxation schemes vary from fuel consumption to registration fees to CO_2 emission levels. The common ground along all policies is that Electric Vehicles are exempted (ACAE 2018). However, the EC in their latest policy programme, Europe on the Move, have introduced unified legislation for CO2 emissions and safety standards for 2020-2030. The success of a transport tax regime is evident when a behaviour change is stimulated. Apart from the behaviour factor, various studies suggest that after 2020, hybrid electric and fuel cell-powered vehicles will increase their market share if governments introduce policies for high fuel price (EAFO project 2018). Europe on the Move, is on the same direction as the policy encompasses measures for fuel price.

Taxation can serve as an important instrument for achieving sustainable mobility. Policies that introduce higher fuel prices can act as incentive to reduce consumption. This can be attained through the purchase of more fuel-efficient vehicles, shift to public transport etc. However, in some cases it has been observed that this can lead to side effects. For example, a lower fuel tax on diesel can foster a shift from petrol to diesel passenger cars. Therefore, a broader approach to taxations is suggested. Taxation imposed on all polluters can be much more effective and can lead to reduction of pollution than a taxation targeting only transportation. Consequently, measures that encourage energy conservation with a wider energy-based tax rather than motor fuel tax can achieve greater results and impact. Estimates of the price elasticity of demand for fuel and/or energy should be made in prior of any policy interventions.

To sum up, there are two main directions for applying a fair tax policy that would ensure sustainable mobility. The first is based on the ‘polluter pays’ principle and implies that those who pollute should be taxed according to how much pollution they create in a transparent matter. The second relates to the fact that taxes should be applied in a broader scope and not only for transportation. Such an approach aims at changing users’ behaviour rather than targeting particular types of vehicles.

7.3.3 Sustainable development

The experts participating in the application of the ANP framework, declared sustainable development as the cornerstone of sustainable mobility, meaning that sustainability should be at the heart of policy making. As described in Chapter 3.3, since 2013 the EC introduce the Sustainable Urban Mobility Plans to support the implementation of sustainable mobility measures. However, the success of sustainable mobility requires acceptance by users. It is, therefore, a necessity to create a social movement towards sustainability. Policies need to reinforce sustainable decision-making and to establish it as mainstream thinking. A social movement needs to evolve in culture and effective ways for communicating sustainable values need to be developed (e.g. through marketing, advertising, influencing, incentivising, etc.).

Strategies for sustainable development are not stand-alone measures. These should be implemented in combination with other policy measures, for instance vehicle regulation, road charging or tax regulations. Collaboration between relevant stakeholders (authorities, transport operators, service providers, etc.) is also an important component for achieving sustainable development. Policy tools such as incentives, compulsory measures or mechanisms encouraging voluntary involvement are needed to overcome the lack of co-operation between main stakeholders. A clear and appropriate definition of the roles played by each stakeholder, including passengers and road users, is also necessary. It is, therefore, recommended that further effort be put into the development of appropriate business models for the successful implementation of sustainable development.

Smart cities/communities

The findings suggested that sustainable development must be the driving force of policy development in order to achieve sustainable mobility. The literature (Chapter 2) suggested that smart cities can be a very effective measure to achieve sustainable mobility. Smart cities are characterised by digital networking. With regards to traffic, for example, this can help make flows more efficient and thus pave the way for fully autonomous driving. However, this requires comprehensive coverage with the next generation of mobile communication networks (5G). Policies must, therefore, put emphasis on the development and European wide implementation of the next generation of mobile communications, in order to enhance the EU's strategic goals towards European multimodal transport information, management and payment systems.

Within the context of a total digital interconnection, there are various concerns arising about Big Data and their security and people's personal rights. Full data acquisition of technology providers may for example lead to abuse of power and data. In this respect, measures on data protection need to focus on the development of mechanisms that prevent data misuse and guarantee the protection of personal rights despite complete data transparency.

Due to very fast pace of increased digitalisation and development towards smart cities, most measures seem to prioritise technology instead of social aspects with hitherto unknown effects on societies and traditional cityscapes. In the course of further digitalisation and digital networking between people and infrastructure, future policies must take into consideration social aspects when planning and developing smart cities. In particular, it is important to identify at an early stage what negative effects could arise on social communities such as privacy concerns or increased cost of leaving in order to counteract potential conflicts and social hotspots within cities. The increased cost of leaving is due to the fact that smart city infrastructure require huge investments. These investments might mean higher rate of taxes.

Develop a national policy framework for sustainable urban travel

The passing from traditional regulation(s) (for example economic regulation) to modern regulation (including social deregulatory initiatives including anti-social dumping practices, incentive-based sector revival, transfer pricing restrictions or quality assurance improvement) can play a role in the creation of a more sustainable mobility. For example, a clear legal and regulatory framework that provides guidelines for government measures and limitations for involvement of the private sector in public transport provision or financing is essential for the effective implementation of sustainable mobility. Already implemented in many countries, but still with room for improvement, is the application of actions that promote cycling, transport demand management tools, car /bike sharing schemes and flexible working schemes and these should be further supported. This can be achieved through the encouragement of employer mobility plans and corporate social responsibility incentives. Lastly, environmental effects such as greenhouse gas emissions and noise should be incorporated in the land-use and transport policy.

Improve data/Big Data collection and analysis

Big Data and analytics have evolved into an essential element of most fields in the economy. Over the past few years, there has been a surge in the interest of the use of Big Data in the field of transport. Many crucial elements in creating smart cities, implementing Mobility as a Service (MaaS) as well as promoting mobility innovations (such as Connected and Autonomous Vehicles), are based on the potential that Big Data possesses. As abundance of information becomes commonplace, the importance of Big Data becomes undoubtable. In the field of transport, Big Data has opened a wide spectrum of opportunities such as pedestrian flow dynamics, real-time traffic management and control, new ways of understanding and predicting travel behavioural (social media, text mining) for optimising transport operations etc. However, observing the emergent interest in the application of Big Data within transport, as well as the extended scope of its applications, it is evident most of the challenges have yet to be addressed. Legal and privacy barriers are still preventing the full exploitation of Big Data’s potential. Furthermore, data is not collected and collated in a consistent way among cities and collection methods are often subject to modification. National governments can take initiatives to harmonise data collection. It would be valuable to develop a consistent methodology at international level that can be used in all such inquiries. This should go hand in hand with a cohesive European wide directive on privacy and data protection act that would be inclusive of all data parameters.

7.3.4 Unemployment - achieving sustainable mobility in the era of economic crisis

All the stakeholders (industry-policy making-academia) agreed that financial recession is the trend that has the biggest impact on sustainable mobility. Financial recession affects unemployment, which also directs the choices of passengers to more economically efficient means, therefore, changing the directions of trends as it is connected to the disposable income of the users. Sustainable mobility, especially in the form of eco-innovations, can have positive long-term effects on the economy, which outweigh some potential short-term losses. Thus, with the right financial instruments in place, financial recession can be overcome and sustainable mobility can be achieved, as the experts declared during the ANP. Therefore, the role of policy-making is to get incentives right in order to overcome the short-term losses and reap the longer-term benefits.

Unemployment is one of the characteristics of the economic crisis, which impacts on mobility demand. Innovative financing and an efficient fiscal policy should be implemented to meet the unemployment challenge and achieve sustainable mobility. Fiscal policy and the objectives of sustainable mobility should be aligned. Harmonisation with other measures, macroeconomic, foreign trade and industrial, is also a necessity.

Investment is a success accelerator for overcoming unemployment and fostering sustainable mobility. For example, during the ANP at Megatrends level analysis, it was demonstrated that 'Infrastructure investment' is the most important Megatrend in achieving sustainable mobility. Europe on the Move policy package supports the investment of the TEN-T infrastructure. Alternative funding streams can enable the development of sustainable mobility and provide higher employment rates that would ensure the harmonisation of the transport system. One form of funding stream, very frequently used in transport infrastructure, as shown in the literature review, is Public-Private-Partnerships. For the successful implementation of PPPs, the following measures should be implemented: develop model contracts, share refinancing benefits, coherence and inclusive guidance from governments which includes specifics for procurement procedures, streamlined speed and cost of procurement, cohesive legislation and improved decision support tools. With regards to the policy agenda and strategic frameworks associated with regulations, a strong commitment to deregulation and increased private sector participation is needed (Estache et al., 2004). A reform path is required to achieve harmonised and efficient regulations that must be accompanied by a strong political commitment at the national as well as at the international level. History suggests that fine-tuning is often more difficult to implement than large reforms. If transport ministers are to endorse this emerging policy agenda, a new hybrid model of PPP will emerge with a significantly larger positive impact for users and operators alike as well as current and future taxpayers.

7. 3. 5 Pricing

An improved fiscal and pricing strategy is required. Under the low emission mobility strategy adopted in 2016 (Chapter 3.1), pricing measures are introduced especially in the field of the use of digital technologies and smart pricing. Externalities of transport depend on the number of variables such as kilometers driven, road type, and time of day, car type and driving behaviour (Rietveld, 2001). The present pricing system of car use and ownership in most European countries is that the degree of differentiation between the variables is small, except for the car type/model aspect. Variabilisation of taxes can give a solution to this problem. According to Rietveld (2001), 'variabilisation is a budgetary neutral shift of fixed to variable taxes'. That practically means that the total tax receipts remain continuous. When the demand for transport is inelastic, the application of this method is simple because the travel volume is stable. On the other hand, the leisure traveler is more flexible in choosing times for a day trip (i.e. in off peak periods), so leisure travel is demand elastic. The factors that affect transport demand elasticity relate to demographics, economic activity (e.g. commercial), the availability of transport options, geography/land use, and prices (e.g. parking, vehicle use costs, public transport etc.) (Litman, 2018). Elasticities need to be taken into consideration when applying pricing policies. For example, a flat per kilometer fee might affect social trips and a shift towards non-motorised modes. A peak time fee, will affect shifts in time and mode of commute or even boost remote working.

Setting a pricing policy that corresponds to the economic challenges but is also socially equitable is necessary. The European wide GALILEO programme already provides the communications technology backbone of such transport pricing applications. With regards to the pricing structure, there is a need to creating a framework for the monetary valuation of social costs. According to Ricci (2013), recent research identifies SRMC (short run marginal cost) pricing as the most suitable and efficient reference for setting and adopting charging levels. The EC, back in 1998 (p 10), defined marginal costs as 'those variable costs that reflect the cost of an additional vehicle or transport unit using the infrastructure. Strictly speaking, they can vary every minute, with different transport users, at different times, in different conditions and in different places'. Although the SRMC pricing has gained support since back in the 1990s, schemes should be aligned with other policy measures to ensure sustainability of the mobility (Ricci, 2013). These include synergy with parking measures, cross subsidisation: avoid identical pricing schemes for all types of trips (ie urban and rural), regulations where it has been proven that pricing has little effect on the reduction of traffic (for example, charging for the marginal cost of noise) and keeping the prices of urban public transportation affordable. The pricing schemes that can be used are:

- Carbon prices.
- Reform of fossil-fuel subsidies.
- Congestion charges and other road user charges.
- Parking prices.

For the effective implementation of the schemes, the policy mix needs to encompass:

- Land use planning (e.g. dedicated bus lanes).
- Development of standards (e.g. fuel economy standards).
- Development of technology-based standards (e.g. for electric vehicle charging infrastructure).
- Public procurement programmes (e.g. to support electric vehicle charging infrastructure with PPPs).

7.4 Contribution of the research

As indicated in the literature review (Chapter 2.3) a number of studies have investigated the Megatrends that affect transport on the European scale. The table below presents the common Megatrends that were identified by the research projects (Table 7.2):

Projects	Common trends identified across the projects	Trends identified in this research
OPTIMISM 2013 FUTRE 2014 ERRAC 2014 CIPTEC 2015 Mobility4EU 2016 WaterbornTP 2016 INTEND 2018	Urbanisation Globalisation Ageing of population Lifestyle changes Sustainable mobility measures Energy production and demand	Unemployment Sustainable development Charges Taxation Pricing

Table 7.2: Megatrends identified in EU projects

Source: Author

These Megatrends were also identified as being important during the Delphi study. However, only INTEND conducted impact analysis while the rest of the project focused on just identification of Megatrends. The validation of the Megatrends was primarily done during brainstorming sessions and workshops. Also, the focus of the Megatrends was on transport in general.

So this research contributed overall to the following aspects:

Megatrends with a focus on sustainable mobility

The final list of Megatrends identified in this research, after the impact and sensitivity analysis, varies significantly from the ones identified by the projects above as the focus was different. It was narrowed down to the ones that affect the achievement of sustainable mobility. It can be observed that the experts denoted that Megatrends related to monetary issues need to be considered the most when drafting developing policy directions that would support the successful application of sustainable mobility.

Combination of two foresight methodological approaches

The majority of the studies on Megatrends relied on literature review and workshops/brainstorming sessions for the validation. This research has used a systematic approach combining two foresight methods, Delphi and ANP. ANP is used for the first time in the transport foresight field. Although it did provide reliability of results due to the structured and heavy involvement of experts, at the same time it proved to be very challenging for the self-same reason. The questionnaires were lengthy, complicated and required considerable thought and effort. The experts reported that it took them from an hour to ninety minutes to complete. Therefore, this method can only be recommended to researchers who have a good network of expert contacts already in place who are willing to give the time to complete the questionnaires.

Interdependency of Megatrends

During the scenario development process, the experts indicated that in order to achieve sustainable mobility the key Megatrends need to be treated as a group of trends that impact on each other and, therefore, changes need to be done in a holistic way including adjustments on all important trends. The ANP analysis also confirmed this. So far, it has been the only study in the area of Megatrends that has looked upon this factor of connection of trends which in practice implies that policy development needs to consider all the five trends and when a change is implemented in one of them, then the policies related to the rest, need to be adjusted too.

7.5 Summary and conclusions of the chapter

This chapter provided the answers to the research questions. This research has contributed in the identification of new key Megatrends connected with sustainable mobility that were not found before in other studies as of major importance. The interdependency of Megatrends was also explored as the relation of Megatrends impacts the policy mix.

In policy terms, the main directions that are put forward in this chapter aim at addressing the Megatrends identified both at individual micro-level, but also some suggestions have been given at creating a macro-environment that will foster sustainable mobility application. The micro –level policies include charging schemes such as road tolls and zonal schemes, taxation which should focus on polluter pays principle but also taxes should target at changing the users' behaviour and therefore should be applied on a broader scope and not only for transportation. Some areas that are worth attention when drawing sustainable development policies are the development of smart cities, sustainable urban travel and a better exploitation of Big Data applications. Unemployment which was also one of the Megatrends identified in Chapter 6, should be addressed in order to achieve sustainable mobility. This can be done through investment schemes especially in the area of infrastructure. The expansion of the Public-Private-Partnerships can also support in achieving this goal. Lastly, pricing schemes can mainly include carbon prices, reform of fossil-fuel subsidies, parking prices and road user charges.

The macro-environmental policies, that need to be put in place, include:

- Involvement of users in policy making.
- Harmonisation of policies across the European countries.
- Emphasis on Research and Development activities.
- Economic policy.

Lastly, strategies have been suggested in terms of charges and taxation that relate to the polluter pays principle. Sustainable development strategies that receive public acceptance and require multi-stakeholder involvement are also crucial. With regards to the pricing schemes, there is a great amount of measures but key to their successful implementation is the adoption of the short run marginal cost theory.

CHAPTER 8

CONCLUSIONS

Introduction

Chapter 8 aims to draw conclusions on the research conducted, the methodologies used and the results delivered. The chapter also provides limitations of the research and suggested areas of future work.

8.1 Concluding remarks

The starting point of this research was the importance of sustainable mobility as recognised by the European Commission, but also previous research projects implemented by the researcher. Megatrends are acknowledged as key to the development of policies for sustainable mobility as they determine transport demand and supply in the long run.

The research path followed is demonstrated in Figure 8. 1:

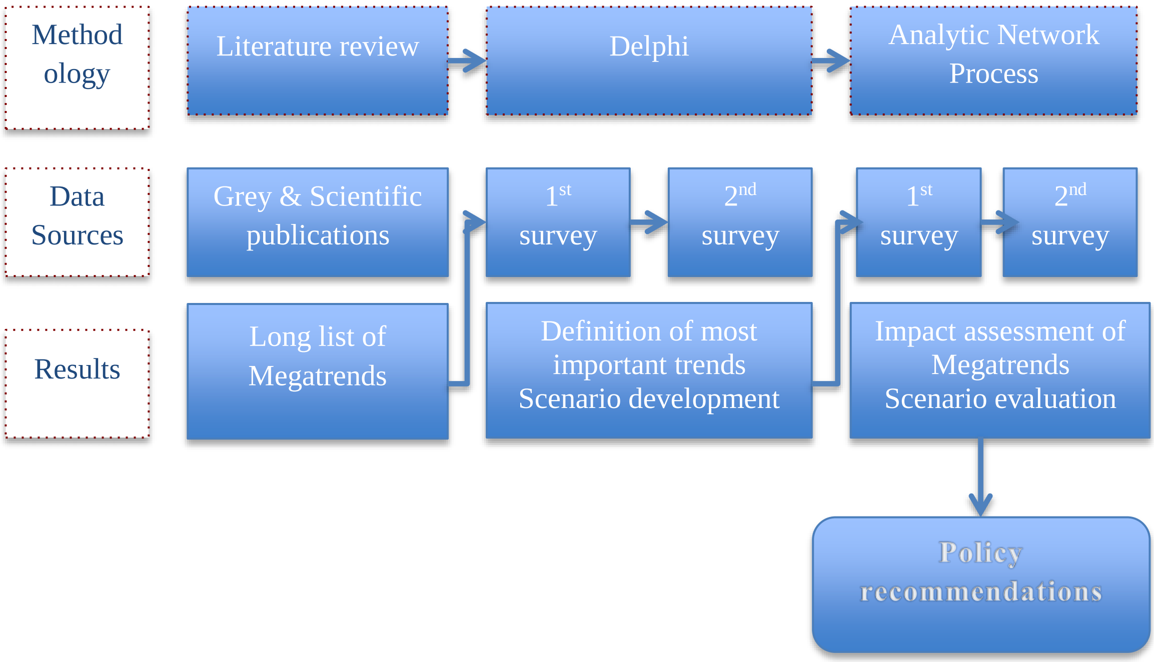

Figure 8. 1: Research path

Source: Author

An intermediate step had to be introduced before the Analytic Network Process in order to identify the most prominent Megatrends that would be further tested using the ANP model. The Delphi method was used to identify the twelve most prominent trends on which the research focused. These were assessed based on their impact on sustainable mobility.

The main conclusions of the research include:

- There is no single recipe of policy directions that fits all countries. Directions should be provided by the EC at European Level and local governments should parameterise the policies to fit with local needs, but always respecting the European generic rules on fairness and transparency.
- The visions of the different groups of experts are similar. This presents a big opportunity for applying policies that would be accepted by the main stakeholders and, therefore, increases their chances of success.
- Policies need to be introduced and further enhanced for the trends that appear to be most influential in achieving sustainable mobility: charges, taxation, pricing, sustainable development, unemployment and development of large metropolitan cities.
- It is of critical importance to align policies with Megatrends to achieve sustainable mobility. Also, Megatrends impact on each other and, therefore, when a change is implemented on one, the policies for the rest need to be redesigned, as the impact will affect the whole 'chain' of trends and, therefore, policies.
- Apart from the individual policies that correspond to the specific Megatrends identified in this research, the literature review has also revealed that the macro-environment should also be congruous with the sustainable mobility objective. Figure 8. 2 shows the marco-enviromental elements:

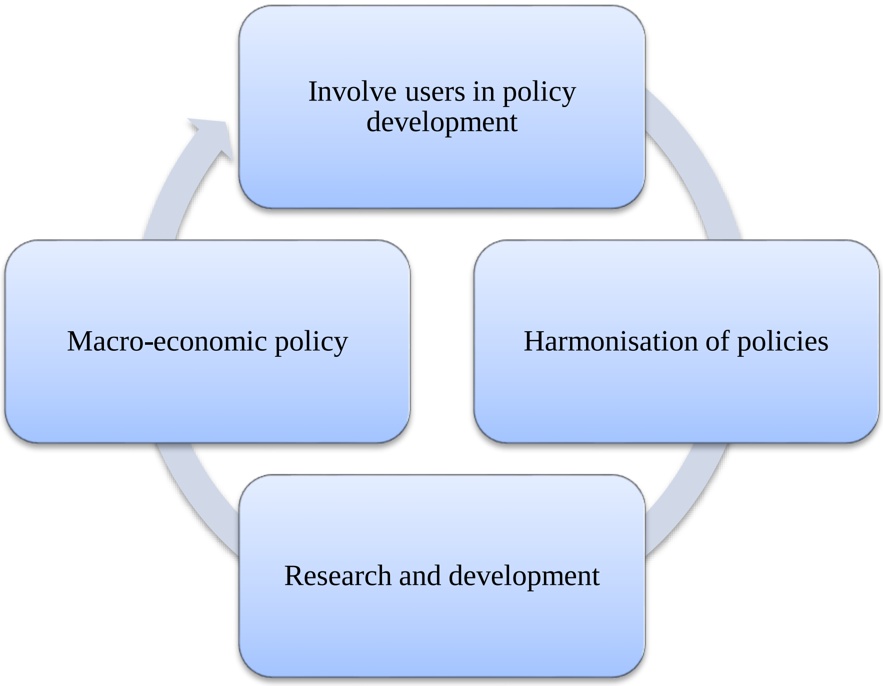

Figure 8. 2: Macro-environmental policies

Source: Author

- Sustainable development policies should be at the heart of the policies mixture, as this will drive sustainable mobility too. So, it is important to incorporate sustainability considerations into policy development.
- According to the findings, the policy mixture that should be applied is presented at Figure 8.3. The first column shows the directions that should be followed. The second column focuses on the specific areas of concern and the tools that can be used and the third column shows the type of measure.

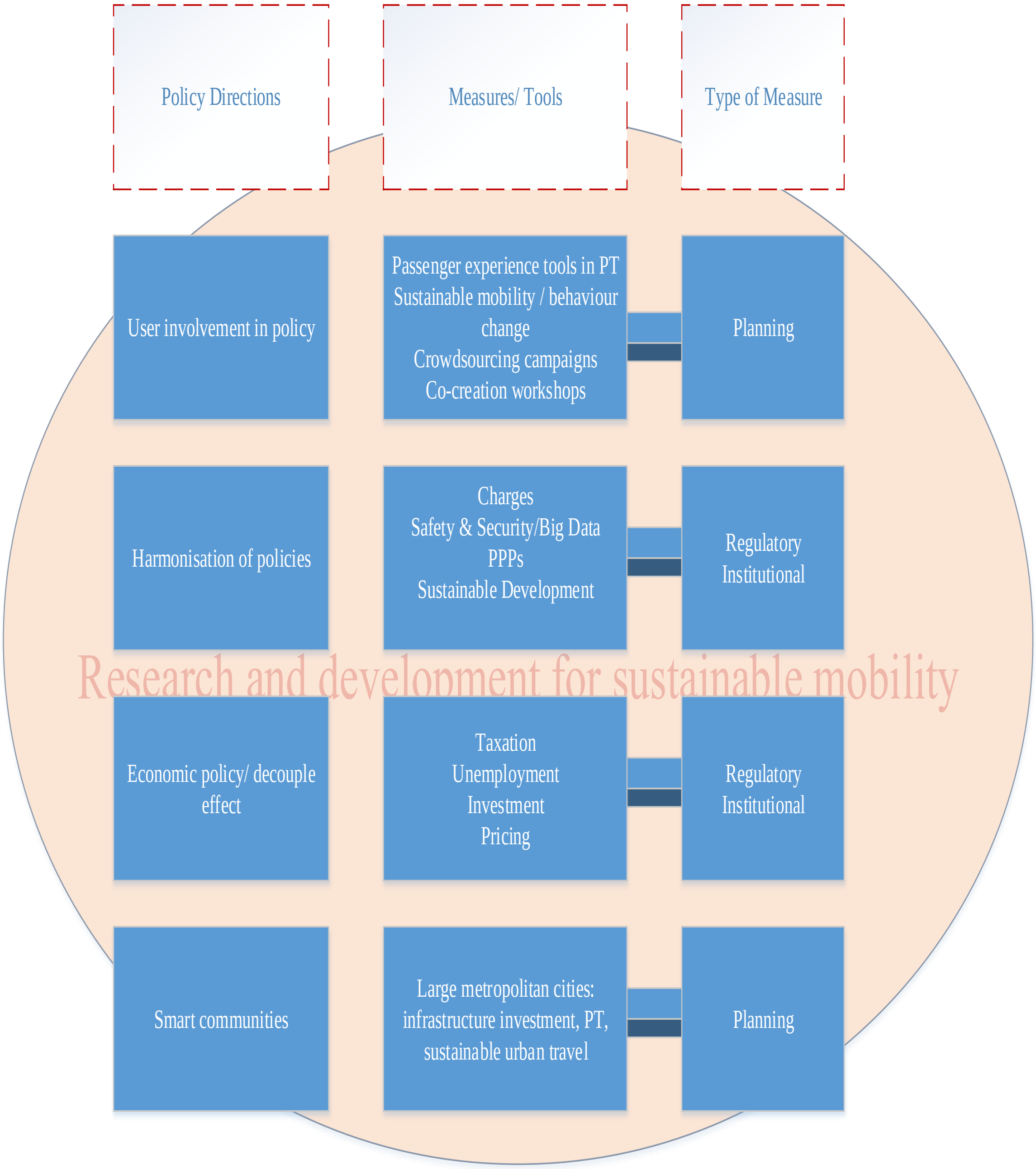

Figure 8.3: Summary of suggested policy directions

Source: Author

8.2 Limitations of the research

The limitations of the research are likely to impact on the quality of the findings and the capacity to successfully answer the research questions. The main limitations relate to:

- The chosen research methods (ANP and Delphi).
- Ability to recommendations for policy directions/interpretation of results.
- The nature of foresight science itself.

8.2.1 Research methodologies applied

Two methodologies have been used in this research, the Delphi and the Analytic Network Process. In both, the sample used was based on the involvement of the researchers in previous research projects, and also a search in CORDIS to identify coordinators and participants of similar research projects. The data collection mechanism applied, implies the following possible limitations:

- The size of the sample was limited. However, the research aimed at extracting expert views and not of the whole population.
- Sample breadth and users. This limitation could have been avoided if the users were also involved in the process. So, to broaden the scope of the questionnaires and involve users in the Delphi and ANP process. The extent of the impact of this limitation though was narrowed by the fact that user groups/networks were invited to participate. So the users' voice was integrated, but not to a great extent.
- Although the ANP process allowed conclusions to be drawn on the impacts and interactions of the Megatrends, at the same time it imposed a limitation in terms of the design of the scenarios. This relates to the complexity of the ANP questionnaires. The experts suggested limiting the scenarios to three because by adding one (or more) scenarios, the complexity of the questionnaires would have been greater and, therefore, the recruitment of participants would have been very difficult and response rates among those who did agree to participate in principle would be lower in practice. The relationship between the number of scenarios and questionnaire complexity is not linear, but exponential.

- The first Delphi questionnaire, which was used to combine the predominant trends into a smaller group, which could usefully be modelled by ANP, was based on the results of the literature review. However, despite the thoroughness of the searches undertaken, there might still be Megatrends that were not identified and, therefore, did not contribute to the research. To reduce the impact of this potential limitation, an open question was added to the first Delphi questionnaire asking the experts to indicate whether there were any trends not found in the questionnaire.
- The data collection process was done predominantly online. Although this offered the advantage of ensuring anonymity of the responders and allowed the researcher to reach a geographically spread sample, it at the same time imposed some important constraints. These relate to the difficulties participants may have encountered in understanding and interpreting survey questions, especially those in the ANP, some questions were complicated and the questionnaires were long. To minimise the impact, some explanations were given to potential participants over the phone, however, it is possible that some responders might have given unintended answers.
- The probability of occurrence of each of the scenarios was not measured. Experts indicated which scenario is more likely to achieve sustainable mobility, however, they were not asked to determine the degree of uncertainty.

8.2.2 The nature of foresight science

The two foresight methods used in this thesis are Megatrends analysis and scenario building. Foresight, by its nature, is a participative method which aims to generate visions and is driven by the participants' understanding of socio-economic and technological developments. In this thesis, during the Delphi and the ANP phases, an active involvement of the experts was encouraged which, however, introduces some limitations:

Lack of piloting

Although the experts did express their opinions, the foresight did not go beyond that; meaning that the piloting of new policy options is not part of the process and, therefore, foresight constitutes only one step in the policy development chain. The recommendations provided in terms of policy directions and instruments need to be adopted in the national and regional environments and further tested.

Dependency on judgments

As the method used relied on the experts' judgements, there is a degree of uncertainty of the results. Some of the experts might have overlooked (weak) signals and, therefore, their knowledge and judgements could have been affected. Similarly, different groups of experts, drawn from a single panel, were used at different stages of the data collection; using the same group of experts throughout may have generated different results. To minimise the impact of this limitation, the choice of experts was based on their experience. Also, experts from all European countries were invited to participate. A total of 21 countries were finally represented.

Speed of change

With some of the Megatrends and emerging changes, it might not be possible to predict them on time. Expert views were based on opinions held at the time of the research. These opinions can change with time and, therefore, input data will change too. Also, if unexpected events happen (wild cards) then the outcome will be different too. When the speed of change is fast then the scenarios might be considered as wrong or in need of redesign after a short period of time.

8.2.3 Drawing recommendations for policy directions/interpretation of results

The policy directions given are for Europe as an entity. The suggestions provided are for general directions and not for micro-decisions on specific directions. These should be taken on national government level. For example, a fair and transparent framework for transport policy should be adopted at European level; however, the specific tools to implement the policy can be decided on national level. This requires a greater understanding and analysis of the conditions and objectives of each country than is presented here.

Furthermore, the spectrum of current policies with regards to the top ranked Megatrends has not been elaborated. A thorough study of policies and instruments for implementation against the identified Megatrends would have been beneficial for identifying the gaps. This would have enabled suggestions on the improvement of existing policies the introduction of new ones.

Lastly, enforcing policy directions at the EU level, the EC might be a relatively straightforward process. However, adoption of policies at national level and, to some extent, parameterisation of the policies can be a long process with practical obstacles. For example, by the time a country has gone through the process of regulating for a particular policy (which might take many years), the Megatrends might start moving towards a different direction and, therefore, the particular policy might not be the most effective tool any more.

8.3 Areas of future work

The areas of future work concern three main pillars of activities:

- Gap analysis.
- Identification of priorities on country level.
- Piloting of policies.
- Freight transport.

8.3.1 Gap analysis

The research has led to identification and definition of priorities for policy directions. Further investigation of existing policies in the light of the arguments of this thesis could be very beneficial. Based on identified Megatrends, the current state of the art and policy imperatives, a gap analysis can be carried out to detect the gaps between the future challenges imposed by the Megatrends and the existing transport policies. This will allow the identification of existing policy gaps both in terms of introducing completely new policies or the improvement of the existing ones.

The gap analysis can be performed on two levels. The first includes on a European level and the second a (micro) country level.

With regards to the European level gap analysis the process will include an analysis of the European Commission imperatives that concern the enforcement of sustainable mobility on the countries. The political imperatives can be identified with literature review will be compared with the main Megatrends identified in this research. The gaps will represent areas where have been identified as key in the application of sustainable mobility (such as the taxation) and have not been thorough addressed by the policy.

On a country level, the analysis can be performed by using a text mining tool. Again the next step will be to compare the results of the key policies in place with the results of the research. A matrix of key Megatrends against policies can be developed which will reveal the underrepresented areas (policy gaps)

8.3.2 Priorities at country or territorial level

Although suggestions have been made for policy directions at European level, each of the policies will need to be further adjusted to the needs of the national or regional governments. For example, some countries might be in a more urgent need of applying measures for sustainable development while other might have already put sustainability at the centre of their policy framework. Each of the suggested policy directions can be elaborated further and specific measures and tools extrapolated. The creation of a 'tool-box', which can serve as a set of checklists enabling the classification of regions/countries by their sustainable mobility capacity, should be developed.

8.3.2 Piloting of policies

A thorough investigation into the policies that relate to the five top ranked priorities can bring very useful findings. This can be done, for example, by identifying and analysing case studies of practices that have been applied in certain countries/regions. The lessons learnt can be extracted and good practices suggested based on the transferability of each practice. This will involve the introduction of certain criteria that can be applied in order to classify a practice as good.

Another dimension is the testing of policies in specific environments. According to HM Government (2014), foresight thinking can include testing and implementing (Figure 8.4) so, instead of just adopting policies that have worked in other countries and in order to minimize the risk of failure, simulation tools can be used to test the policies. Agent based tools can be one possible route to modeling the reaction of specific users to the introduction of policies. In an Agent Based Model (ABM), a system's dynamic behaviour is represented through rules governing the actions of a number of autonomous agents. For example, the EC funded project FUPOL (http://www.fupol.eu/en), developed a library of causal models to 'allow citizens testing the benefits and shortages of different proposed urban policies and check new policies according to their own beliefs' (Piera, Miquel Angel, et al., 2013, p403).

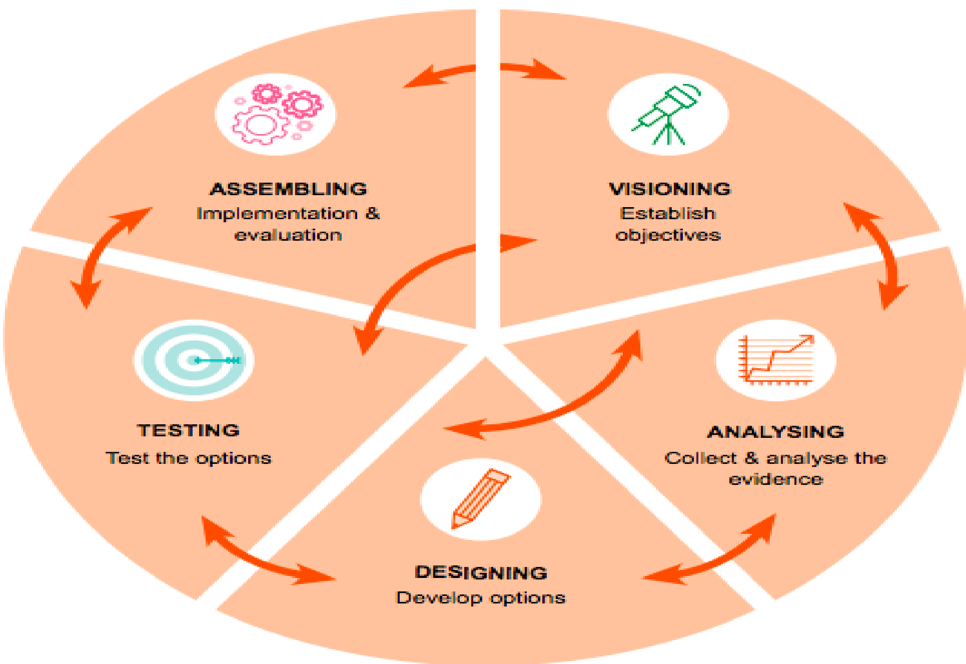

Figure 8.4: Foresight thinking

Source: Adapted from HM Government (2014) Futures Toolkit. Available at: https://www.gov.uk/government/publications/ futures-toolkit-for-policy-makers-and-analysts

8.3.3 Freight

This research focused on passenger mobility. However, the impact of Megatrends on sustainable freight transportation might be different. Also, the policies concerning freight are different to the ones of passenger mobility. To deliver a holistic sustainable mobility policy approach, it will be beneficial to also conduct a similar research on Megatrends and suitable policies in the field of freight too.

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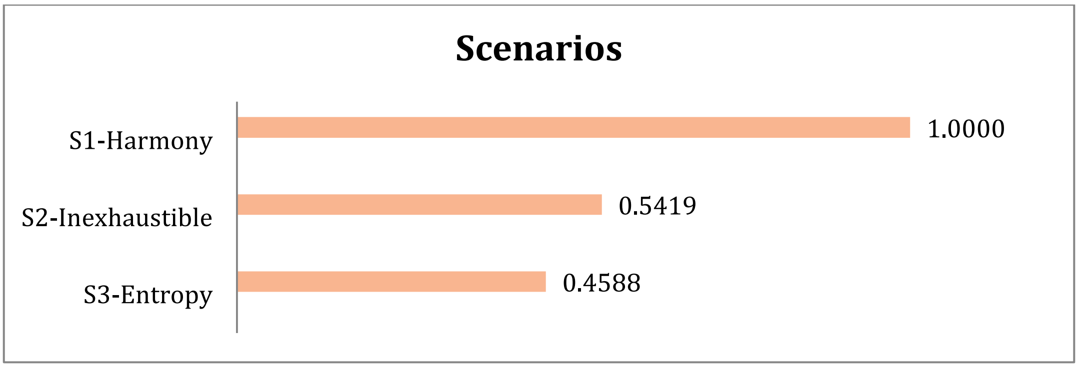
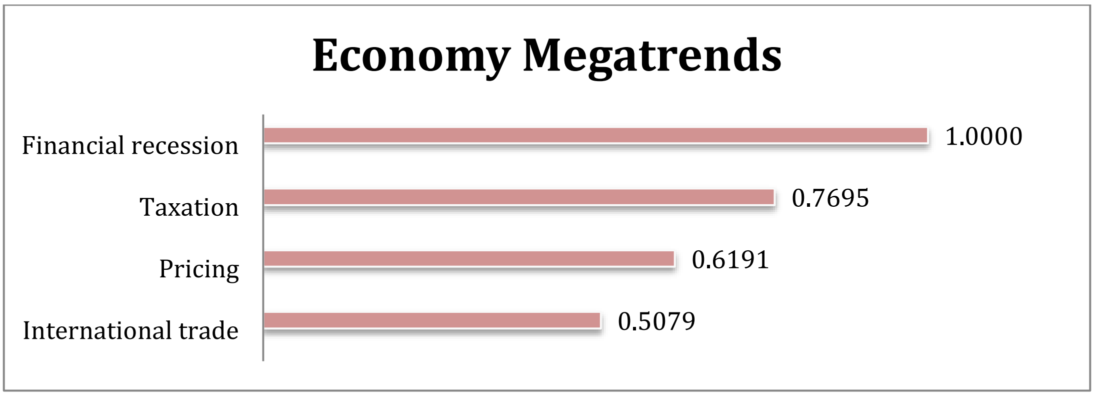
ANNEX A- SENSITIVITY ANALYSIS

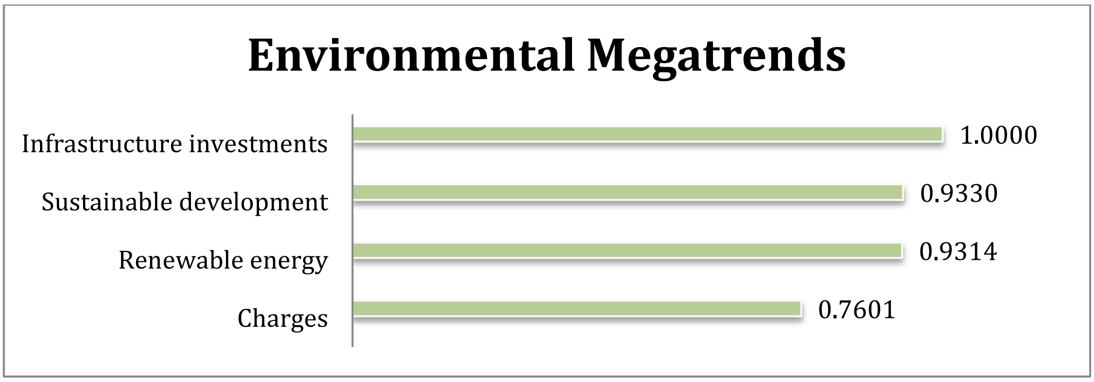
A.1 Node Analysis

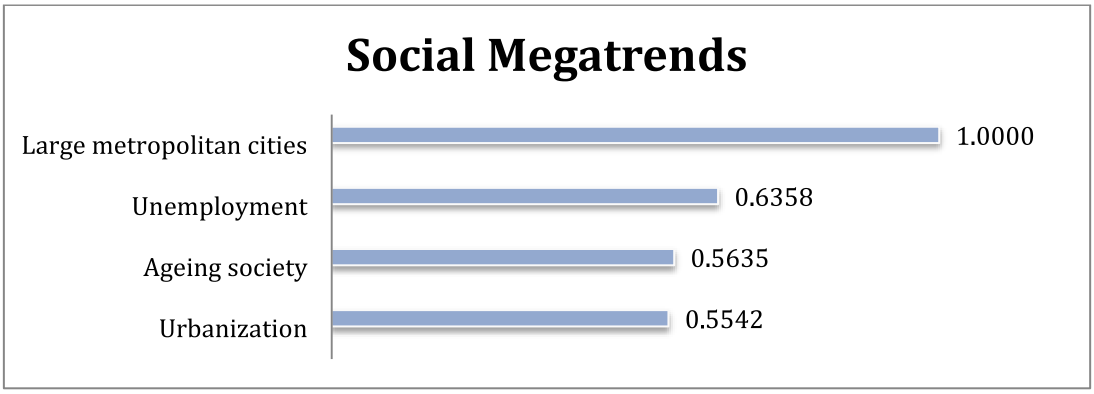
Aggregation node analysis

Aggregation	Priority for nodes			
Elements	Ranking	Ideals	Normalized By Cluster	Score
Scenarios				
S1-Harmony	1	1.0000	0.4998	0.0400
S2-Inexhaustible	2	0.5419	0.2709	0.0217
S3-Entropy	3	0.4588	0.2293	0.0184
Economy Megatrends				
Financial recession	1	1.0000	0.3453	0.1079
Taxation	2	0.7695	0.2657	0.0831
Pricing	3	0.6191	0.2138	0.0668
International trade	4	0.5079	0.1754	0.0548
Environment Megatrends				
Infrastructure investments	1	1.0000	0.2759	0.1107
Sustainable development	2	0.9330	0.2574	0.1033
Renewable energy	3	0.9314	0.2570	0.1031
Charges	4	0.7601	0.2097	0.0841
Social Megatrends				
Large metropolitan cities	1	1.0000	0.3632	0.0748
Unemployment	2	0.6358	0.2309	0.0476
Ageing society	3	0.5635	0.2046	0.0422
Urbanization	4	0.5542	0.2013	0.0415



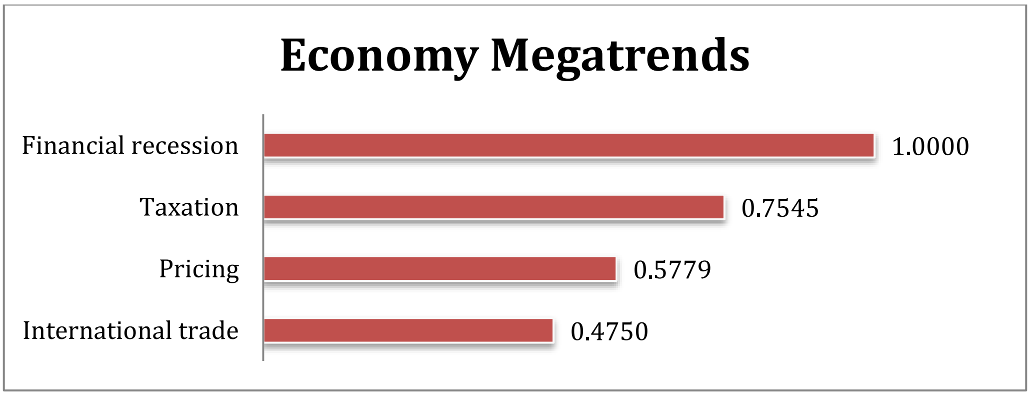

Economy Megatrends
Financial recession
Taxation
Pricing
International trade
1.0000
0.7695
0.6191
0.5079

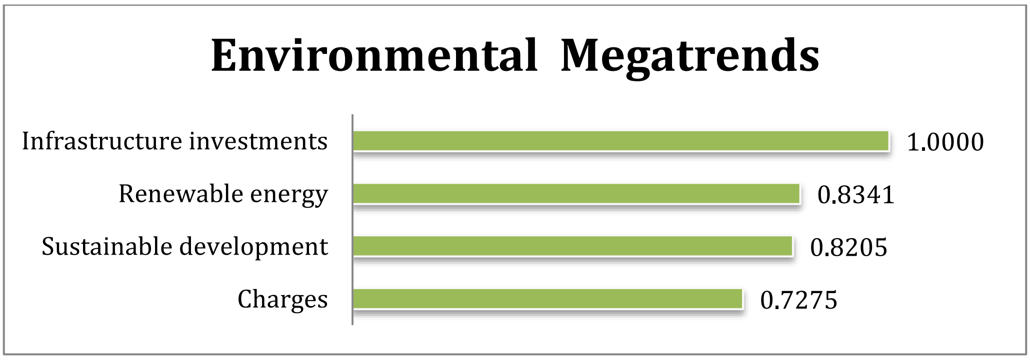

Environmental Megatrends
Infrastructure investments
Sustainable development
Renewable energy
Charges
1.0000
0.9330
0.9314
0.7601

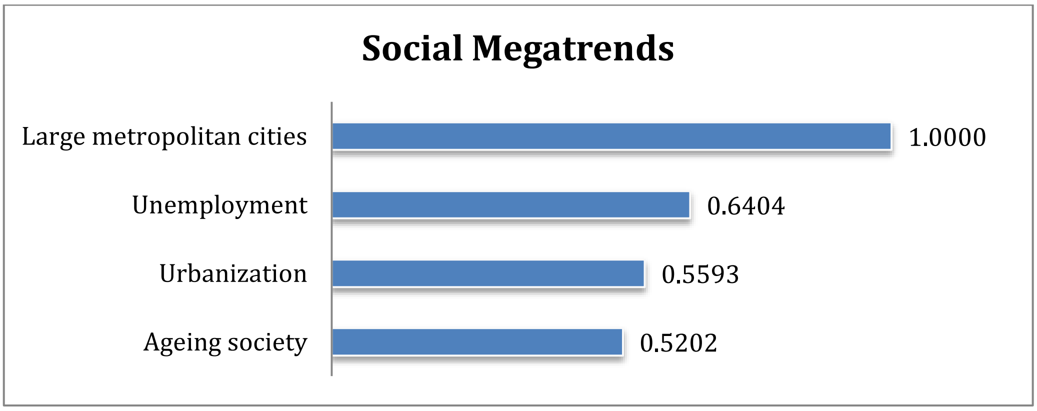

Social Megatrends
Large metropolitan cities
Unemployment
Ageing society
Urbanization
1.0000
0.6358
0.5635
0.5542

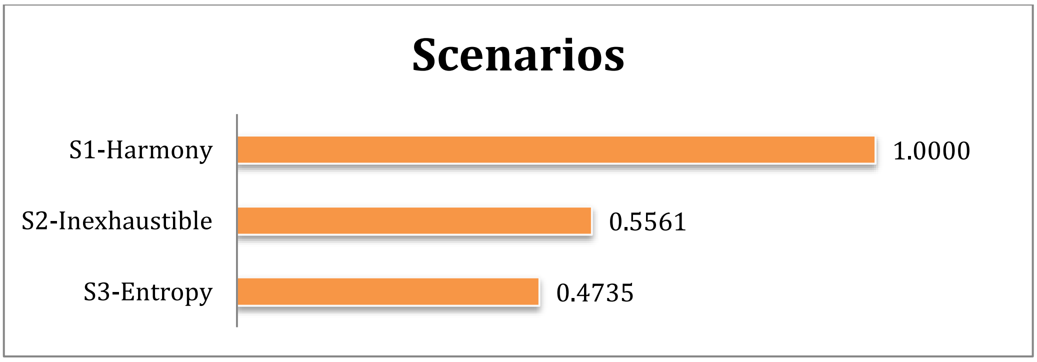
Node analysis policy makers

Policy makers	Priority for nodes			
Elements	Ranking	Ideals	Normalized By Cluster	Score
Scenarios				
S1-Harmony	1	1.0000	0.4927	0.0407
S2-Inexhaustible	2	0.5561	0.2740	0.0226
S3-Entropy	3	0.4735	0.2333	0.0193
Economy Megatrends				
Financial recession	1	1.0000	0.3562	0.1064
Taxation	2	0.7545	0.2687	0.0803
Pricing	3	0.5779	0.2059	0.0615
International trade	4	0.4750	0.1692	0.0506
Environment Megatrends				
Infrastructure investments	1	1.0000	0.2957	0.1039
Sustainable development	3	0.8205	0.2426	0.0853
Renewable energy	2	0.8341	0.2466	0.0867
Charges	4	0.7275	0.2151	0.0756
Social Megatrends				
Large metropolitan cities	1	1.0000	0.3677	0.0982
Unemployment	2	0.6404	0.2355	0.0629
Ageing society	4	0.5202	0.1913	0.0511
Urbanization	3	0.5593	0.2056	0.0549



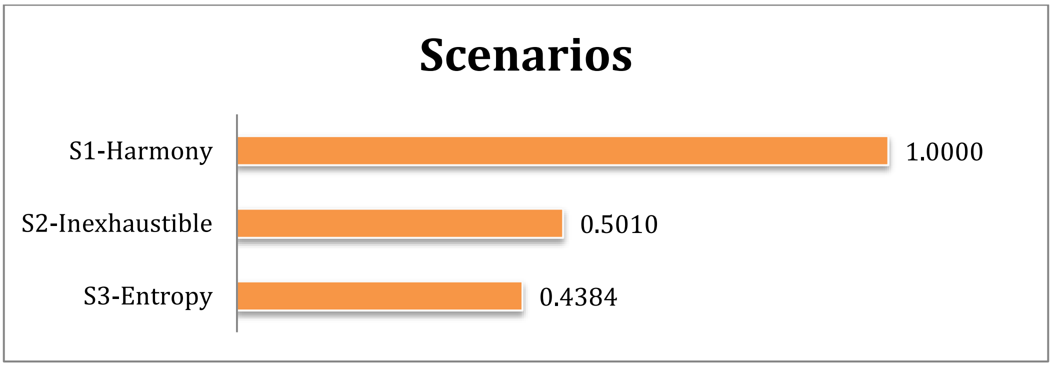


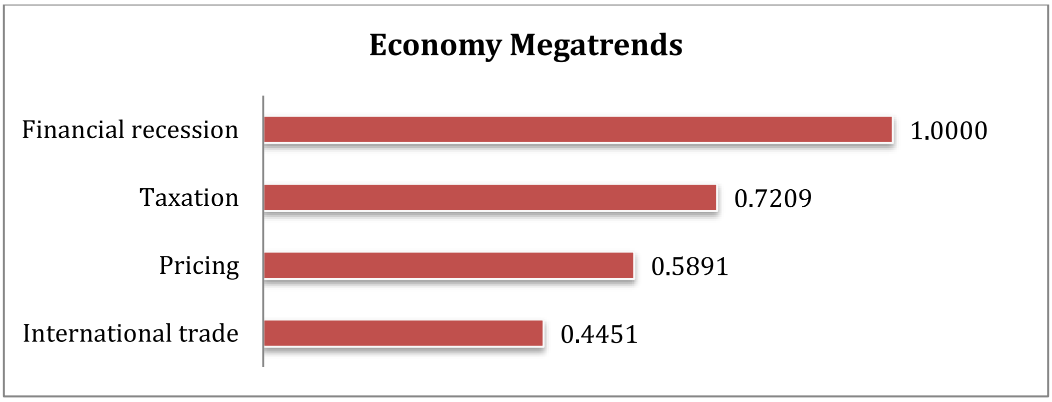


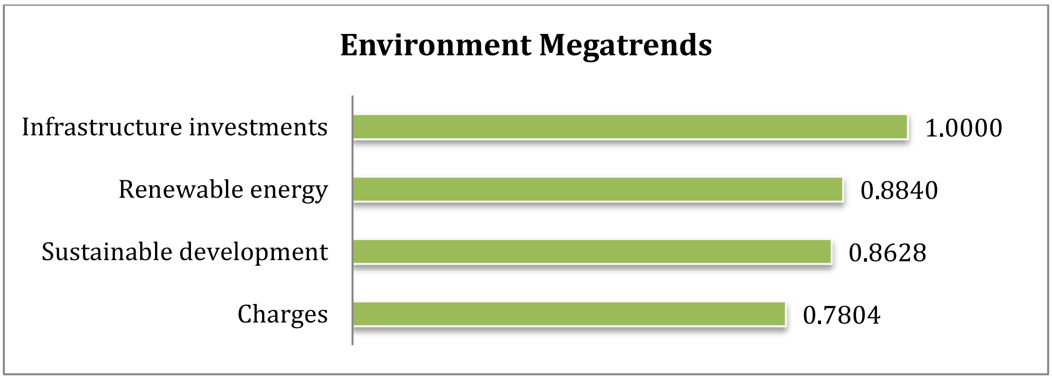


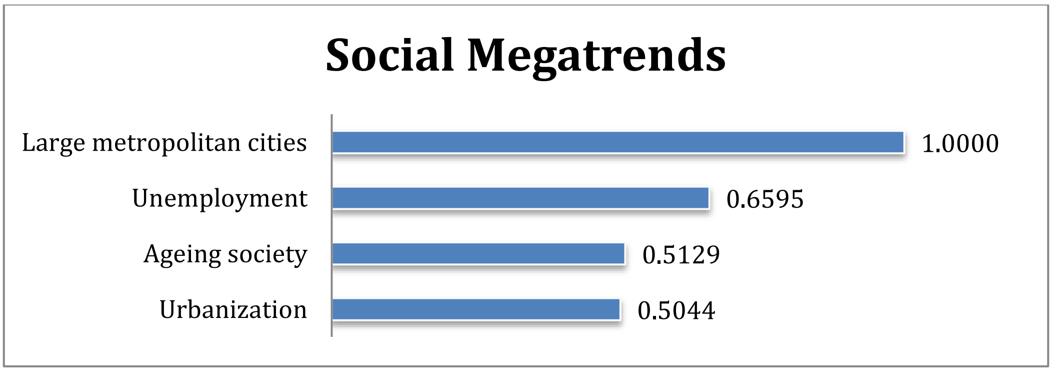
Node analysis for industry

Industry	Priority for nodes			
Elements	Ranking	Ideals	Normalized By Cluster	Score
Scenarios				
S1-Harmony	1	1.0000	0.5156	0.0425
S2-Inexhaustible	2	0.5010	0.2583	0.0213
S3-Entropy	3	0.4384	0.2260	0.0187
Economy Megatrends				
Financial recession	1	1.0000	0.3630	0.1085
Taxation	2	0.7209	0.2617	0.0782
Pricing	3	0.5891	0.2138	0.0639
International trade	4	0.4451	0.1616	0.0483
Environment Megatrends				
Infrastructure investments	1	1.0000	0.2835	0.0997
Sustainable development	3	0.8628	0.2446	0.0860
Renewable energy	2	0.8840	0.2506	0.0881
Charges	4	0.7804	0.2213	0.0778
Social Megatrends				
Large metropolitan cities	1	1.0000	0.3736	0.0998
Unemployment	2	0.6595	0.2464	0.0658
Ageing society	3	0.5129	0.1916	0.0512
Urbanization	4	0.5044	0.1884	0.0503


Scenarios
S1-Harmony
1.0000
S2-Inexhaustible
0.5010
S3-Entropy
0.4384

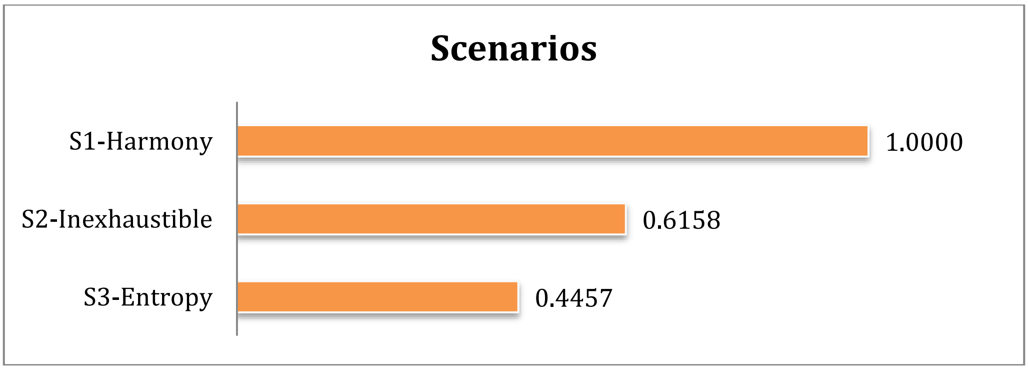

Economy Megatrends
Financial recession
1.0000
Taxation
0.7209
Pricing
0.5891
International trade
0.4451

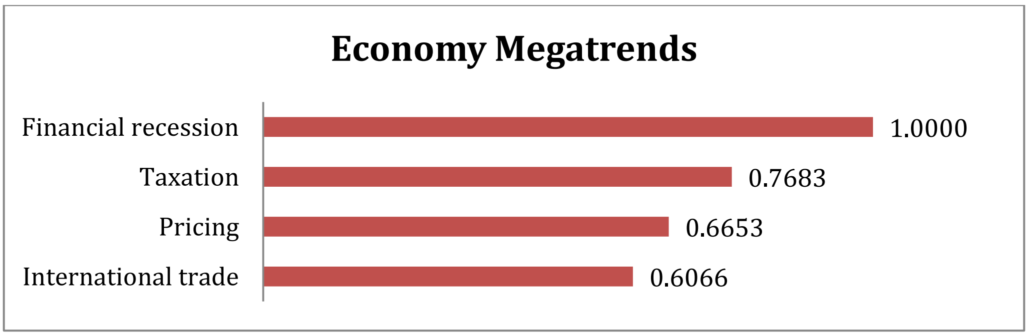

Environment Megatrends
Infrastructure investments
1.0000
Renewable energy
0.8840
Sustainable development
0.8628
Charges
0.7804

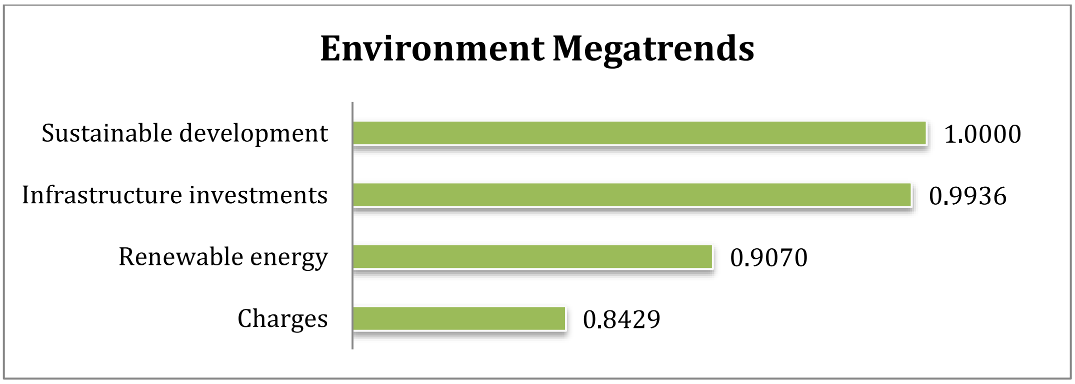

Social Megatrends
Large metropolitan cities
1.0000
Unemployment
0.6595
Ageing society
0.5129
Urbanization
0.5044

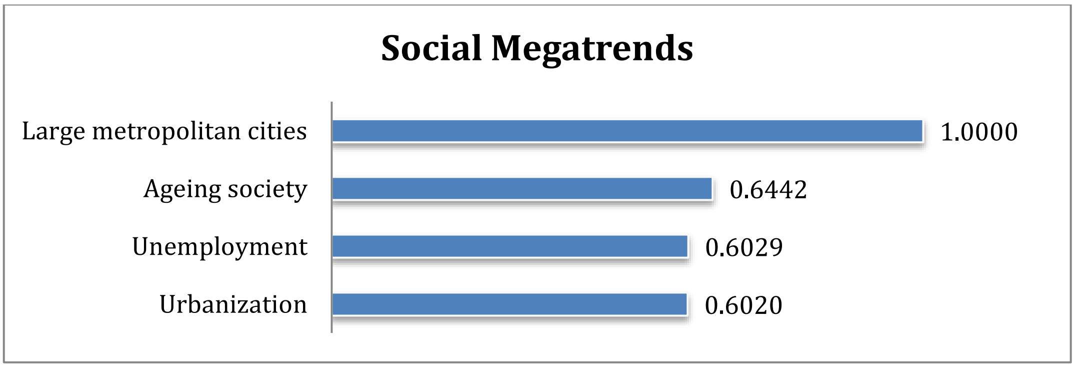
Node analysis for academics

Academia	Priority for nodes			
Elements	Ranking	Ideals	Normalized By Cluster	Score
Scenarios				
S1-Harmony	1	1.0000	0.4851	0.0381
S2-Inexhaustible	2	0.6158	0.2987	0.0235
S3-Entropy	3	0.4457	0.2162	0.0170
Economy Megatrends				
Financial recession	1	1.0000	0.3289	0.1001
Taxation	2	0.7683	0.2527	0.0769
Pricing	3	0.6653	0.2188	0.0666
International trade	4	0.6066	0.1995	0.0607
Environment Megatrends				
Infrastructure investments	2	0.9936	0.2654	0.0937
Sustainable development	1	1.0000	0.2671	0.0943
Renewable energy	3	0.9070	0.2423	0.0855
Charges	4	0.8429	0.2252	0.0795
Social Megatrends				
Large metropolitan cities	1	1.0000	0.3510	0.0927
Unemployment	3	0.6029	0.2116	0.0559
Ageing society	2	0.6442	0.2261	0.0597
Urbanization	4	0.6020	0.2113	0.0558






Environment Megatrends
Sustainable development
Infrastructure investments
Renewable energy
Charges
1.0000
0.9936
0.9070
0.8429


Social Megatrends
Large metropolitan cities
Ageing society
Unemployment
Urbanization
1.0000
0.6442
0.6029
0.6020

A. 2 Influence analysis

AGGREGATION

Megatrends	Parameter	Distance	S1-Harmon	S2-Inexhau	S3-Entropy	Ranking S1-	Ranking S2-	Ranking S3-
Original Values	0.5	0.0000	0.4998	0.2709	0.2293	1	2	3
Financial recession:upper	0.9	0.1569	0.5626	0.2441	0.1933	1	2	3
International trade:upper	0.9	0.1972	0.4459	0.3243	0.2299	1	2	3
Pricing:upper	0.9	0.3843	0.3767	0.3058	0.3175	1	3	2
Taxation:upper	0.9	0.4863	0.3400	0.3192	0.3408	2	3	1
Charges:upper	0.9	0.4195	0.3864	0.2881	0.3255	1	3	2
Infrastructure investments:upper	0.9	0.1622	0.5300	0.2778	0.1921	1	2	3
Renewable energy:upper	0.9	0.3129	0.6041	0.2383	0.1576	1	2	3
Sustainable development:upper	0.9	0.4431	0.6553	0.2169	0.1277	1	2	3
Ageing society:upper	0.9	0.2265	0.5678	0.2548	0.1774	1	2	3
Large metropolitan cities:upper	0.9	0.3101	0.5992	0.2426	0.1582	1	2	3
Unemployment:upper	0.9	0.6575	0.3295	0.2904	0.3801	2	3	1
Urbanization:upper	0.9	0.0629	0.5076	0.2775	0.2149	1	2	3
Financial recession:lower	0.1	0.0230	0.4905	0.2749	0.2346	1	2	3
International trade:lower	0.1	0.0156	0.5047	0.2666	0.2287	1	2	3
Pricing:lower	0.1	0.0377	0.5115	0.2678	0.2207	1	2	3
Taxation:lower	0.1	0.0600	0.5194	0.2651	0.2156	1	2	3
Charges:lower	0.1	0.0191	0.5042	0.2709	0.2250	1	2	3
Infrastructure investments:lower	0.1	0.0401	0.4899	0.2716	0.2385	1	2	3
Renewable energy:lower	0.1	0.0289	0.4903	0.2738	0.2360	1	2	3
Sustainable development:lower	0.1	0.0516	0.4814	0.2775	0.2411	1	2	3
Ageing society:lower	0.1	0.0022	0.4994	0.2708	0.2298	1	2	3
Large metropolitan cities:lower	0.1	0.0162	0.4948	0.2722	0.2331	1	2	3
Unemployment:lower	0.1	0.0358	0.5092	0.2697	0.2211	1	2	3
Urbanization:lower	0.1	0.0028	0.5008	0.2701	0.2291	1	2	3

INDUSTRY

Megatrends	Parameter	Distance	S1-Harmon	S2-Inexhau	S3-Entropy	Ranking S1	Ranking S2	Ranking S3
Original Values	0.5	0.0000	0.5156	0.2583	0.2260	1	2	3
Financial recession:upper	0.9	0.2518	0.6024	0.2284	0.1691	1	2	3
International trade:upper	0.9	0.2507	0.4316	0.3231	0.2453	1	2	3
Pricing:upper	0.9	0.3842	0.3889	0.2982	0.3129	1	3	2
Taxation:upper	0.9	0.4050	0.3601	0.3223	0.3176	1	2	3
Charges:upper	0.9	0.5003	0.3337	0.3271	0.3391	2	3	1
Infrastructure investments:upper	0.9	0.1758	0.5484	0.2653	0.1863	1	2	3
Renewable energy:upper	0.9	0.2815	0.6123	0.2253	0.1624	1	2	3
Sustainable development:upper	0.9	0.4718	0.6846	0.1960	0.1194	1	2	3
Ageing society:upper	0.9	0.2583	0.6072	0.2251	0.1677	1	2	3
Large metropolitan cities:upper	0.9	0.3918	0.6566	0.2059	0.1375	1	2	3
Unemployment:upper	0.9	0.7958	0.3348	0.2593	0.4059	2	3	1
Urbanization:upper	0.9	0.0661	0.4984	0.2606	0.2410	1	2	3
Financial recession:lower	0.1	0.0375	0.5037	0.2618	0.2345	1	2	3
International trade:lower	0.1	0.0176	0.5219	0.2538	0.2243	1	2	3
Pricing:lower	0.1	0.0364	0.5278	0.2544	0.2178	1	2	3
Taxation:lower	0.1	0.0452	0.5333	0.2509	0.2158	1	2	3
Charges:lower	0.1	0.0279	0.5261	0.2542	0.2197	1	2	3
Infrastructure investments:lower	0.1	0.0431	0.5037	0.2606	0.2358	1	2	3
Renewable energy:lower	0.1	0.0257	0.5062	0.2619	0.2318	1	2	3
Sustainable development:lower	0.1	0.0488	0.4977	0.2653	0.2371	1	2	3
Ageing society:lower	0.1	0.0025	0.5145	0.2589	0.2266	1	2	3
Large metropolitan cities:lower	0.1	0.0301	0.5044	0.2627	0.2329	1	2	3
Unemployment:lower	0.1	0.0590	0.5291	0.2582	0.2127	1	2	3
Urbanization:lower	0.1	0.0064	0.5178	0.2576	0.2246	1	2	3

POLICY MAKERS

Megatrends	Parameter	Distance	S1-Harmon	S2-Inexhau	S3-Entropy	Ranking S1-	Ranking S2-	Ranking S3-
Original Values	0.5	0.0000	0.4927	0.2740	0.2333	1	2	3
Financial recession:upper	0.9	0.1388	0.5239	0.2751	0.2009	1	2	3
International trade:upper	0.9	0.4435	0.4531	0.4020	0.1449	1	2	3
Pricing:upper	0.9	0.4674	0.3760	0.2872	0.3368	1	3	2
Taxation:upper	0.9	0.7932	0.2976	0.2840	0.4184	2	3	1
Charges:upper	0.9	0.6561	0.3051	0.3086	0.3864	3	2	1
Infrastructure investments:upper	0.9	0.3084	0.5970	0.2416	0.1614	1	2	3
Renewable energy:upper	0.9	0.4140	0.6433	0.2200	0.1367	1	2	3
Sustainable development:upper	0.9	0.4355	0.6523	0.2160	0.1317	1	2	3
Ageing society:upper	0.9	0.1397	0.5277	0.2716	0.2007	1	2	3
Large metropolitan cities:upper	0.9	0.2998	0.5969	0.2397	0.1634	1	2	3
Unemployment:upper	0.9	0.5385	0.3309	0.3102	0.3590	2	3	1
Urbanization:upper	0.9	0.2096	0.5145	0.3011	0.1844	1	2	3
Financial recession:lower	0.1	0.0215	0.4875	0.2741	0.2383	1	2	3
International trade:lower	0.1	0.0312	0.4966	0.2655	0.2380	1	2	3
Pricing:lower	0.1	0.0413	0.5030	0.2733	0.2237	1	2	3
Taxation:lower	0.1	0.0905	0.5140	0.2738	0.2122	1	2	3
Charges:lower	0.1	0.0356	0.5021	0.2729	0.2250	1	2	3
Infrastructure investments:lower	0.1	0.0639	0.4723	0.2795	0.2482	1	2	3
Renewable energy:lower	0.1	0.0362	0.4799	0.2783	0.2418	1	2	3
Sustainable development:lower	0.1	0.0433	0.4769	0.2797	0.2434	1	2	3
Ageing society:lower	0.1	0.0048	0.4948	0.2727	0.2326	1	2	3
Large metropolitan cities:lower	0.1	0.0195	0.4863	0.2758	0.2379	1	2	3
Unemployment:lower	0.1	0.0377	0.5040	0.2715	0.2245	1	2	3
Urbanization:lower	0.1	0.0096	0.4937	0.2714	0.2349	1	2	3

ACADEMIA

Megatrends	Parameter	Distance	S1-Harmon	S2-Inexhau	S3-Entropy	Ranking S1-	Ranking S2-	Ranking S3-
Original Values	0.5	0.0000	0.4851	0.2987	0.2162	1	2	3
Financial recession:upper	0.9	0.1173	0.5401	0.2637	0.1963	1	2	3
International trade:upper	0.9	0.1286	0.4359	0.3371	0.2269	1	2	3
Pricing:upper	0.9	0.2457	0.3659	0.3689	0.2652	2	1	3
Taxation:upper	0.9	0.3701	0.3602	0.3436	0.2962	1	2	3
Charges:upper	0.9	0.3791	0.3690	0.3329	0.2982	1	2	3
Infrastructure investments:upper	0.9	0.1301	0.4970	0.3149	0.1881	1	2	3
Renewable energy:upper	0.9	0.2362	0.5656	0.2693	0.1651	1	2	3
Sustainable development:upper	0.9	0.3789	0.6351	0.2306	0.1343	1	2	3
Ageing society:upper	0.9	0.2499	0.5598	0.2780	0.1622	1	2	3
Large metropolitan cities:upper	0.9	0.2042	0.5346	0.2933	0.1721	1	2	3
Unemployment:upper	0.9	0.7357	0.3100	0.3148	0.3752	3	2	1
Urbanization:upper	0.9	0.0673	0.5108	0.2786	0.2106	1	2	3
Financial recession:lower	0.1	0.0130	0.4789	0.3021	0.2190	1	2	3
International trade:lower	0.1	0.0088	0.4877	0.2961	0.2162	1	2	3
Pricing:lower	0.1	0.0243	0.4930	0.2961	0.2109	1	2	3
Taxation:lower	0.1	0.0288	0.4955	0.2945	0.2100	1	2	3
Charges:lower	0.1	0.0181	0.4923	0.2933	0.2144	1	2	3
Infrastructure investments:lower	0.1	0.0279	0.4785	0.2993	0.2222	1	2	3
Renewable energy:lower	0.1	0.0203	0.4780	0.3014	0.2206	1	2	3
Sustainable development:lower	0.1	0.0458	0.4662	0.3077	0.2261	1	2	3
Ageing society:lower	0.1	0.0099	0.4822	0.2994	0.2183	1	2	3
Large metropolitan cities:lower	0.1	0.0119	0.4830	0.2982	0.2188	1	2	3
Unemployment:lower	0.1	0.0578	0.4990	0.2973	0.2037	1	2	3
Urbanization:lower	0.1	0.0040	0.4849	0.2997	0.2153	1	2	3

A. 3 Rank Influence analysis

AGGREGATION

Megatrends	Parameter Va	Raw Score	S1-Harmon	S2-Inexhau	S3-Entropy	Ranking S1	Ranking S2	Ranking S3
Original Values	0.5	0	0.4998	0.2709	0.2293	3	1	2
Financial recession:upper	0.99	0	0.5848	0.2362	0.1789	3	1	2
International trade:upper	0.99	0	0.4394	0.3331	0.2275	3	1	2
Pricing:upper	0.7888	0.4105	0.4045	0.2977	0.2978	3	1	2
Taxation:upper	0.7395	0.5112	0.3964	0.3018	0.3018	3	2	1
Charges:upper	0.7373	0.5156	0.4418	0.2791	0.2791	3	2	1
Infrastructure investments:upper	0.99	0	0.5270	0.2828	0.1902	3	1	2
Renewable energy:upper	0.99	0	0.6228	0.2324	0.1448	3	1	2
Sustainable development:upper	0.99	0	0.6851	0.2060	0.1089	3	1	2
Ageing society:upper	0.99	0	0.5932	0.2479	0.1589	3	1	2
Large metropolitan cities:upper	0.99	0	0.6313	0.2329	0.1357	3	1	2
Unemployment:upper	0.6223	0.7504	0.4449	0.2776	0.2776	1	2	3
Urbanization:upper	0.99	0	0.5141	0.2773	0.2086	3	1	2
Financial recession:lower	0	0	0.4884	0.2759	0.2357	3	1	2
International trade:lower	0	0	0.5059	0.2656	0.2285	3	1	2
Pricing:lower	0	0	0.5145	0.2670	0.2185	3	1	2
Taxation:lower	0	0	0.5243	0.2636	0.2121	3	1	2
Charges:lower	0	0	0.5051	0.2709	0.2240	3	1	2
Infrastructure investments:lower	0	0	0.4872	0.2719	0.2410	3	1	2
Renewable energy:lower	0	0	0.4877	0.2746	0.2377	3	1	2
Sustainable development:lower	0	0	0.4768	0.2791	0.2441	3	1	2
Ageing society:lower	0	0	0.4993	0.2707	0.2299	3	1	2
Large metropolitan cities:lower	0	0	0.4937	0.2725	0.2339	3	1	2
Unemployment:lower	0	0	0.5115	0.2694	0.2191	3	1	2
Urbanization:lower	0	0	0.5010	0.2699	0.2290	3	1	2

POLICY-MAKERS

Megatrends	Parameter Va	Raw Score	S1-Harmon	S2-Inexhau	S3-Entropy	Ranking S1	Ranking S2	Ranking S3
Original Values	0.5	0	0.4927	0.2740	0.2333	3	1	2
Financial recession:upper	0.99	0	0.5391	0.2738	0.1871	3	1	2
International trade:upper	0.99	0	0.4485	0.4261	0.1254	3	1	2
Pricing:upper	0.6522	0.6894	0.4390	0.2805	0.2805	1	2	3
Taxation:upper	0.5814	0.8339	0.4471	0.2765	0.2765	1	2	3
Charges:upper	0.6537	0.6863	0.4321	0.2839	0.2840	1	2	3
Infrastructure investments:upper	0.99	0	0.6107	0.2366	0.1528	3	1	2
Renewable energy:upper	0.99	0	0.6710	0.2102	0.1188	3	1	2
Sustainable development:upper	0.99	0	0.6775	0.2063	0.1163	3	1	2
Ageing society:upper	0.99	0	0.5463	0.2669	0.1868	3	1	2
Large metropolitan cities:upper	0.99	0	0.6309	0.2274	0.1417	3	1	2
Unemployment:upper	0.6745	0.6439	0.4184	0.2908	0.2908	1	2	3
Urbanization:upper	0.99	0	0.5251	0.3048	0.1701	3	1	2
Financial recession:lower	0	0	0.4865	0.2741	0.2394	3	1	2
International trade:lower	0	0	0.4975	0.2633	0.2392	3	1	2
Pricing:lower	0	0	0.5056	0.2732	0.2212	3	1	2
Taxation:lower	0	0	0.5194	0.2738	0.2068	3	1	2
Charges:lower	0	0	0.5043	0.2726	0.2230	3	1	2
Infrastructure investments:lower	0	0	0.4669	0.2810	0.2521	3	1	2
Renewable energy:lower	0	0	0.4767	0.2794	0.2439	3	1	2
Sustainable development:lower	0	0	0.4728	0.2812	0.2460	3	1	2
Ageing society:lower	0	0	0.4954	0.2723	0.2323	3	1	2
Large metropolitan cities:lower	0	0	0.4850	0.2761	0.2388	3	1	2
Unemployment:lower	0	0	0.5068	0.2708	0.2223	3	1	2
Urbanization:lower	0	0	0.494008	0.27067	0.235323	3	1	2

INDUSTRY

Megatrends	Parameter Va	Raw Score	S1-Harmon	S2-Inexhau	S3-Entropy	Ranking S1	Ranking S2	Ranking S3
Original Values	0.5	0	0.5156	0.2583	0.2260	3	1	2
Financial recession:upper	0.99	0	0.6315	0.2193	0.1491	3	1	2
International trade:upper	0.99	0	0.4180	0.3345	0.2475	3	1	2
Pricing:upper	0.7546	0.4805	0.4280	0.2860	0.2860	1	2	3
Taxation:upper	0.9819	0.0166	0.3334	0.3336	0.3329	3	2	1
Charges:upper	0.8102	0.3669	0.3810	0.3095	0.3095	2	1	3
Infrastructure investments:upper	0.99	0	0.5445	0.2707	0.1847	3	1	2
Renewable energy:upper	0.99	0	0.6249	0.2210	0.1542	3	1	2
Sustainable development:upper	0.99	0	0.7142	0.1844	0.1014	3	1	2
Ageing society:upper	0.99	0	0.6389	0.2137	0.1474	3	1	2
Large metropolitan cities:upper	0.99	0	0.7009	0.1894	0.1097	3	1	2
Unemployment:upper	0.5730	0.8509	0.4819	0.2591	0.2591	1	2	3
Urbanization:upper	0.99	0	0.4979	0.2592	0.2429	3	1	2
Financial recession:lower	0	0	0.5010	0.2626	0.2364	3	1	2
International trade:lower	0	0	0.5235	0.2526	0.2238	3	1	2
Pricing:lower	0	0	0.5309	0.2534	0.2157	3	1	2
Taxation:lower	0	0	0.5377	0.2490	0.2132	3	1	2
Charges:lower	0	0	0.5286	0.2532	0.2182	3	1	2
Infrastructure investments:lower	0	0	0.5004	0.2612	0.2384	3	1	2
Renewable energy:lower	0	0	0.5037	0.2629	0.2334	3	1	2
Sustainable development:lower	0	0	0.4932	0.2670	0.2398	3	1	2
Ageing society:lower	0	0	0.5143	0.2591	0.2267	3	1	2
Large metropolitan cities:lower	0	0	0.5019	0.2637	0.2344	3	1	2
Unemployment:lower	0	0	0.5324	0.2581	0.2095	3	1	2
Urbanization:lower	0	0	0.5183	0.2574	0.2242	3	1	2

ACADEMIA

Megatrends	Parameter Va	Raw Score	S1-Harmon	S2-Inexhau	S3-Entropy	Ranking S1	Ranking S2	Ranking S3
Original Values	0.5	0	0.4851	0.2987	0.2162	3	1	2
Financial recession:upper	0.99	0	0.5645	0.2512	0.1843	3	1	2
International trade:upper	0.99	0	0.4242	0.3462	0.2297	3	1	2
Pricing:upper	0.99	0	0.3419	0.3401	0.3181	3	1	2
Taxation:upper	0.9380	0.1062	0.3478	0.3479	0.3043	3	2	1
Charges:upper	0.8947	0.1944	0.3678	0.3679	0.2643	3	2	1
Infrastructure investments:upper	0.99	0	0.4898	0.3223	0.1879	3	1	2
Renewable energy:upper	0.99	0	0.5776	0.2648	0.1576	3	1	2
Sustainable development:upper	0.99	0	0.6639	0.2162	0.1199	3	1	2
Ageing society:upper	0.99	0	0.5788	0.2727	0.1484	3	1	2
Large metropolitan cities:upper	0.99	0	0.5478	0.2916	0.1606	3	1	2
Unemployment:upper	0.7082	0.5750	0.3831	0.3085	0.3085	1	2	3
Urbanization:upper	0.99	0	0.5187	0.2738	0.2075	3	1	2
Financial recession:lower	0	0	0.4776	0.3029	0.2195	3	1	2
International trade:lower	0	0	0.4883	0.2955	0.2163	3	1	2
Pricing:lower	0	0	0.4949	0.2954	0.2096	3	1	2
Taxation:lower	0	0	0.4981	0.2935	0.2084	3	1	2
Charges:lower	0	0	0.4940	0.2920	0.2140	3	1	2
Infrastructure investments:lower	0	0	0.4766	0.2995	0.2239	3	1	2
Renewable energy:lower	0	0	0.4761	0.3022	0.2218	3	1	2
Sustainable development:lower	0	0	0.4615	0.3099	0.2286	3	1	2
Ageing society:lower	0	0	0.4816	0.2996	0.2188	3	1	2
Large metropolitan cities:lower	0	0	0.4827	0.2980	0.2193	3	1	2
Unemployment:lower	0	0	0.5025	0.2969	0.2006	3	1	2
Urbanization:lower	0	0	0.4849	0.3000	0.2151	3	1	2

A. 4 Marginal influence analysis

AGGREGATION

Megatrends	D(Normal) S1-Harmony	D(Normal) S2-Inexhaustible	D(Normal) S3-Entropy	Total	Calc Err
Original	0.4998	0.2709	0.2293	0.0000	0.0000
Financial recession:upper	0.0746	-0.0506	-0.0240	0.0933	0.0008
International trade:upper	-0.1761	0.0186	0.1575	0.2370	0.0008
Pricing:upper	-0.4145	0.1151	0.2995	0.5242	0.0006
Taxation:upper	-0.5050	0.1488	0.3563	0.6357	0.0006
Charges:upper	-0.2082	0.1753	0.0329	0.2742	0.0005
Infrastructure investments:upp	0.1783	-0.0164	-0.1619	0.2414	0.0010
Renewable energy:upper	0.3259	-0.0998	-0.2261	0.4091	0.0008
Sustainable development:uppe	0.4497	-0.1494	-0.3003	0.5610	0.0007
Ageing society:upper	0.0598	-0.0044	-0.0554	0.0816	0.0006
Large metropolitan cities:uppe	0.1467	-0.0373	-0.1093	0.1867	0.0005
Unemployment:upper	-0.4881	0.0630	0.4251	0.6503	0.0007
Urbanization:upper	-0.0614	0.0448	0.0165	0.0778	0.0005
Financial recession:lower	0.0252	-0.0104	-0.0148	0.0310	0.0000
International trade:lower	-0.0120	0.0104	0.0016	0.0160	0.0000
Pricing:lower	-0.0287	0.0075	0.0212	0.0365	0.0000
Taxation:lower	-0.0482	0.0143	0.0339	0.0607	0.0000
Charges:lower	-0.0123	0.0003	0.0120	0.0172	0.0000
Infrastructure investments:low	0.0231	-0.0012	-0.0219	0.0319	0.0000
Renewable energy:lower	0.0226	-0.0069	-0.0157	0.0284	0.0000
Sustainable development:lowe	0.0464	-0.0168	-0.0296	0.0576	0.0000
Ageing society:lower	0.0014	0.0001	-0.0015	0.0021	0.0000
Large metropolitan cities:lower	0.0138	-0.0036	-0.0101	0.0175	0.0000
Unemployment:lower	-0.0238	0.0030	0.0208	0.0318	0.0000
Urbanization:lower	-0.0023	0.0018	0.0004	0.0030	0.0000

POLICY-MAKERS

Megatrends	D(Normal) 1-Harmony	D(Normal) 2-Inexhaustible	D(Normal) 3-Entropy	Total	Calc Err
Original	0.4927	0.2740	0.2333	0.0000	0.0000
Financial recession:upper	-0.0037	0.0193	-0.0157	0.0252	0.0008
International trade:upper	-0.1479	0.3809	-0.2331	0.4704	0.0007
Pricing:upper	-0.4028	0.0507	0.3521	0.5373	0.0006
Taxation:upper	-0.5871	0.0325	0.5546	0.8082	0.0006
Charges:upper	-0.3416	0.0496	0.2920	0.4521	0.0006
Infrastructure investments:upp	0.3715	-0.1073	-0.2643	0.4684	0.0006
Renewable energy:upper	0.4600	-0.1629	-0.2971	0.5713	0.0010
Sustainable development:uppe	0.5118	-0.1795	-0.3323	0.6361	0.0006
Ageing society:upper	-0.0268	0.0366	-0.0098	0.0464	0.0006
Large metropolitan cities:uppe	0.1593	-0.0449	-0.1144	0.2012	0.0009
Unemployment:upper	-0.4726	0.1081	0.3645	0.6066	0.0006
Urbanization:upper	-0.0225	0.1019	-0.0794	0.1311	0.0009
Financial recession:lower	0.0145	-0.0006	-0.0139	0.0201	0.0000
International trade:lower	-0.0096	0.0212	-0.0116	0.0260	0.0000
Pricing:lower	-0.0253	0.0016	0.0237	0.0347	0.0000
Taxation:lower	-0.0525	0.0005	0.0520	0.0739	0.0000
Charges:lower	-0.0247	0.0031	0.0216	0.0329	0.0000
Infrastructure investments:low	0.0496	-0.0135	-0.0361	0.0628	0.0000
Renewable energy:lower	0.0314	-0.0106	-0.0207	0.0391	0.0000
Sustainable development:lowe	0.0389	-0.0142	-0.0248	0.0483	0.0000
Ageing society:lower	-0.0045	0.0031	0.0014	0.0056	0.0000
Large metropolitan cities:lowe	0.0180	-0.0053	-0.0127	0.0227	0.0000
Unemployment:lower	-0.0286	0.0064	0.0222	0.0368	0.0000
Urbanization:lower	-0.0022	0.0064	-0.0042	0.0080	0.0000

INDUSTRY

Megatrends	D(Normal) 1-Harmony	D(Normal) 2-Inexhaustible	D(Normal) 3-Entropy	Total	Calc Err
Original	0.5156	0.2583	0.2260	0.0000	0.0000
Financial recession:upper	0.1266	-0.0532	-0.0734	0.1557	0.0008
International trade:upper	-0.2711	0.2007	0.0705	0.3446	0.0007
Pricing:upper	-0.4092	0.1298	0.2794	0.5122	0.0005
Taxation:upper	-0.4678	0.1876	0.2801	0.5766	0.0009
Charges:upper	-0.3484	0.1364	0.2120	0.4301	0.0010
Infrastructure investments:upp	0.2030	-0.0224	-0.1806	0.2727	0.0006
Renewable energy:upper	0.3475	-0.1170	-0.2304	0.4330	0.0006
Sustainable development:uppe	0.5183	-0.1844	-0.3339	0.6435	0.0005
Ageing society:upper	0.1236	-0.0470	-0.0766	0.1529	0.0010
Large metropolitan cities:uppe	0.2438	-0.0922	-0.1515	0.3015	0.0009
Unemployment:upper	-0.4790	0.0138	0.4652	0.6679	0.0009
Urbanization:upper	-0.1086	0.0326	0.0760	0.1365	0.0008
Financial recession:lower	0.0323	-0.0090	-0.0234	0.0409	0.0000
International trade:lower	-0.0157	0.0113	0.0044	0.0198	0.0000
Pricing:lower	-0.0301	0.0098	0.0203	0.0376	0.0000
Taxation:lower	-0.0437	0.0184	0.0253	0.0538	0.0000
Charges:lower	-0.0270	0.0106	0.0164	0.0334	0.0000
Infrastructure investments:low	0.0282	-0.0049	-0.0232	0.0369	0.0000
Renewable energy:lower	0.0221	-0.0085	-0.0136	0.0273	0.0000
Sustainable development:lowe	0.0451	-0.0174	-0.0277	0.0557	0.0000
Ageing society:lower	0.0035	-0.0017	-0.0018	0.0042	0.0000
Large metropolitan cities:lowe	0.0303	-0.0118	-0.0185	0.0374	0.0000
Unemployment:lower	-0.0347	0.0005	0.0343	0.0488	0.0000
Urbanization:lower	-0.0051	0.0016	0.0034	0.0064	0.0000

ACADEMIA

Megatrends	D(Normal) S1-Harmony	D(Normal) S2-Inexhaustible	D(Normal) S3-Entropy	Total	Calc Err
Original	0.4851	0.2987	0.2162	0.0000	0.0000
Financial recession:upper	0.0524	-0.0562	0.0038	0.0770	0.0006
International trade:upper	-0.1165	0.0948	0.0217	0.1517	0.0001
Pricing:upper	-0.2918	0.0917	0.2001	0.3655	0.0001
Taxation:upper	-0.3102	0.1148	0.1954	0.3841	0.0001
Charges:upper	-0.2340	0.1544	0.0796	0.2914	0.0006
Infrastructure investments:upp	0.1365	0.0029	-0.1394	0.1952	0.0005
Renewable energy:upper	0.2850	-0.1028	-0.1821	0.3535	0.0010
Sustainable development:uppe	0.4545	-0.1934	-0.2611	0.5587	0.0010
Ageing society:upper	0.1353	-0.0345	-0.1008	0.1722	0.0007
Large metropolitan cities:uppe	0.0736	0.0022	-0.0758	0.1056	0.0007
Unemployment:upper	-0.5737	0.0608	0.5129	0.7719	0.0008
Urbanization:upper	0.0125	-0.0371	0.0246	0.0463	0.0007
Financial recession:lower	0.0172	-0.0088	-0.0084	0.0210	0.0000
International trade:lower	-0.0067	0.0066	0.0001	0.0094	0.0000
Pricing:lower	-0.0198	0.0066	0.0132	0.0247	0.0000
Taxation:lower	-0.0261	0.0105	0.0157	0.0322	0.0000
Charges:lower	-0.0183	0.0135	0.0049	0.0233	0.0000
Infrastructure investments:low	0.0152	-0.0009	-0.0142	0.0208	0.0000
Renewable energy:lower	0.0165	-0.0062	-0.0103	0.0204	0.0000
Sustainable development:lowe	0.0471	-0.0225	-0.0246	0.0577	0.0000
Ageing society:lower	0.0077	-0.0020	-0.0057	0.0097	0.0000
Large metropolitan cities:lowe	0.0066	0.0008	-0.0074	0.0099	0.0000
Unemployment:lower	-0.0349	0.0036	0.0313	0.0470	0.0000
Urbanization:lower	0.0007	-0.0027	0.0019	0.0034	0.0000

A. 5 Perspective analysis

AGGREGATION

Megatrends	Parameter	Distance	Normal S1-	Normal S2-	Normal S3-Entropy	Ranking S1-Harm	Ranking S2-	Ranking S3-
Original Values	0.5000	0.0000	0.4998	0.2709	0.2293	1	2	3
Financial recession	0.9984	0.1075	0.5871	0.2355	0.1775	1	2	3
International trade	0.9938	0.0872	0.4392	0.3335	0.2273	1	2	3
Pricing	0.9969	0.1826	0.3551	0.3122	0.3327	1	3	2
Taxation	0.9984	0.2403	0.3085	0.3290	0.3625	3	2	1
Charges	0.9984	0.2003	0.3478	0.2946	0.3576	2	3	1
Infrastructure investments	0.9875	0.0491	0.5271	0.2827	0.1902	1	2	3
Renewable energy	0.9969	0.1558	0.6241	0.2320	0.1439	1	2	3
Sustainable development	0.9984	0.2337	0.6878	0.2050	0.1072	1	2	3
Ageing society	0.9984	0.1224	0.5958	0.2472	0.1571	1	2	3
Large metropolitan cities	0.9984	0.1699	0.6346	0.2320	0.1335	1	2	3
Unemployment	0.9992	0.2898	0.2836	0.2958	0.4207	3	2	1
Urbanization	0.9938	0.0263	0.5144	0.2773	0.2084	1	2	3

POLICY-MAKERS

Megatrends	Parameter	Distance	Normal S1-	Normal S2-	Normal S3-Entropy	Ranking S1-Harm	Ranking S2-	Ranking S3-
Original Values	0.5000	0.0000	0.4927	0.2740	0.2333	1	2	3
Financial recession	0.9969	0.0672	0.5404	0.2736	0.1860	1	2	3
International trade	0.9984	0.1945	0.4481	0.4283	0.1236	1	2	3
Pricing	0.9969	0.1813	0.3577	0.2889	0.3534	1	3	2
Taxation	0.9984	0.3238	0.2580	0.2860	0.4560	3	2	1
Charges	0.9992	0.3219	0.2452	0.3211	0.4337	3	2	1
Infrastructure investments	0.9969	0.1488	0.6116	0.2362	0.1522	1	2	3
Renewable energy	0.9984	0.2244	0.6735	0.2093	0.1171	1	2	3
Sustainable development	0.9969	0.2311	0.6792	0.2056	0.1152	1	2	3
Ageing society	0.9969	0.0733	0.5479	0.2665	0.1857	1	2	3
Large metropolitan cities	0.9984	0.1765	0.6343	0.2262	0.1395	1	2	3
Unemployment	0.9984	0.2602	0.2904	0.3190	0.3906	3	2	1
Urbanization	0.9969	0.0788	0.5260	0.3051	0.1690	1	2	3

INDUSTRY

Megatrends	Parameter	Distance	Normal S1-	Normal S2-	Normal S3-Entropy	Ranking S1-Harm	Ranking S2-	Ranking S3-
Original Values	0.5000	0.0000	0.5156	0.2583	0.2260	1	2	3
Financial recession	0.9984	0.1481	0.6345	0.2184	0.1471	1	2	3
International trade	0.9969	0.1269	0.4170	0.3353	0.2477	1	2	3
Pricing	0.9969	0.1874	0.3661	0.3053	0.3286	1	3	2
Taxation	0.9984	0.2307	0.3282	0.3359	0.3359	3	2	1
Charges	0.9992	0.2938	0.2781	0.3478	0.3740	3	2	1
Infrastructure investments	0.9938	0.0519	0.5443	0.2710	0.1847	1	2	3
Renewable energy	0.9938	0.1366	0.6253	0.2208	0.1539	1	2	3
Sustainable development	0.9984	0.2491	0.7168	0.1834	0.0998	1	2	3
Ageing society	0.9984	0.1569	0.6421	0.2125	0.1453	1	2	3
Large metropolitan cities	0.9992	0.2354	0.7057	0.1876	0.1066	1	2	3
Unemployment	0.9992	0.3287	0.2825	0.2599	0.4577	2	3	1
Urbanization	0.9750	0.0242	0.4980	0.2595	0.2425	1	2	3

ACADEMIA

Megatrends	Parameter	Distance	Normal S1-	Normal S2-	Normal S3-Entropy	Ranking S1-Harm	Ranking S2-	Ranking S3-
Original Values	0.5000	0.0000	0.4851	0.2987	0.2162	1	2	3
Financial recession	0.9984	0.1010	0.5671	0.2499	0.1830	1	2	3
International trade	0.9969	0.0796	0.4233	0.3469	0.2299	1	2	3
Pricing	0.9984	0.1838	0.3393	0.3407	0.3200	2	1	3
Taxation	0.9984	0.1954	0.3277	0.3548	0.3175	2	1	3
Charges	0.9984	0.1913	0.3296	0.3888	0.2816	2	1	3
Infrastructure investments	0.9938	0.0373	0.4894	0.3227	0.1879	1	2	3
Renewable energy	0.9938	0.1152	0.5781	0.2646	0.1573	1	2	3
Sustainable development	0.9984	0.2225	0.6666	0.2149	0.1186	1	2	3
Ageing society	0.9969	0.1204	0.5803	0.2723	0.1474	1	2	3
Large metropolitan cities	0.9969	0.0854	0.5487	0.2915	0.1598	1	2	3
Unemployment	0.9984	0.2816	0.2771	0.3179	0.4050	3	2	1
Urbanization	0.9938	0.0431	0.5190	0.2736	0.2074	1	2	3

ANNEX B – NODE SENSITIVITIES (GRAPHS)

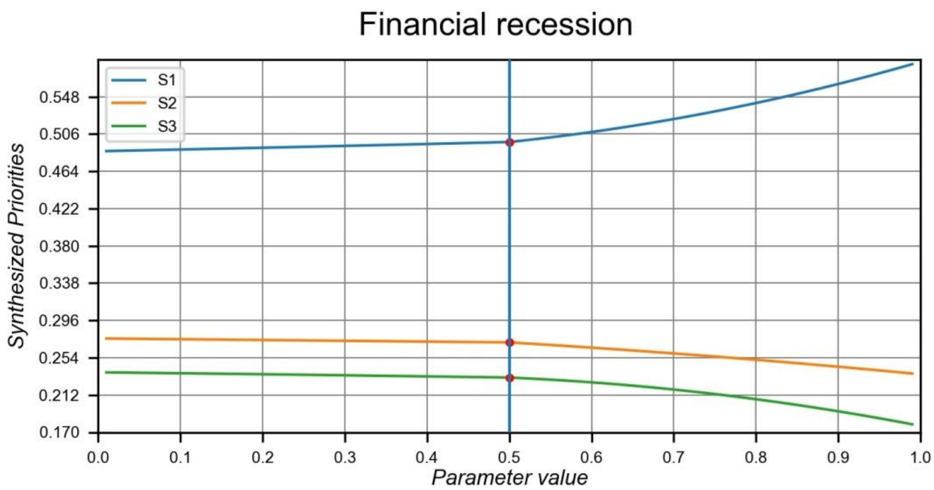
In Annex B **NODE SENSITIVITIES** for all Megatrends are given. The graphs of sensitivity analysis are organized in two groups:

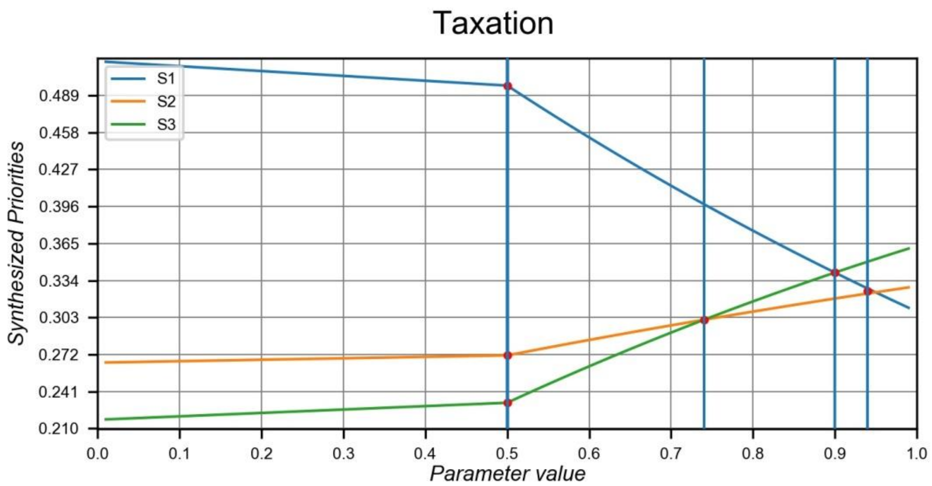
1) The sensitivity of the sustainable mobility scenarios with respect to other Megatrends per groups
2) The sensitivity of the significant Megatrends with respect to other Megatrends in clusters per group

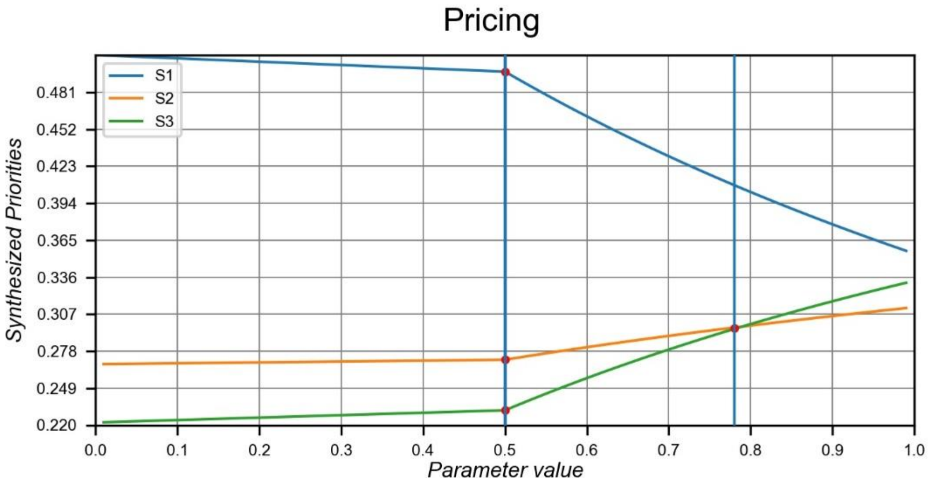
B. 1 Scenarios versus Megatrends

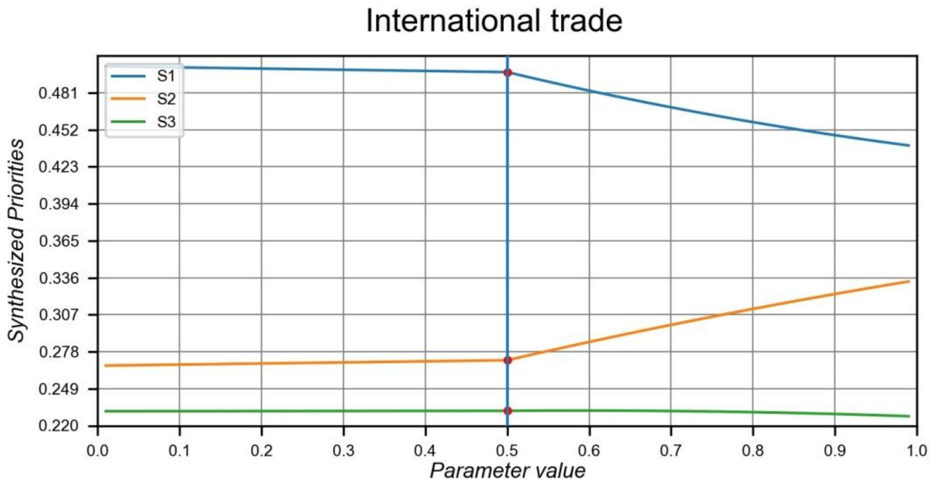
Aggregation group

Economy Megatrends

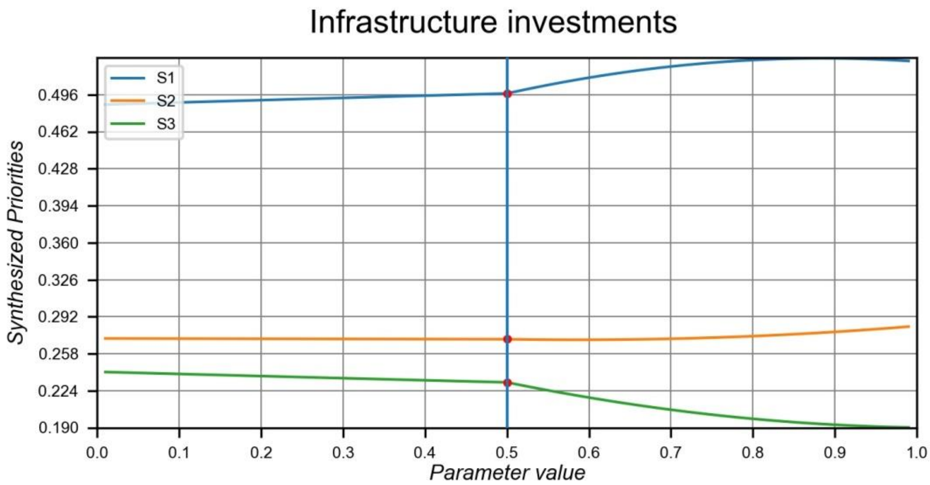


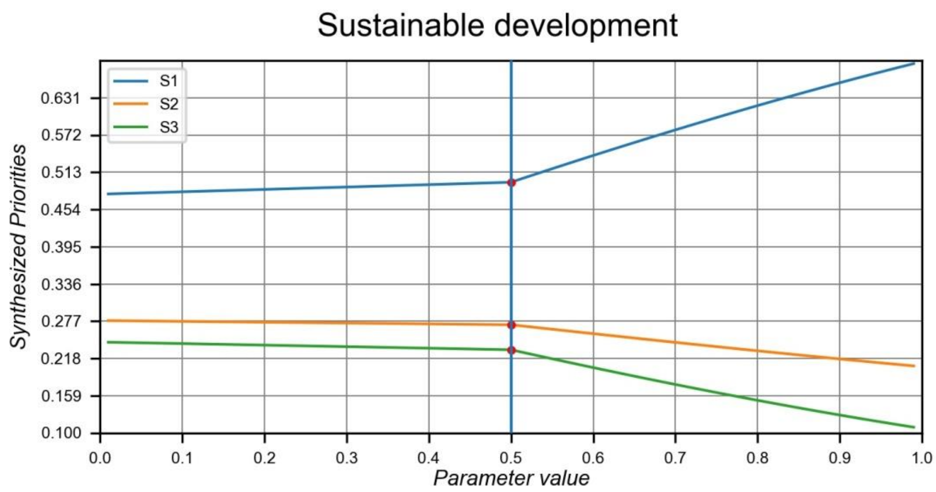


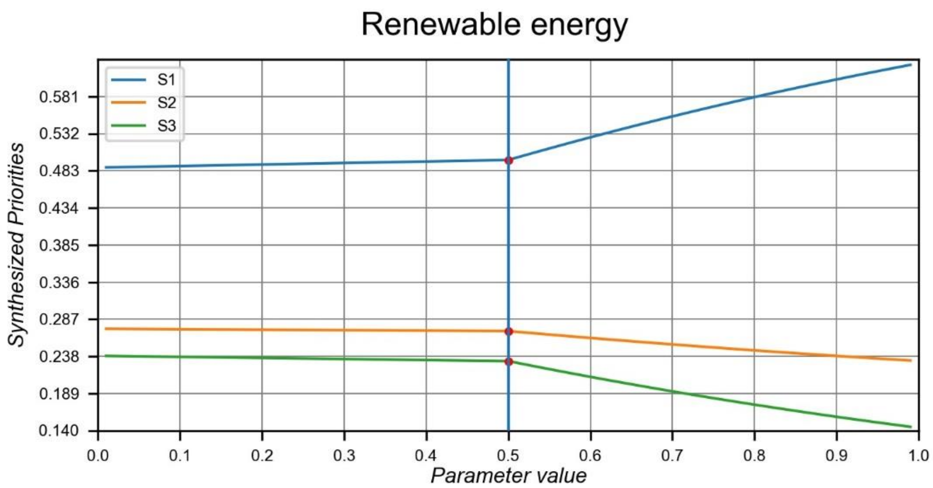


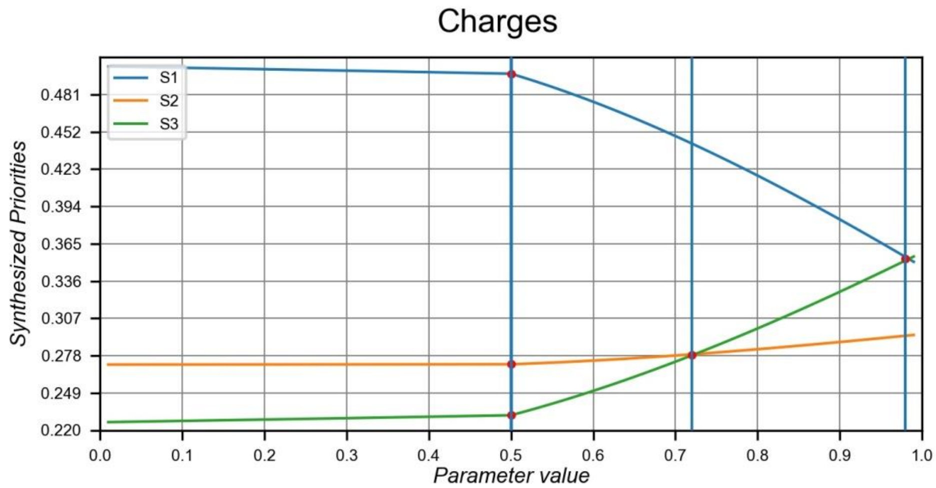


Environmental Megatrends

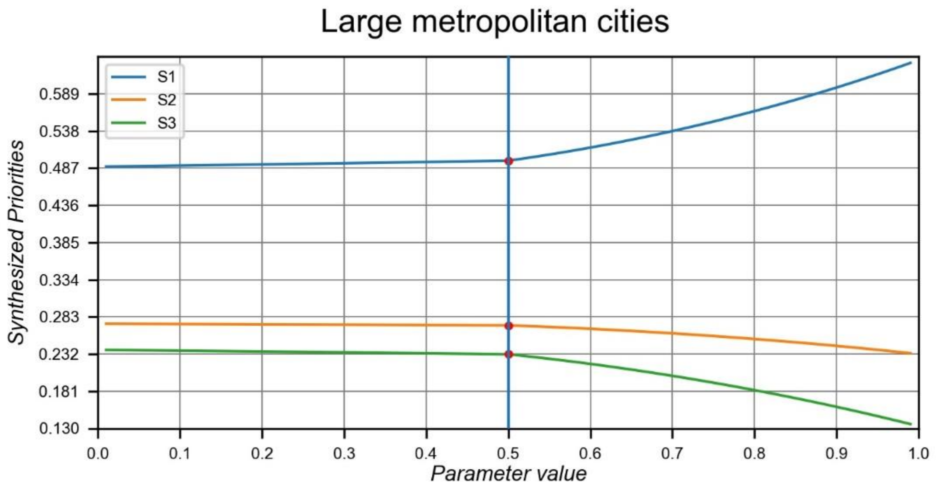


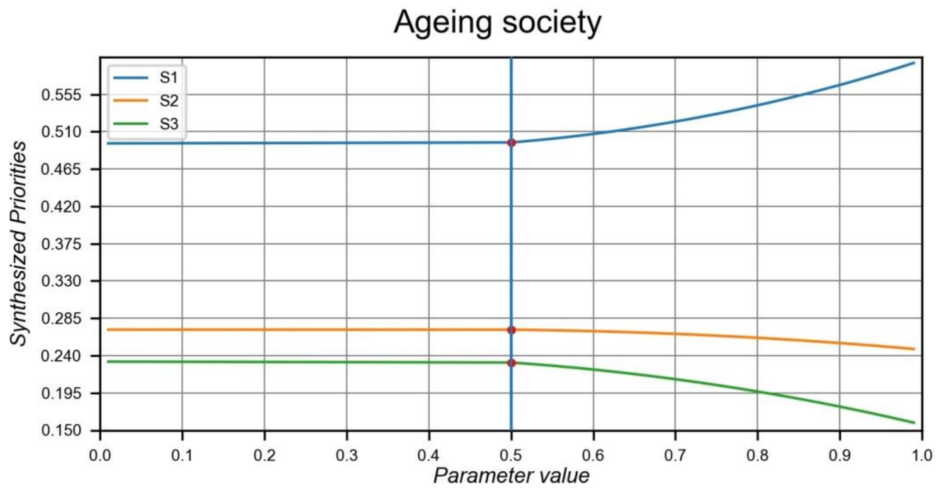

Sustainable development
S1
S2
S3
Synthesized Priorities
0.631
0.572
0.513
0.454
0.395
0.336
0.277
0.218
0.159
0.100
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Parameter value

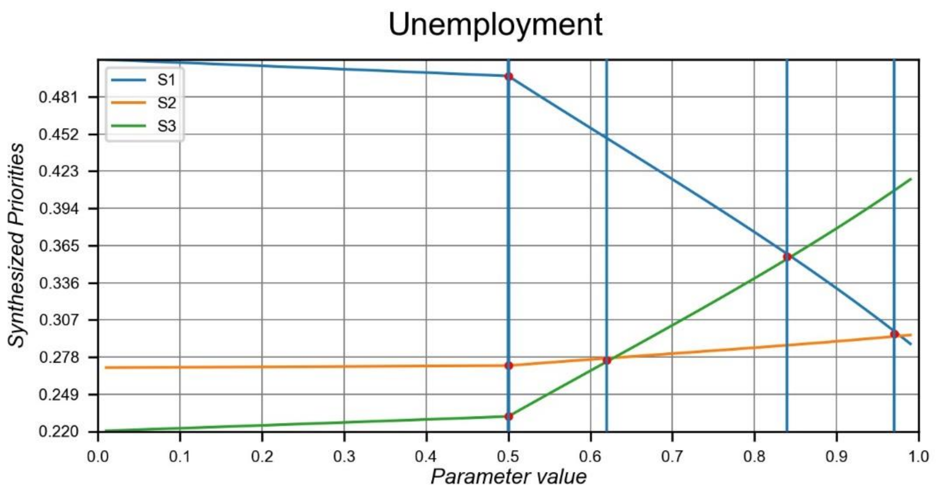

Renewable energy
S1
S2
S3
Synthesized Priorities
0.581
0.532
0.483
0.434
0.385
0.336
0.287
0.238
0.189
0.140
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Parameter value

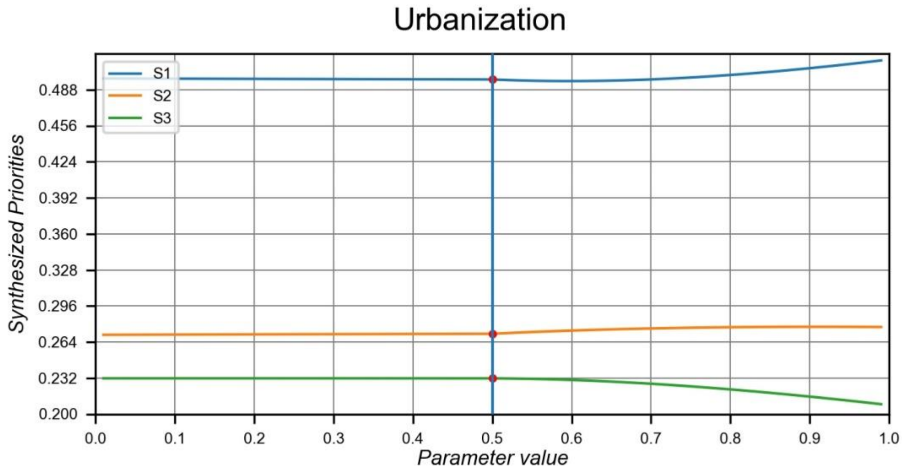

Charges
S1
S2
S3
Synthesized Priorities
0.481
0.452
0.423
0.394
0.365
0.336
0.307
0.278
0.249
0.220
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Parameter value

Social Megatrends



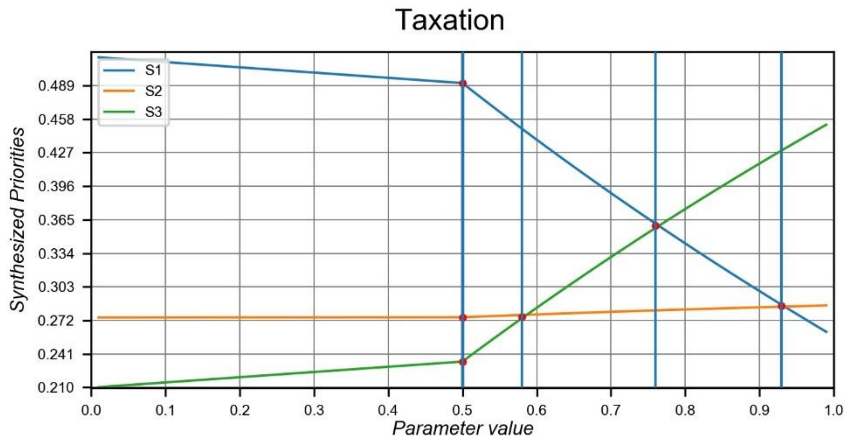


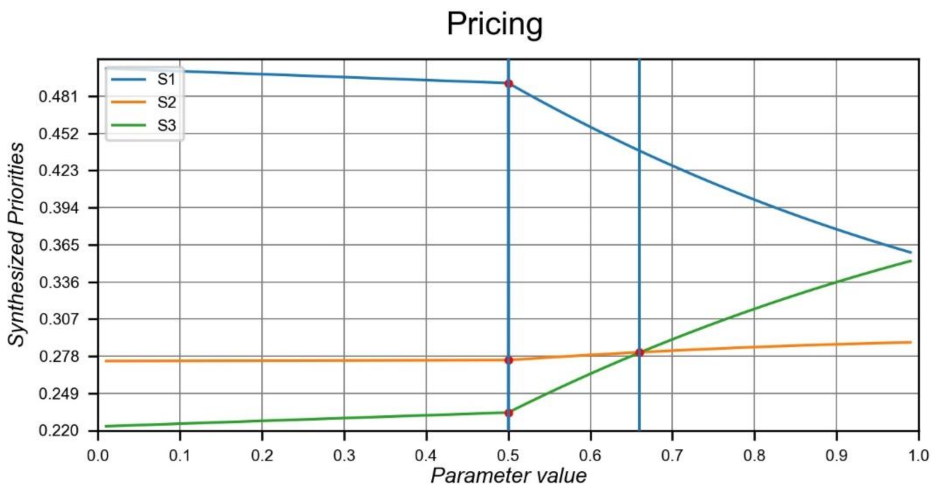




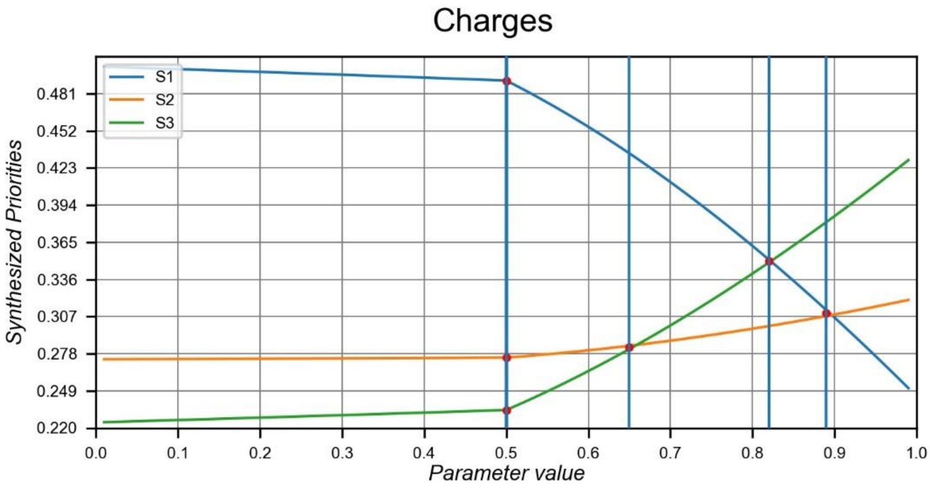
Policy makers group

Economy Megatrends

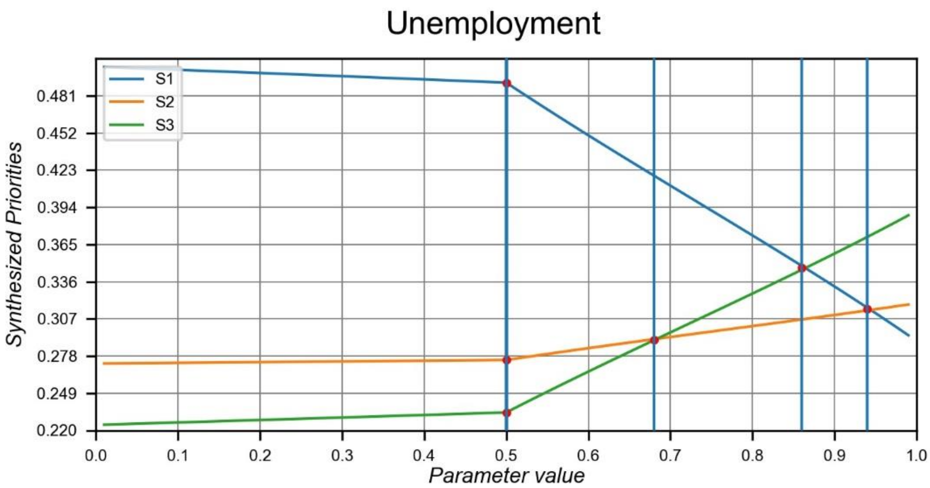




Environmental Megatrends

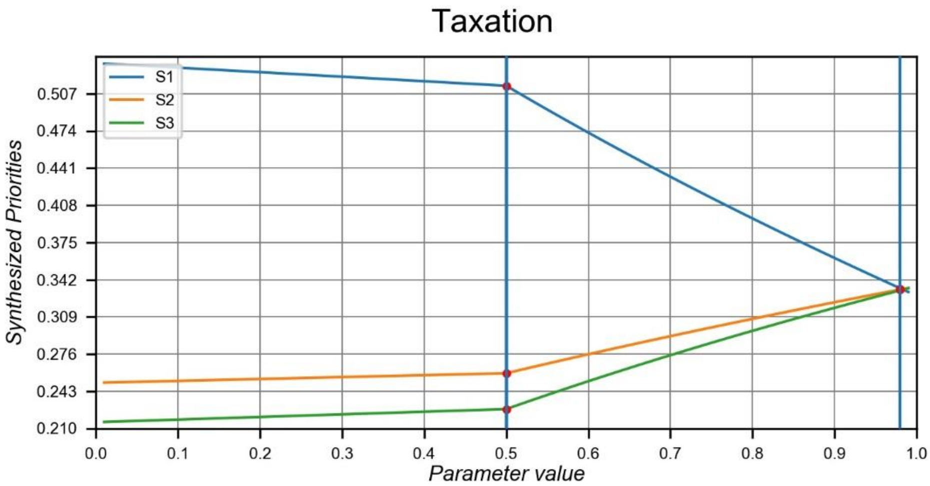


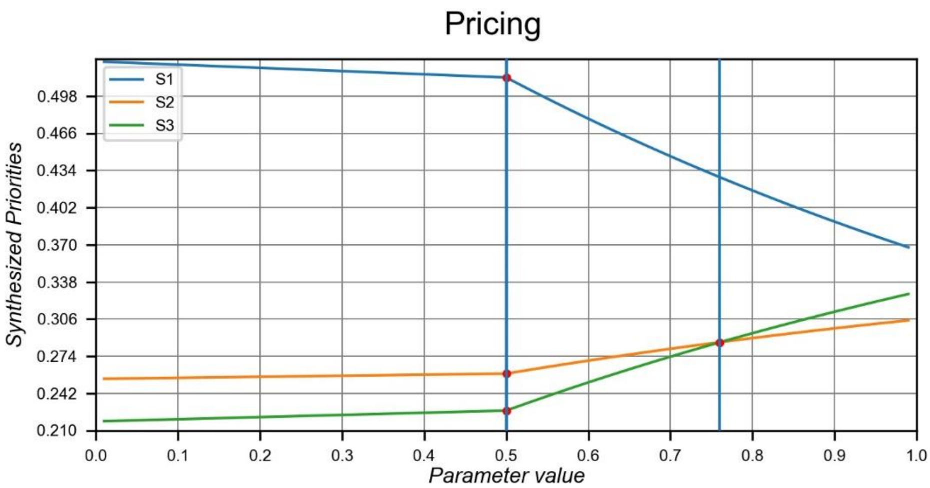
Social Megatrends



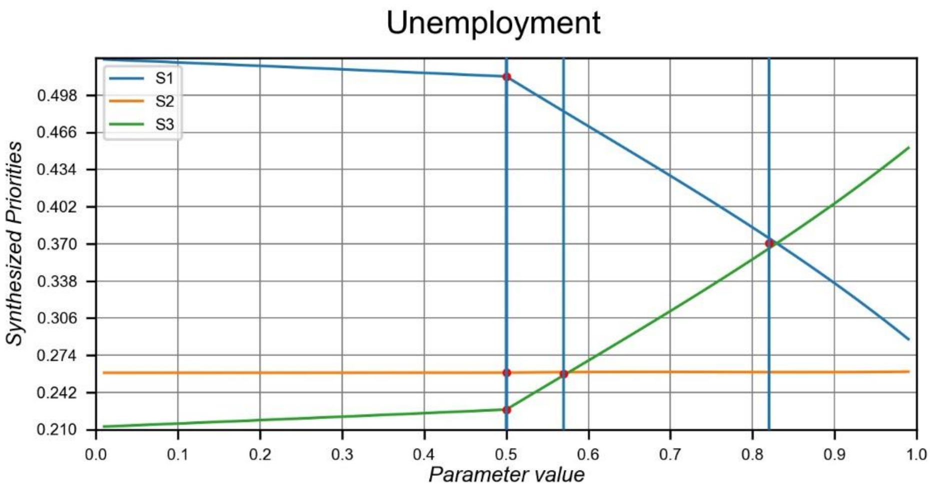
Industry group

Economy Megatrends



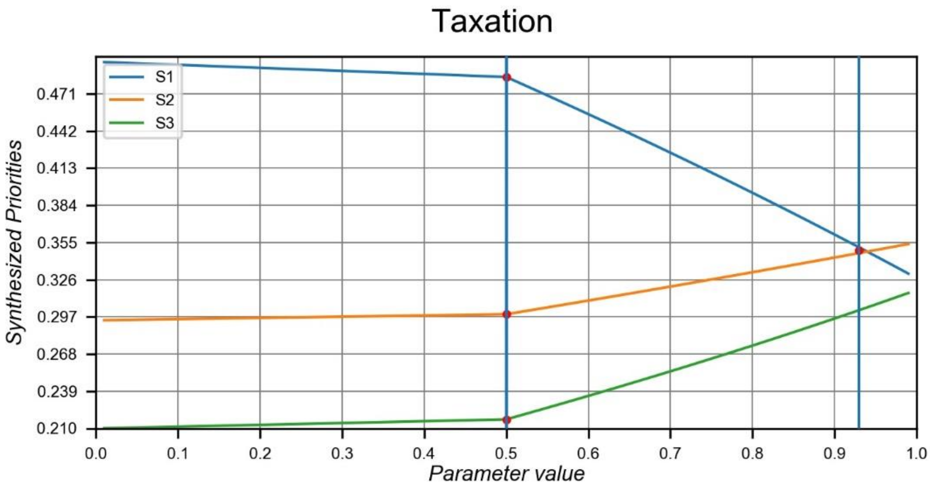


Social Megatrends

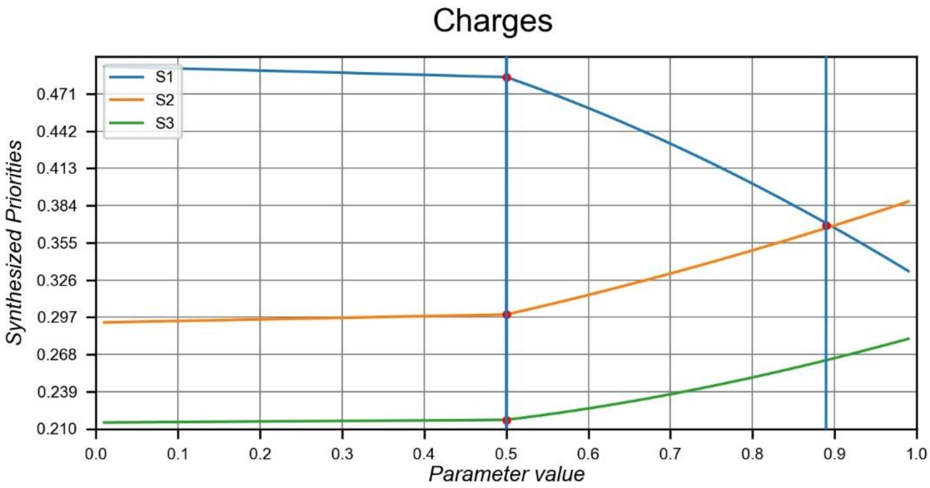


Academia group

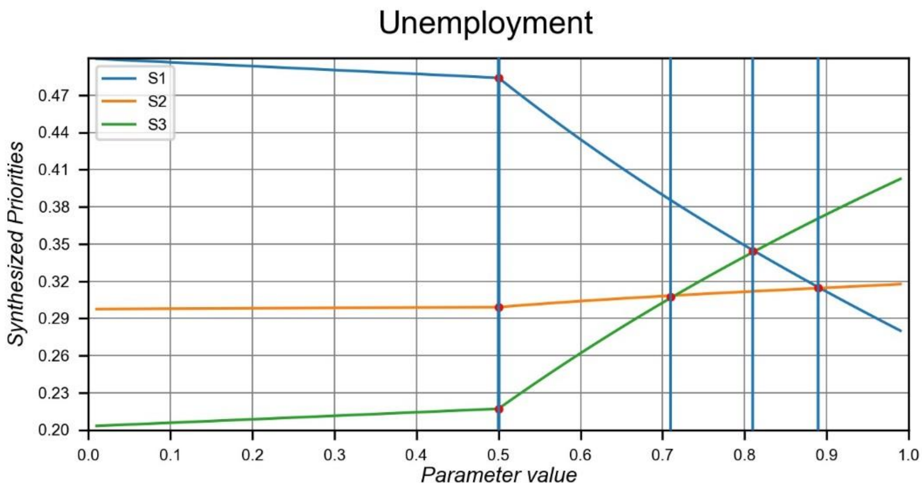
Economy Megatrends



Environmental Megatrends



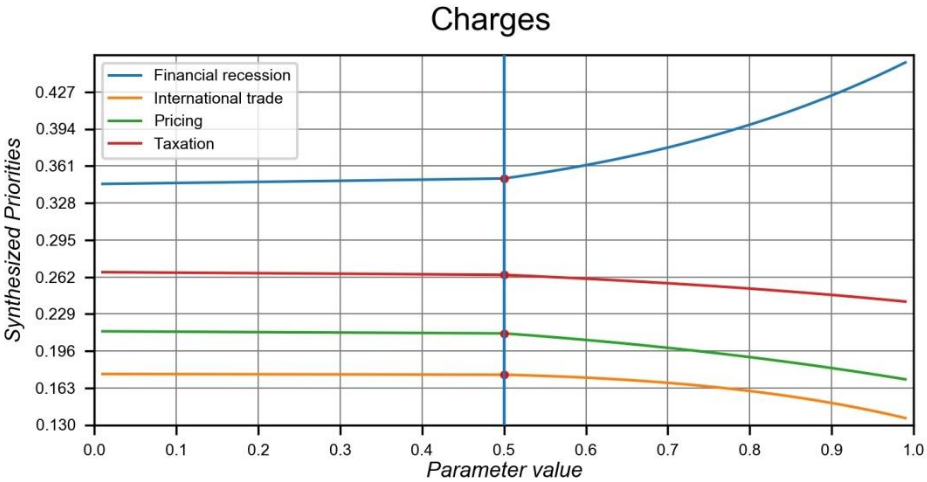
Social Megatrends

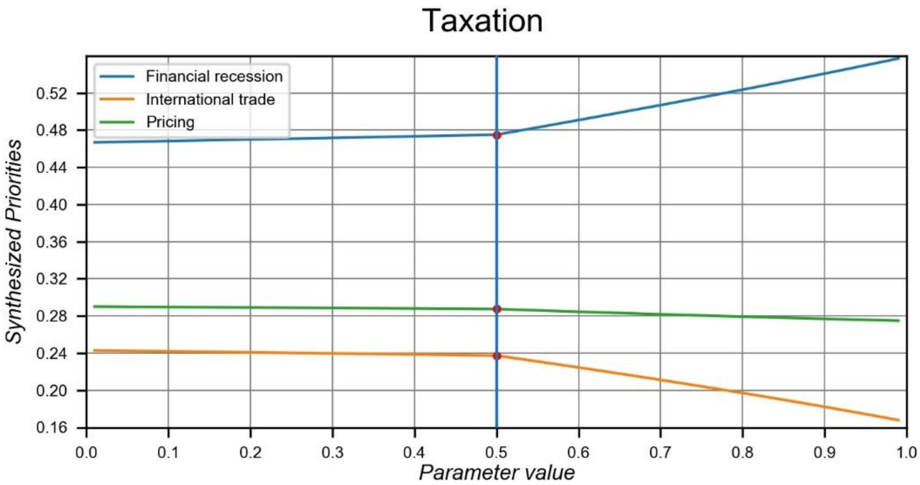


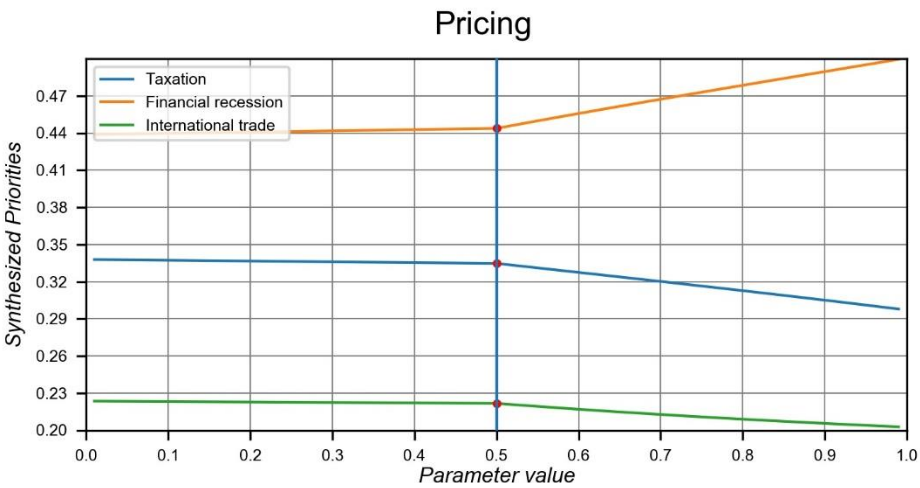
B. 2 Significant Megatrends vs Megatrends in clusters

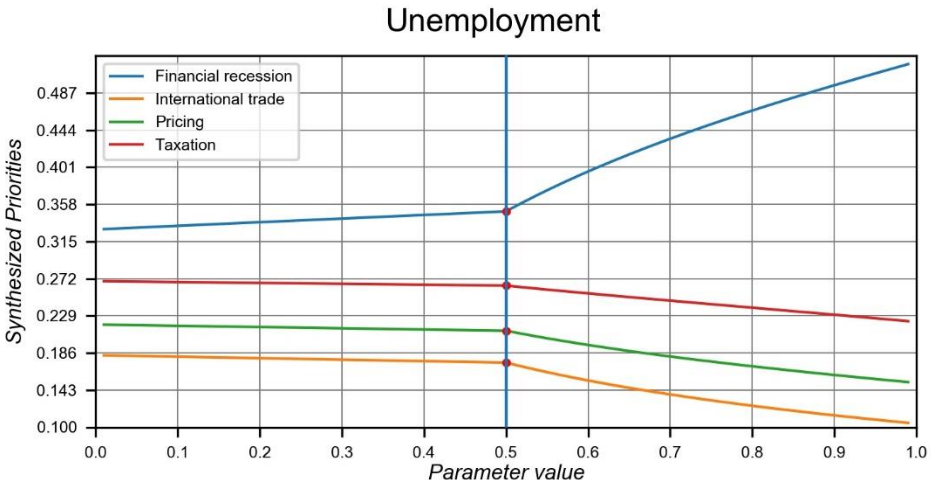
Aggregation group

Megatrends vs Megatrends in economy cluster

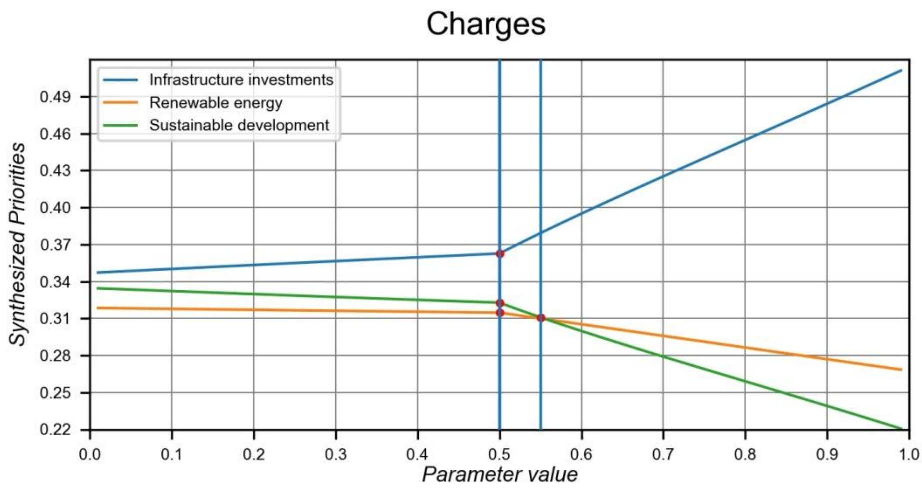


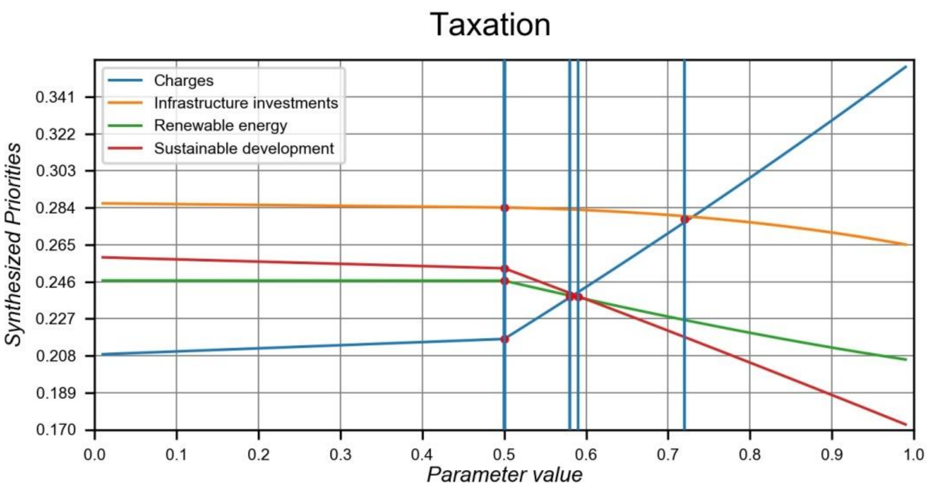


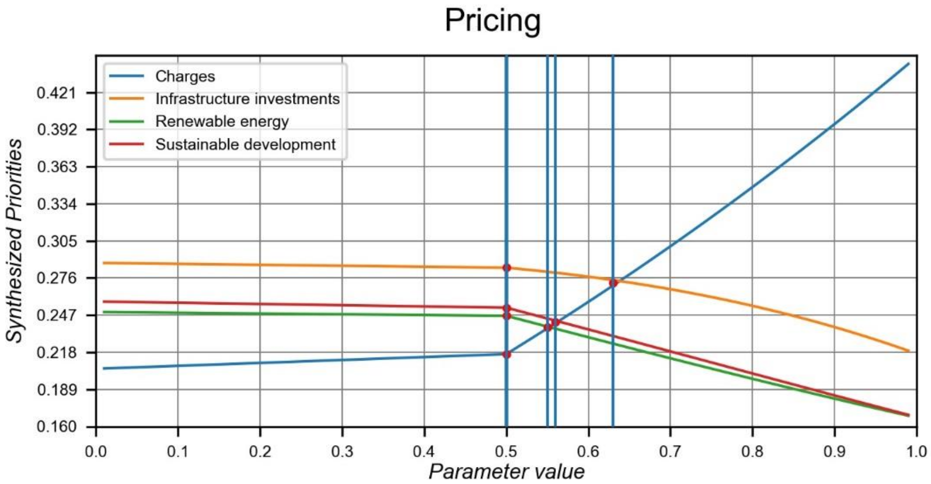


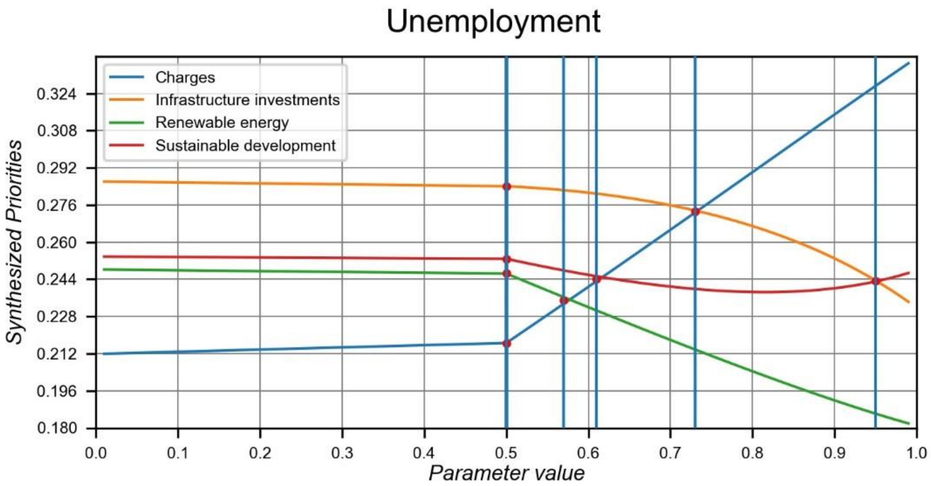


Megatrends vs Megatrends in environmental cluster

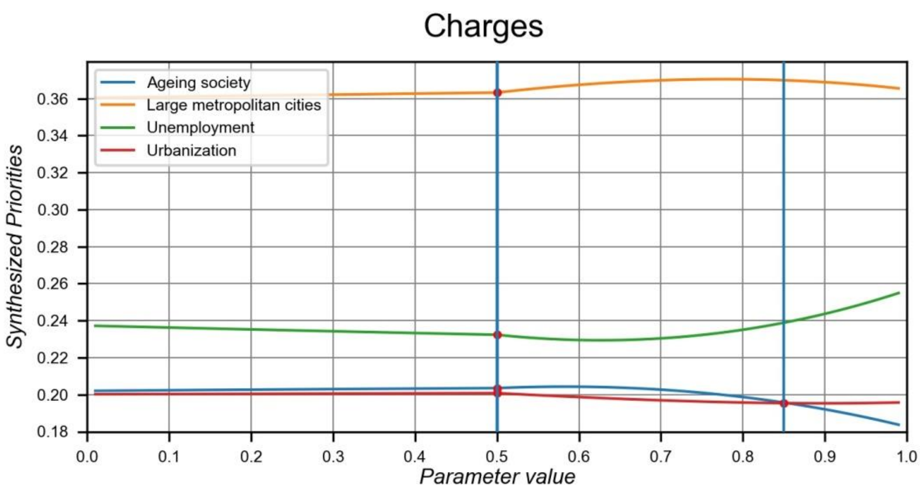


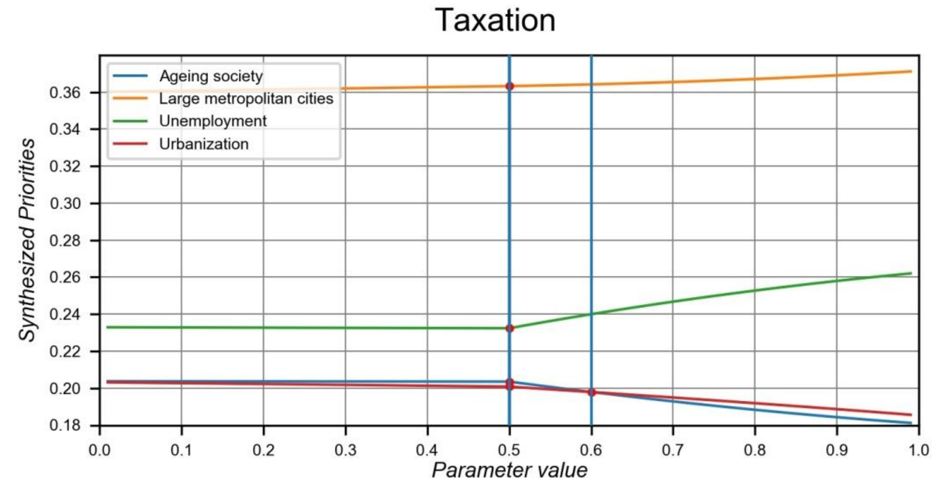


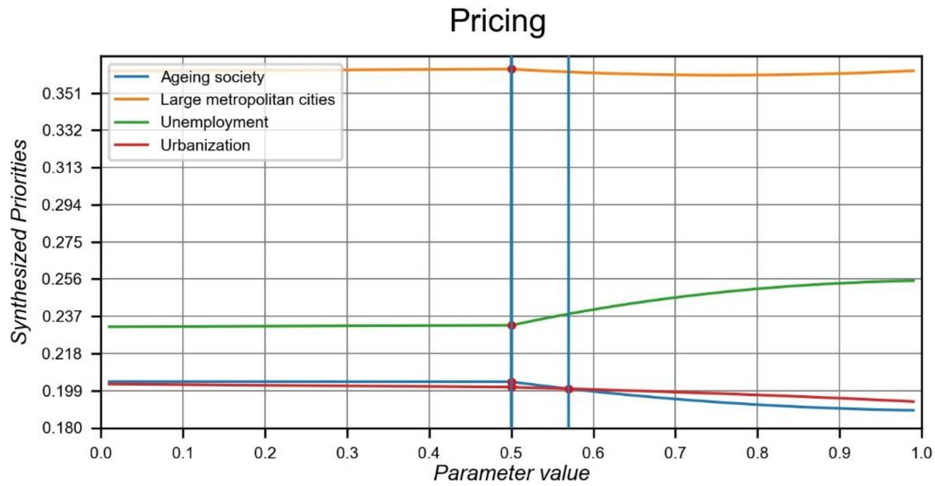


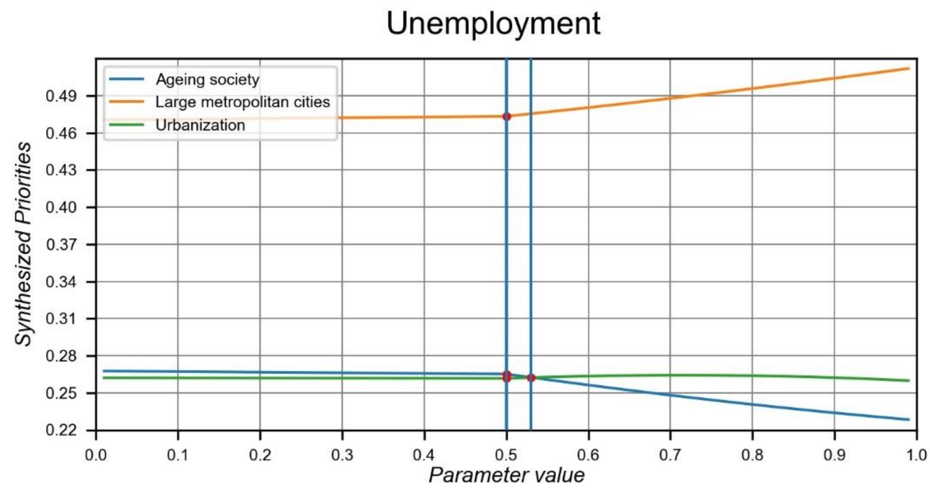


Megatrends vs Megatrends in social cluster



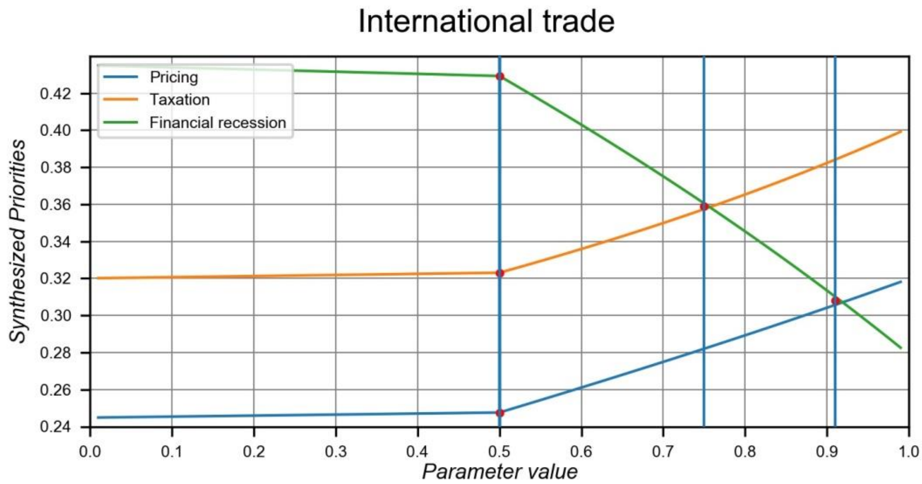

Taxation
Ageing society
Large metropolitan cities
Unemployment
Urbanization
Synthesized Priorities
Parameter value


Pricing
Ageing society
Large metropolitan cities
Unemployment
Urbanization
Synthesized Priorities
Parameter value

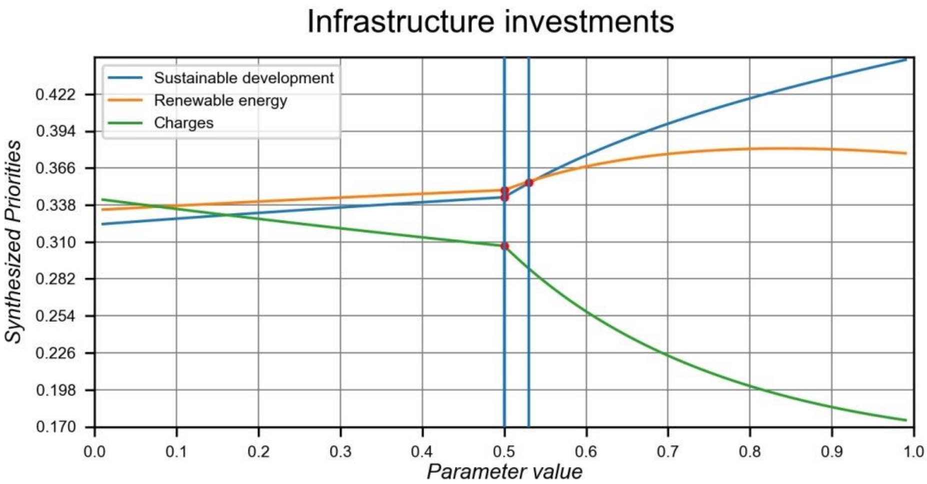

Unemployment
Ageing society
Large metropolitan cities
Urbanization
Synthesized Priorities
Parameter value

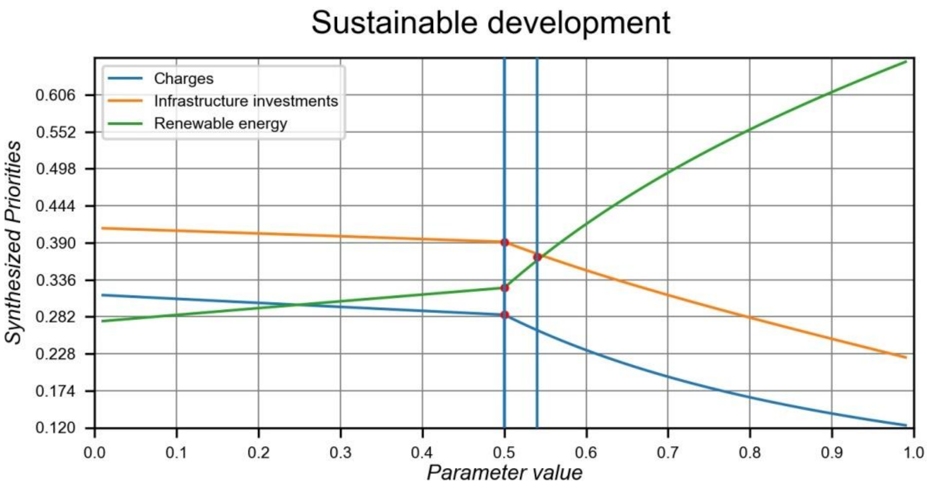
Policy makers group

Megatrends vs Megatrends in economy cluster

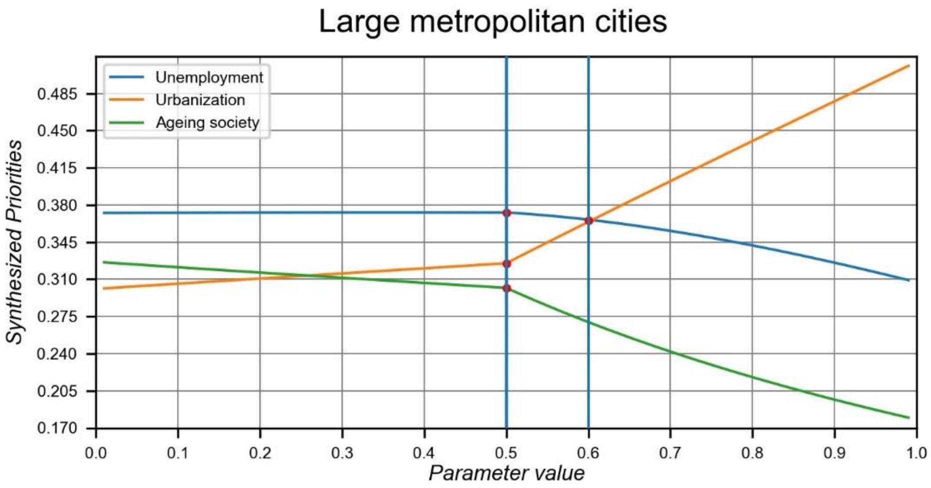


Megatrends vs Megatrends in environmental cluster



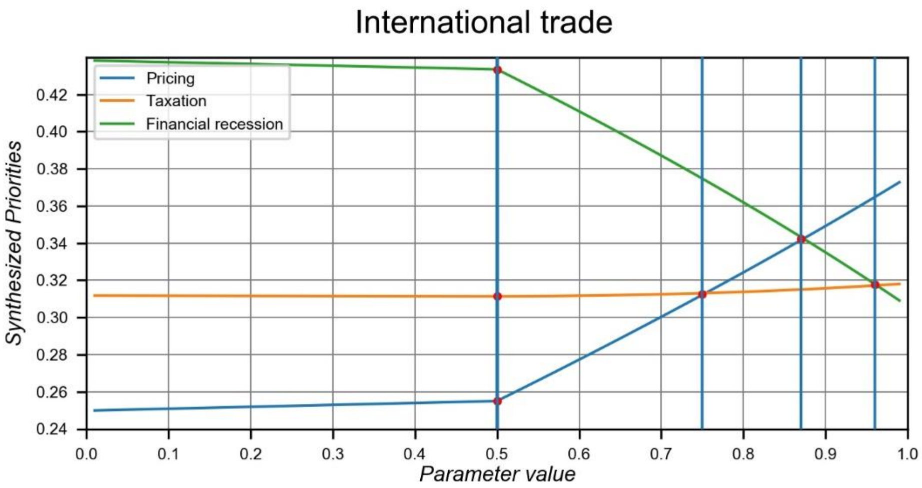


Megatrends vs Megatrends in social cluster

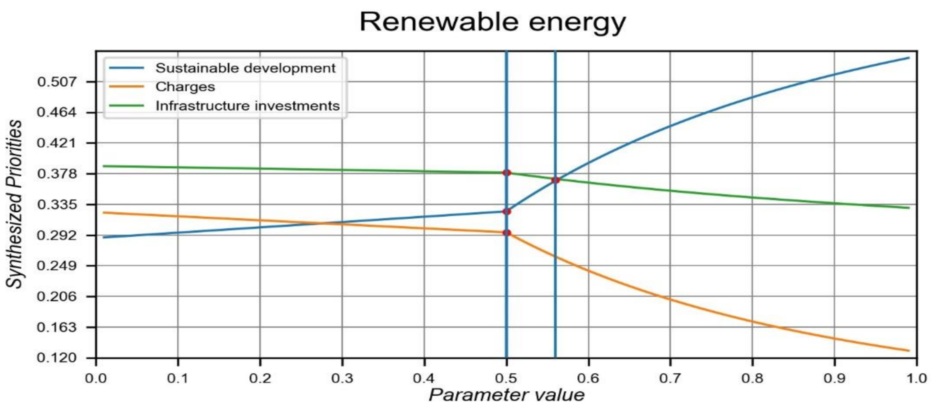


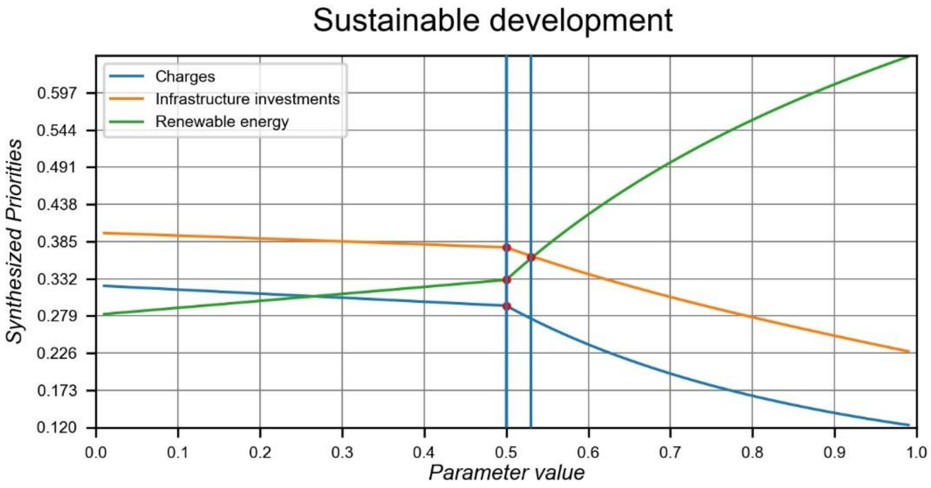
Industry group

Megatrends vs Megatrends in economy cluster

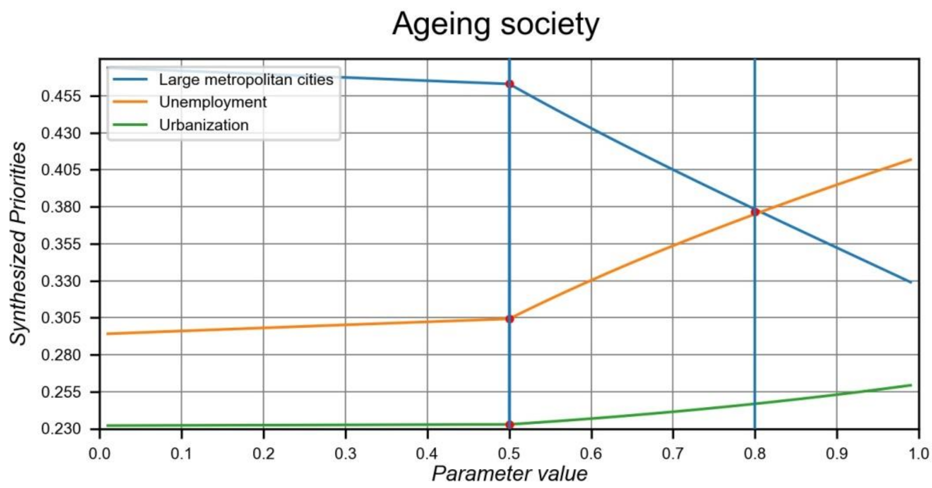


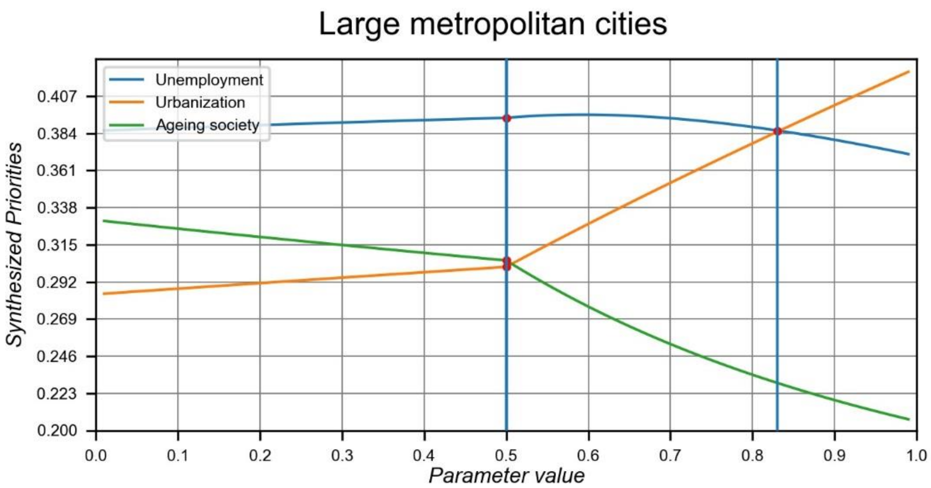
Megatrends vs Megatrends in environmental cluster

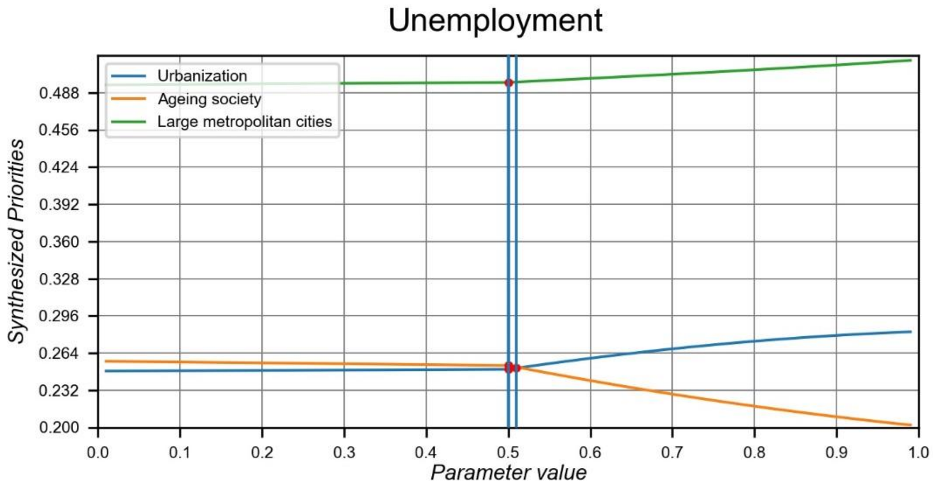




Megatrends vs Megatrends in social cluster

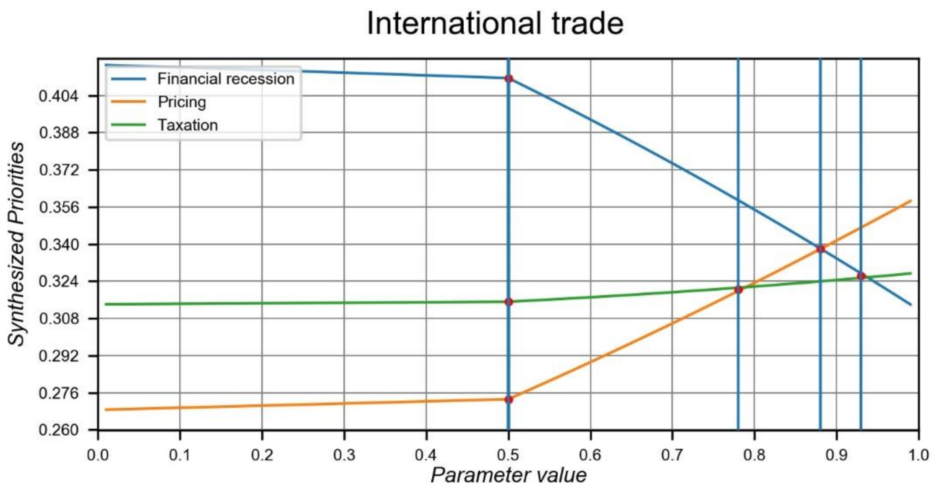




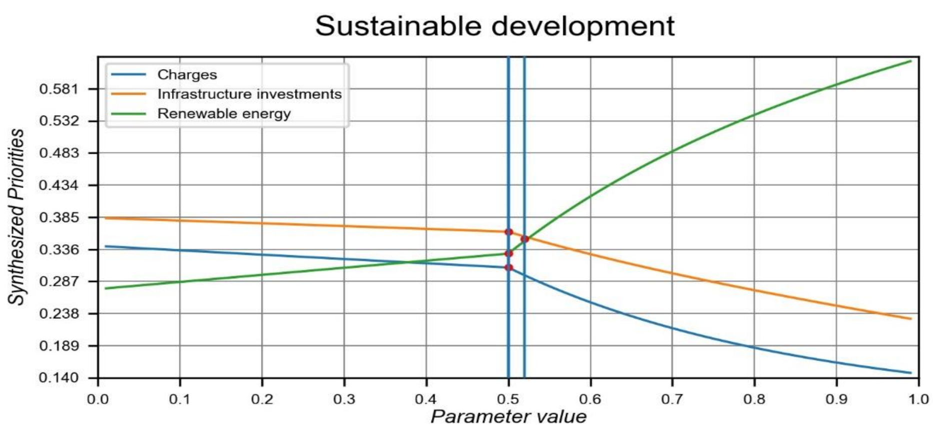


Academia group

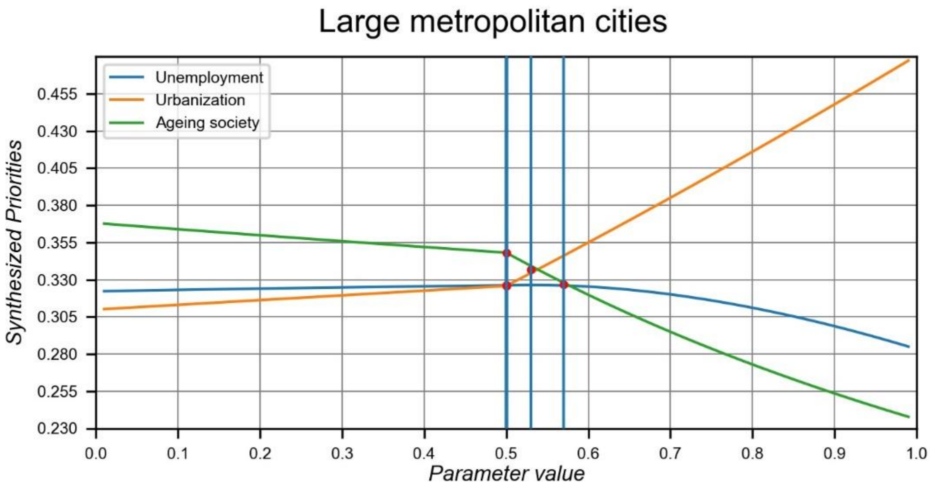
Megatrends vs Megatrends in economy cluster

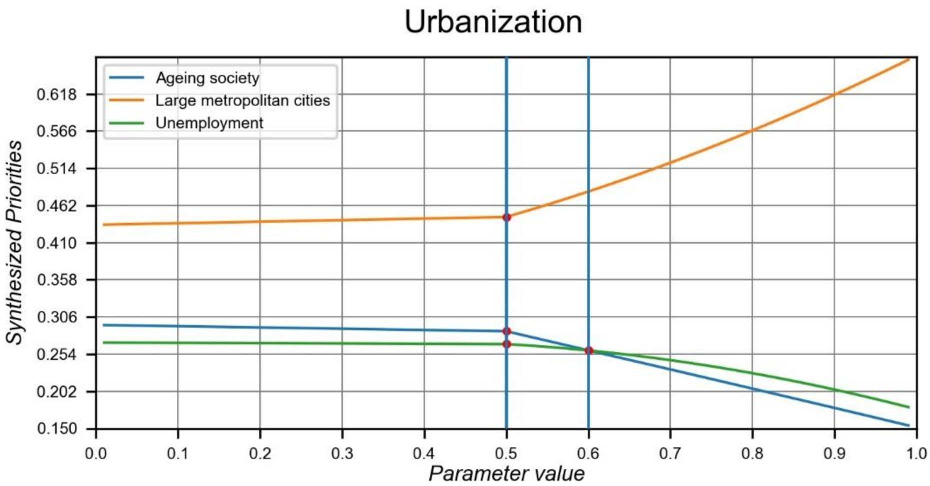


Megatrends vs Megatrends in environmental cluster



Megatrends vs Megatrends in social cluster





ANNEX C- KRUSKAL WALLIS TEST

Kruskal-Wallis Test: Ageing society versus Transport mode experience

Kruskal-Wallis Test on Ageing society

Transport mode experience	**N**	**Median**	**Ave Rank**	**Z**
All/Cross modal	8	4.000	18.4	-0.18
Surface	23	6.000	18.9	-0.08
Water	6	4.500	20.3	031
Overall	37		19.00	
H = 0.11 DF = 2 P = 0.947 H = 0.11 DF = 2 P = 0.946 (adjusted for ties)				

Kruskal-Wallis Test: Development of l versus Transport mode experience

Kruskal-Wallis Test on Development of large metropolitan cities

Transport mode experience	**N**	**Median**	**Ave Rank**	**Z**
All/Cross modal	8	2.500	19.0	0.00
Surface	23	2.000	18.8	-0.16
Water	6	2.000	19.8	0.21
Overall	37		19.0	
H = 0.04 DF = 2 P = 0.978 H = 0.05 DF = 2 P = 0.977 (adjusted for ties)				

Kruskal-Wallis Test: Urbanisation versus Transport mode experience

Kruskal-Wallis Test on Urbanisation

Transport mode experience	**N**	**Median**	**Ave Rank**	**Z**
All/Cross modal	8	4.000	18.6	-0.11

Surface	23	5.000	20.0	0.75
Water	6	3.000	15.5	-0.87
Overall	37		19.0	
H = 0.85 DF = 2 P = 0.654 H = 0.86 DF = 2 P = 0.649 (adjusted for ties)				

Kruskal-Wallis Test: Financial recess versus Transport mode experience

Kruskal-Wallis Test on Financial recession

Transport mode experience	N	Median	Ave Rank	Z
All/Cross modal	8	9.000	23.8	1.42
Surface	23	5.000	16.1	-2.07
Water	6	8.000	23.6	1.13
Overall	37		19.0	
H = 4.27 DF = 2 P = 0.118 H = 4.34 DF = 2 P = 0.114 (adjusted for ties)				

Kruskal-Wallis Test: Unemployment rate versus Transport mode experience

Kruskal-Wallis Test on Unemployment rate

Transport mode experience	N	Median	Ave Rank	Z
All/Cross modal	8	7.000	18.3	-0.22
Surface	23	6.000	18.7	-0.25
Water	6	7.500	21.3	0.58
Overall	37		19.00	
H = 0.34 DF = 2 P = 0.843 H = 0.35 DF = 2 P = 0.841 (adjusted for ties)				

Kruskal-Wallis Test: International Tr versus Transport mode experience

Kruskal-Wallis Test on International Trade

Transport mode experience	N	Median	Ave Rank	Z
All/Cross modal	8	10.500	19.6	0.17
Surface	23	11.000	20.2	0.85
Water	6	7.000	13.8	-1.30
Overall	37		19.0	
H = 1.70 DF = 2 P = 0.427 H = 1.80 DF = 2 P = 0.407 (adjusted for ties)				

Kruskal-Wallis Test: Sustainable Deve versus Transport mode experience

Kruskal-Wallis Test on Sustainable Development

Transport mode experience	N	Median	Ave Rank	Z
All/Cross modal	8	5.500	15.4	-1.07
Surface	23	8.00	21.9	2.11
Water	6	4.500	12.6	-1.59
Overall	37		19	
H = 4.70 DF = 2 P = 0.096 H = 4.75 DF = 2 P = 0.093 (adjusted for ties)				

Kruskal-Wallis Test: Renewable energy versus Transport mode experience

Kruskal-Wallis Test on Renewable energy options

Transport mode experience	N	Median	Ave Rank	Z
All/Cross modal	8	7.000	19.1	0.04
Surface	23	8.000	20.4	1.00
Water	6	5.500	13.5	-1.36
Overall	37		19	
H = 1.93 DF = 2 P = 0.381 H = 1.96 DF = 2 P = 0.375 (adjusted for ties)				

Kruskal-Wallis Test: Charges versus Transport mode experience

Kruskal-Wallis Test on Charges

Transport mode experience	N	Median	Ave Rank	Z
All/Cross modal	8	7.500	21.4	0.72
Surface	23	7.000	18.2	-0.55
Water	6	8.500	18.7	-0.08
Overall	37		19.0	
H = 0.53 DF = 2 P = 0.769 H = 0.53 DF = 2 P = 0.766 (adjusted for ties)				

Kruskal-Wallis Test: Inadequate infra versus Transport mode experience

Kruskal-Wallis Test on Inadequate infrastructure

Transport mode experience	N	Median	Ave Rank	Z
All/Cross modal	8	5.500	15.7	-0.98
Surface	23	7.000	19.4	0.27
Water	6	7.500	22.0	0.74
Overall	37		19	
H = 1.24 DF = 2 P = 0.539 H = 1.25 DF = 2 P = 0.534 (adjusted for ties)				

Kruskal-Wallis Test: Taxation of fuels versus Transport mode experience

Kruskal-Wallis Test on Taxation of fuels

Transport mode experience	N	Median	Ave Rank	Z
All/Cross modal	8	7.000	17.8	-0.37
Surface	23	7.000	18.8	-0.16
Water	6	8.500	21.5	0.62
Overall	37		19.0	
H = 0.44 DF = 2 P = 0.804 H = 0.44 DF = 2 P = 0.802 (adjusted for ties)				

Kruskal-Wallis Test: Pricing versus Transport mode experience

Kruskal-Wallis Test on Pricing

Transport mode experience	**N**	**Median**	**Ave Rank**	**Z**
All/Cross modal	8	5.000	14.9	-1.22
Surface	23	6.000	17.6	-1.02
Water	6	11.500	29.9	2.70
Overall	37		19.0	
H = 7.66 DF = 2 P = 0.022 H = 7.75 DF = 2 P = 0.021 (adjusted for ties)				

ANNEX D- DELPHI QUESTIONNAIRES

D.1 First questionnaire

CONSENT FORM

Full title of Project:
Towards sustainable mobility in Europe: key Megatrends that affect passenger mobility in the medium and long term

Name, position and contact address of Researcher:
Content removed on data protection grounds

Instructions for participants

Thank you for agreeing to complete this questionnaire, which will provide important information on future mobility trends.
This is an online questionnaire whose objective is to collect experts' opinions on the importance of critical factors in terms of their impacts on passenger mobility;

This questionnaire consists of 11 groups of factors, which relate to the following influential areas:

Demographics;
Behaviour;
Spatial organisation;
Economy;
Social structures;
Globalisation;
Environment;
Institutional structures and policies
Transport policies
Information and Communication Technologies;
Vehicle Technologies ;

We kindly ask you to rate the importance of each factor, in terms of its impact on sustainable passenger mobility, from a range of 1 (little importance) to 5 (great importance);
If you have no idea/opinion on the importance of a specific factor please simply tick the "0" box.
Since we have only provided, for each influential area, a selection of critical factors, at the end of the list of each group there is an 'Other Factors' section to allow you to suggest/identify other factors that you might consider critical that were not already included in the original list.

Demographics

Please rate the factors (1 not important, 5 very important, 0 no opinion)

1. Factors related to demographics

	Importance					
	1	**2**	**3**	**4**	**5**	**0**
a. Migration	☐	☐	☐	☐	☐	☐
b. Ageing	☐	☐	☐	☐	☐	☐
c. Fertility and birth rates	☐	☐	☐	☐	☐	☐

2. If you believe there are some other factors of high importance that we have missed please add them *(Optional)*

Behaviour

Please rate the importance of each factor (1 not important, 5 very important, 0 no opinion)

3. Factors related to behaviour

	Importance					
	1	**2**	**3**	**4**	**5**	**0**
a. Resistance to accept emerging technologies	☐	☐	☐	☐	☐	☐
b. Environmental concern	☐	☐	☐	☐	☐	☐
c. Data privacy	☐	☐	☐	☐	☐	☐
d. Compliance with the legislation	☐	☐	☐	☐	☐	☐

4. If you believe there are some other factors of high importance that we have missed please add them *(Optional)*

Spatial organisation

Please rate the factors (1 not important, 5 very important, 0 no opinion)

5. Critical factors for spatial organisation

	Importance					
	1	**2**	**3**	**4**	**5**	**0**
a. Urbanisation	☐	☐	☐	☐	☐	☐
b. Development of large metropolitan areas	☐	☐	☐	☐	☐	☐
c. Urban sprawl	☐	☐	☐	☐	☐	☐

6. If you believe there are some other factors of high importance that we have missed please add them *(Optional)*

Continue >

Economy

Please rate the factors (1 not important, 5 very important, 0 no opinion)

7. Critical factors related to economy

	Importance					
	1	**2**	**3**	**4**	**5**	**0**
a. Financial recession	☐	☐	☐	☐	☐	☐
b. Market competition	☐	☐	☐	☐	☐	☐
c. Geographic distribution of production and activities	☐	☐	☐	☐	☐	☐

8. If you believe there are some other factors of high importance that we have missed please add them *(Optional)*

Social Structures

Please rate the factors (1 not important, 5 very important, 0 no opinion)

9. Factors related to Social Structures

	Importance					
	1	**2**	**3**	**4**	**5**	**0**
a. Unemployment rate	☐	☐	☐	☐	☐	☐
b. Unequal distribution of wealth	☐	☐	☐	☐	☐	☐
c. Flexible working	☐	☐	☐	☐	☐	☐
d. Women's increased role in the economy	☐	☐	☐	☐	☐	☐
e. Working conditions and legislation	☐	☐	☐	☐	☐	☐

10. If you believe there are some other factors of high importance that we have missed please add them *(Optional)*

Globalisation

Please rate the factors (1 not important, 5 very important, 0 no opinion)

11. Factors related to Globalization

	Importance					
	1	2	3	4	5	0
a. Shortage of energy resources	☐	☐	☐	☐	☐	☐
b. Global regulation gaps	☐	☐	☐	☐	☐	☐
c. (Re)distribution of income and wealth	☐	☐	☐	☐	☐	☐
d. Economic & political conflicts (contrasting interests)	☐	☐	☐	☐	☐	☐
e. International trade	☐	☐	☐	☐	☐	☐
f. Higher competition	☐	☐	☐	☐	☐	☐

12. If you believe there are some other factors of high importance that we have missed please add them *(Optional)*

Enviroment

Please rate the factors (1 not important, 5 very important, 0 no opinion)

13. Factors related to environment

	Importance					
	1	**2**	**3**	**4**	**5**	**0**
a. Energy use levels	☐	☐	☐	☐	☐	☐
b. Sustainable development	☐	☐	☐	☐	☐	☐
c. Renewable energy options	☐	☐	☐	☐	☐	☐
d. Energy prices	☐	☐	☐	☐	☐	☐

14. If you believe there are some other factors of high importance that we have missed please add them *(Optional)*

Institutional structures and policies

Please rate the factors (1 not important, 5 very important, 0 no opinion)

15. Factors related to institutional structures and policies

	Importance					
	1	**2**	**3**	**4**	**5**	**0**
a. Cohesion policy	☐	☐	☐	☐	☐	☐
b. EU enlargement	☐	☐	☐	☐	☐	☐
c. Participation of citizens in decision making	☐	☐	☐	☐	☐	☐
d. Allocation of power (centralized or decentralized)	☐	☐	☐	☐	☐	☐

16. If you believe there are some other factors of high importance that we have missed please add them *(Optional)*

Transport policies

Please rate the factors (1 not important, 5 very important, 0 no opinion)

17. Factors related to transport policies

	Importance					
	1	**2**	**3**	**4**	**5**	**0**
a. Traffic law	☐	☐	☐	☐	☐	☐
b. Internalisation of externalities (e.g. carbon taxes)	☐	☐	☐	☐	☐	☐
c. Subsidies and incentives (e.g. scrapping schemes)	☐	☐	☐	☐	☐	☐
d. Inadequate infrastructure investments	☐	☐	☐	☐	☐	☐
e. Encouragement of public-private partnerships	☐	☐	☐	☐	☐	☐
f. Opening of transport markets to competition	☐	☐	☐	☐	☐	☐
g. Pricing (eg for parking and motorways)	☐	☐	☐	☐	☐	☐
h. Charges (e.g. for congestion)	☐	☐	☐	☐	☐	☐
i. Governments' support of sustainable mobility schemes	☐	☐	☐	☐	☐	☐
j. Taxation of fuels	☐	☐	☐	☐	☐	☐
k. Vehicle taxation	☐	☐	☐	☐	☐	☐

18. If you believe there are some other factors of high importance that we have missed please add them *(Optional)*

Information and Communication Technologies (ICT)

Please rate the factors (1 not important, 5 very important, 0 no opinion)

19. Factors related to ICT

	Importance					
	1	**2**	**3**	**4**	**5**	**0**
a. Diffusion and market up-take of ICT	☐	☐	☐	☐	☐	☐
b. R&D spending	☐	☐	☐	☐	☐	☐
c. Innovation performance	☐	☐	☐	☐	☐	☐
d. Improved safety	☐	☐	☐	☐	☐	☐
e. Improved traveler experience	☐	☐	☐	☐	☐	☐

20. If you believe there are some other factors of high importance that we have missed please add them *(Optional)*

Vehicle Technologies

Please rate the factors not important, 5 very important, 0 no opinion)

21. Factors related to vehicle technologies

	Importance					
	1	**2**	**3**	**4**	**5**	**0**
a. R&D spending levels	☐	☐	☐	☐	☐	☐
b. Innovation performance	☐	☐	☐	☐	☐	☐
c. Diffusion and uptake of technologies by market	☐	☐	☐	☐	☐	☐
d. Improved safety	☐	☐	☐	☐	☐	☐

22. If you believe there are some other factors of high importance that we have missed please add them *(Optional)*

Personal information

23. Country *(Optional)*

24. Transport mode experience (air, water, surface) *(Optional)*

25. Specific research experience (eg planning, engineering , modelling, etc) *(Optional)*

D. 2 Second questionnaire

CONSENT FORM

Full title of Project:
Towards sustainable mobility in Europe: key trends that will affect mobility behaviour, patterns and needs

Name, position and contact address of Researcher:
Content removed on data protection grounds

Instructions for participants

Thank you for agreeing to complete this questionnaire, which will provide important information on future mobility trends. This is the second expect online questionnaire which builds on the results of the first stage of the Delphi study. The first online questionnaire has permitted to identify the key factors affecting sustainable passenger transport mobility according to their importance

The objective of this questionnaire is to rank to the most important factors as indicated by the experts during the first round and allow us to identify the scenario variables for further investigation

The questionnaire consists of a list of 12 important factors that respond to 7 key trends (Demographics, Spatial Organisation, Economy, Social Structure, Globalisation, Environment and Transport policies) We kindly ask you to rank the factors in accordance with their importance

Ranking of key factors

1. Please rank the following factors based on their importance in terms of their impact on passenger mobility (ie 1st most important , 12th less important)

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
Ageing society												
Development of large metropolitan areas												
Urbanisation												
Financial recession												
Unemployment rate												
International Trade												
Sustainable Development												
Renewable energy options												
Charges (e.g. for congestion)												
Inadequate infrastructure investments												
Taxation of fuels												
Pricing												

Personal information

2 Country

3 Transport mode experience (air, water, surface)

4 Specific research experience (eg planning, engineering , modelling, etc)

ANNEX E- ANP QUESTIONNAIRES

E.1 First questionnaire

Introduction to the Survey

The Survey Motivation

Thank you for agreeing to complete this questionnaire, which will provide important information on future mobility trends. This questionnaire builds on the results of the first and second stage of the Delphi study where the most important Megatrends were identified.

The objective of this questionnaire is to assess whether there is a relationship between elements within the Megatrends cluster and between clusters, bearing in mind the objective of the model. This will help us identify the most predominant future scenarios

Objective of the model

- to estimate the defined sustainable mobility scenarios. Estimation means overview of the different trends and factors influence on the sustainable mobility scenarios selection. The scenarios reflect the feasibility of social, economic and ecological trends as well as factors on the future sustainable passenger mobility.

Therefore, we (pre) defined the following three scenarios:

1. All is set up - a well-planned, harmonized and is carried out (the trends are harmonized and lead to the achievement of sustainable mobility, i.e movement, habits and behavior of passengers contribute to reducing the negative effects of transport on society, economy and environment);
2. Inexhaustible - everything is possible, so that there is uncertainty in carrying out (harmonization of trends exist but distortion of harmonization is also possible and may impact the achievement of sustainable mobility)
3. Entropy - disorder, leads to "destruction", the collapse of the system (trends exist independently of each other, so that sustainable mobility cannot be attained).

Participation in the study is entirely voluntary; you can withdraw from the survey at any point of time, without giving a reason for doing so. Please be assured that the information you provide will remain strictly confidential and anonymous. Answers will be reported so that no individual or organization will be identifiable from any publication presenting the results of the survey. By responding to the questionnaire, your consent to take part in the study it is assumed and that you agree to the use of anonymised quotes in publications. Should you wish us to get in touch with you for further explanations, your email can be provided to us voluntary by completing the relevant question.

Content removed on data protection grounds

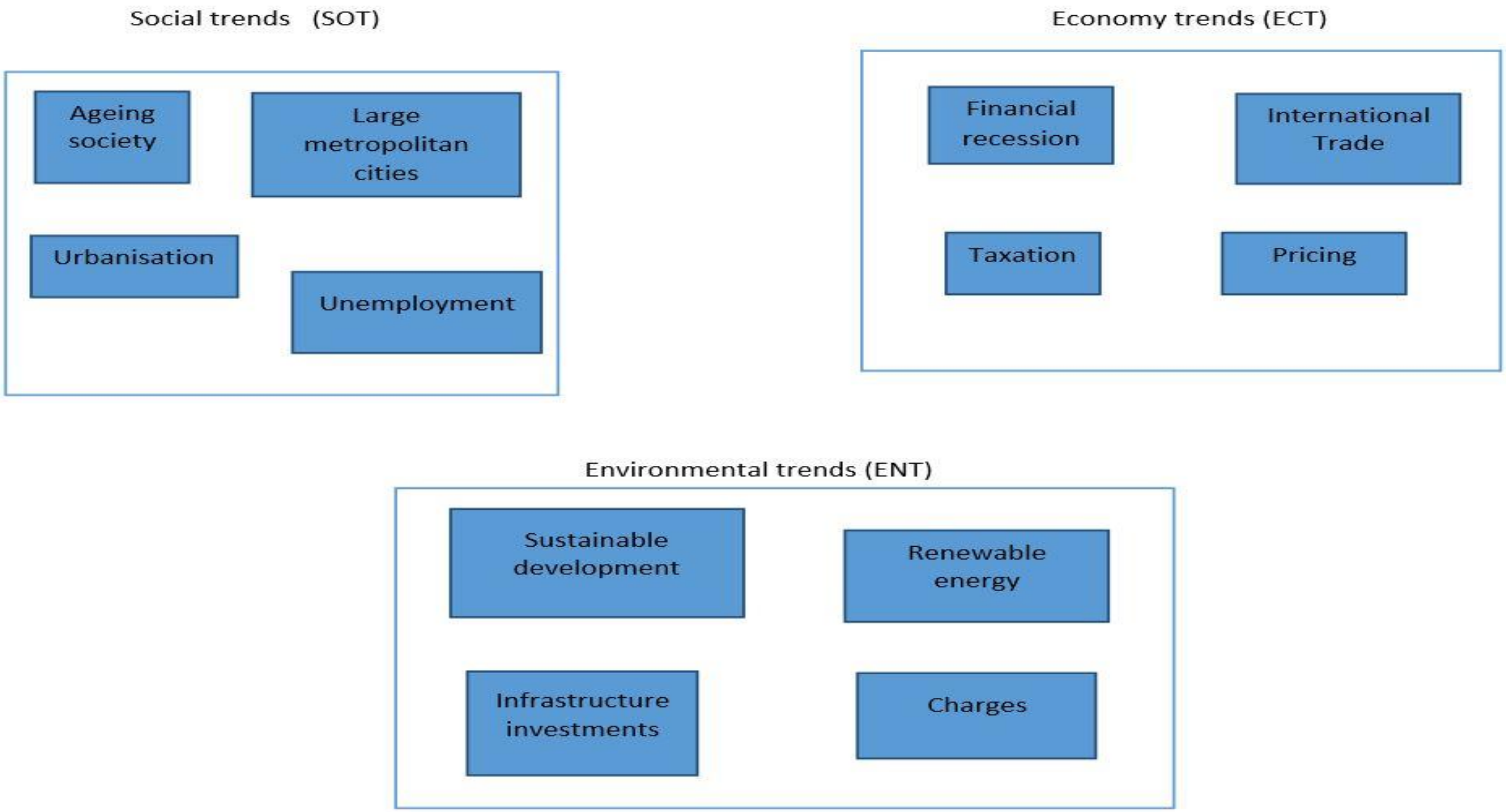
Instructions for participants

Therefore, the relationship between two elements (regardless they belong to the same or different clusters could be:

- one way (the first element in question affects the second)
- feedback (the elements affect each other, in opposite it is assumed to be YES)
- no (the first element does not affect the second)

EXAMPLE of thinking about relationship between elements regarding purpose of this model:

1. In the cluster ENT relation between *sustainable development* and *renewable energy*. It might be feedback between these factors. The use of new renewable energy sources in transport allows achieving the objective of better transport - mobility without further destruction of the biosphere and the natural environment of the earth.
2. In the cluster SOT relation between *ageing society* and *unemployment*. It might be one way relation between these factors. Demographically, the term 'ageing society' usually refers to the rising average age of a population, due to increasing numbers of older people (65 and over), increasing longevity and life expectancy and/or lower fertility (a decreasing birth rate). Living a longer, healthier life is a bonus. The 'problem' is how growing unemployment population should financially support these extra years of healthy life?


Social trends (SOT)
Ageing society
Large metropolitan cities
Urbanisation
Unemployment
Economy trends (ECT)
Financial recession
International Trade
Taxation
Pricing
Environmental trends (ENT)
Sustainable development
Renewable energy
Infrastructure investments
Charges

In the following questions, the relations between two elements, which belong to the same cluster should be estimated.

Top of Form

1 In your opinion what is the relation between elements 'Ageing society' Vs. 'Large metropolitan cities' in 'Social Trends' Cluster?

No

Feedback

One Way

2 In your opinion what is the relation between elements 'Large metropolitan cities' Vs. 'Ageing society' in 'Social Trends' Cluster?

No

One way

3 In your opinion what is the relation between elements 'Ageing society' Vs. 'Urbanisation' in 'Social Trends' Cluster?

No

Feedback

One Way

4 In your opinion what is the relation between elements 'Urbanisation' Vs. 'Ageing society' in 'Social Trends' Cluster?

No

One way

5 In your opinion what is the relation between elements 'Ageing society' Vs. 'Unemployment' in 'Social Trends' Cluster?

No

Feedback

One Way

6 In your opinion what is the relation between elements 'Unemployment' Vs. 'Ageing society' in 'Social Trends' Cluster?

No

One way

7 In your opinion what is the relation between elements 'Large metropolitan cities' Vs. 'Urbanisation' in 'Social Trends' Cluster?

No

Feedback

One Way

8 In your opinion what is the relation between elements 'Urbanisation' Vs. 'Large metropolitan cities' in 'Social Trends' Cluster?

No

One way

9 In your opinion what is the relation between elements 'Large metropolitan cities' Vs. 'Unemployment' in 'Social Trends' Cluster?

No

Feedback

One Way

10 In your opinion what is the relation between elements 'Unemployment' Vs. 'Large metropolitan cities' in 'Social Trends' Cluster?

No

One way

11 In your opinion what is the relation between elements 'Urbanisation' Vs. 'Unemployment' in 'Social Trends' Cluster?

No

Feedback

One Way

12 In your opinion what is the relation between elements 'Unemployment' Vs. 'Urbanisation' in 'Social Trends' Cluster?

No

One way

13 In your opinion what is the relation between elements 'Financial recession' Vs. 'International trade' in 'Economy Trends' Cluster?

No

Feedback

One Way

14 In your opinion what is the relation between elements 'International Trade' Vs. 'Financial recession' in 'Economy Trends' Cluster?

No

One way

15 In your opinion what is the relation between elements 'Financial recession' Vs. 'Taxation' in 'Economy Trends' Cluster?

No

Feedback

One Way

16 In your opinion what is the relation between elements 'Taxation' Vs. 'Financial recession' in 'Economy Trends' Cluster?

No

One way

17 In your opinion what is the relation between elements 'Financial recession' Vs. 'Pricing' in 'Economy Trends' Cluster?

No

Feedback

One Way

18 In your opinion what is the relation between elements 'Pricing' Vs. 'Financial recession' in 'Economy Trends' Cluster?

No

One way

19 In your opinion what is the relation between elements 'International Trade' Vs. 'Taxation' in 'Economy Trends' Cluster?

No

Feedback

One Way

20 In your opinion what is the relation between elements 'Taxation' Vs. 'International Trade' in 'Economy Trends' Cluster?

No

One way

21 In your opinion what is the relation between elements 'International Trade' Vs. 'Pricing' in 'Economy Trends' Cluster?

No

Feedback

One Way

22 In your opinion what is the relation between elements 'Pricing' Vs. 'International Trade' in 'Economy Trends' Cluster?

No

One way

23 In your opinion what is the relation between elements 'Taxation' Vs. 'Pricing' in 'Economy Trends' Cluster?

No

Feedback

One Way

24 In your opinion what is the relation between elements 'Pricing' Vs. 'Taxation' in 'Economy Trends' Cluster?

No

One way

25 In your opinion what is the relation between elements 'Sustainable development' Vs. 'Renewable energy' in 'Environmental trends' Cluster?

No

Feedback

One Way

26 In your opinion what is the relation between elements 'Renewable energy' Vs. 'Sustainable development' in 'Environmental trends' Cluster?

No

One way

27 In your opinion what is the relation between elements 'Sustainable development' Vs. 'Infrastructure investments' in 'Environmental trends' Cluster?

No

Feedback

One Way

28 In your opinion what is the relation between elements 'Infrastructure investments' Vs. 'Sustainable development' in 'Environmental trends' Cluster?

No

One way

29 In your opinion what is the relation between elements 'Sustainable development' Vs. 'Charges' in 'Environmental trends' Cluster?

No

Feedback

One Way

30 In your opinion what is the relation between elements 'Charges' Vs. 'Sustainable development' in 'Environmental trends' Cluster?

No

One way

31 In your opinion what is the relation between elements 'Renewable energy' Vs. 'Infrastructure investments' in 'Environmental trends' Cluster?

No

Feedback

One Way

32 In your opinion what is the relation between elements 'Infrastructure investments' Vs. 'Renewable energy' in 'Environmental trends' Cluster?

No

One way

33 In your opinion what is the relation between elements 'Renewable energy' Vs. 'Charges' in 'Environmental trends' Cluster?

No

Feedback

One Way

34 In your opinion what is the relation between elements 'Charges' Vs. 'Renewable energy' in 'Environmental trends' Cluster?

No

One way

35 In your opinion what is the relation between elements 'Infrastructure investments' Vs. 'Charges' in 'Environmental trends' Cluster?

No

Feedback

One Way

36 In your opinion what is the relation between elements 'Charges' Vs. 'Infrastructure investments' in 'Environmental trends' Cluster?

No

One way

In the following questions, the relations between the each element of the particular cluster should be estimated to element that belongs to other clusters.

37 In your opinion what is the relation between element 'Ageing society' that belong to the 'Social trends' Cluster and element 'Sustainable development' that belong to other clusters?

No

Feedback

One Way

38 In your opinion what is the relation between element 'Sustainable development' that belong to the 'Environmental trends' Cluster and element 'Ageing society' that belong to other clusters?

No

One way

39 In your opinion what is the relation between element 'Ageing society' that belong to the 'Social trends' Cluster and element 'Renewable energy' that belong to other clusters?

No

Feedback

One Way

40 In your opinion what is the relation between element 'Renewable energy' that belong to the 'Environmental trends' Cluster and element 'Ageing society' that belong to other clusters?

No

One way

41 In your opinion what is the relation between element 'Ageing society' that belong to the 'Social trends' Cluster and element 'Infrastructure investments' that belong to other clusters?

No

Feedback

One Way

42 In your opinion what is the relation between element 'Infrastructure investments' that belong to the 'Environmental trends' Cluster and element 'Ageing society' that belong to other clusters?

No

One way

43 In your opinion what is the relation between element 'Ageing society' that belong to the 'Social trends' Cluster and element 'Charges' that belong to other clusters?

No

Feedback

One Way

44 In your opinion what is the relation between element 'Charges' that belong to the 'Environmental trends' Cluster and element 'Ageing society' that belong to other clusters?

No

One way

45 In your opinion what is the relation between elements 'Ageing society' that belong to the 'Social trends' Cluster and element 'Financial recession' that belong to other clusters?

No

Feedback

One Way

46 In your opinion what is the relation between element 'Financial recession' that belong to the 'Economy trends' Cluster and element 'Ageing society' that belong to other clusters?

No

One way

47 In your opinion what is the relation between element 'Ageing society' that belong to the 'Social trends' Cluster and element 'International Trade' that belong to other clusters?

No

Feedback

One Way

48 In your opinion what is the relation between element 'International Trade' that belong to the 'Economy trends' Cluster and element 'Ageing society' that belong to other clusters?

No

One way

49 In your opinion what is the relation between element 'Ageing society' that belong to the 'Social trends' Cluster and element 'Taxation' that belong to other clusters?

No

Feedback

One Way

50 In your opinion what is the relation between element 'Taxation' that belong to the 'Economy trends' Cluster and element 'Ageing society' that belong to other clusters?

No

One way

51 In your opinion what is the relation between element 'Ageing society' that belong to the 'Social trends' Cluster and element 'Pricing' that belong to other clusters?

No

Feedback

One Way

52 In your opinion what is the relation between element 'Pricing' that belong to the 'Economy trends' Cluster and element 'Ageing society' that belong to other clusters?

No

One way

53 In your opinion what is the relation between element 'Large metropolitan cities' that belong to the 'Social trends' Cluster and element 'Sustainable development' that belong to other clusters?

No

Feedback

One Way

54 In your opinion what is the relation between element 'Sustainable development' that belong to the 'Environmental trends' Cluster and element 'Large metropolitan cities' that belong to other clusters?

No

One way

55 In your opinion what is the relation between element 'Large metropolitan cities' that belong to the 'Social trends' Cluster and element 'Renewable energy' that belong to other clusters?

No

Feedback

One Way

56 In your opinion what is the relation between element 'Renewable energy' that belong to the 'Environmental trends' Cluster and element 'Large metropolitan cities' that belong to other clusters?

No

One way

57 In your opinion what is the relation between element 'Large metropolitan cities' that belong to the 'Social trends' Cluster and element 'Infrastructure investments' that belong to other clusters?

No

Feedback

One Way

58 In your opinion what is the relation between element 'Infrastructure investments' that belong to the 'Environmental trends' Cluster and element 'Large metropolitan cities' that belong to other clusters?

No

One way

59 In your opinion what is the relation between element 'Large metropolitan cities' that belong to the 'Social trends' Cluster and element 'Charges' that belong to other clusters?

No

Feedback

One Way

60 In your opinion what is the relation between element 'Charges' that belong to the 'Environmental trends' Cluster and element 'Large metropolitan cities' that belong to other clusters?

No

One way

61 In your opinion what is the relation between element 'Large metropolitan cities' that belong to the 'Social trends' Cluster and element 'Financial recession' that belong to other clusters?

No

Feedback

One Way

62 In your opinion what is the relation between element 'Financial recession' that belong to the 'Economy trends' Cluster and element 'Large metropolitan cities' that belong to other clusters?

No

One way

63 In your opinion what is the relation between element 'Large metropolitan cities' that belong to the 'Social trends' Cluster and element 'International Trade' that belong to other clusters?

No

Feedback

One Way

64 In your opinion what is the relation between element 'International Trade' that belong to the 'Economy trends' Cluster and element 'Large metropolitan cities' that belong to other clusters?

No

One way

65 In your opinion what is the relation between element 'Large metropolitan cities' that belong to the 'Social trends' Cluster and element 'Taxation' that belong to other clusters?

No

Feedback

One Way

66 In your opinion what is the relation between element 'Taxation' that belong to the 'Economy trends' Cluster and element 'Large metropolitan cities' that belong to other clusters?

No

One way

67 In your opinion what is the relation between element 'Large metropolitan cities' that belong to the 'Social trends' Cluster and element 'Pricing' that belong to other clusters?

No

Feedback

One Way

68 In your opinion what is the relation between element 'Pricing' that belong to the 'Economy trends' Cluster and element 'Large metropolitan cities' that belong to other clusters?

No

One way

69 In your opinion what is the relation between element 'Urbanisation' that belong to the 'Social trends' Cluster and element 'Sustainable development' that belong to other clusters?

No

Feedback

One Way

70 In your opinion what is the relation between element 'Sustainable development' that belong to the 'Environmental trends' Cluster and element 'Urbanisation' that belong to other clusters?

No

One way

71 In your opinion what is the relation between element 'Urbanisation' that belong to the 'Social trends' Cluster and element 'Renewable energy' that belong to other clusters?

No

Feedback

One Way

72 In your opinion what is the relation between element 'Renewable energy' that belong to the 'Environmental trends' Cluster and element 'Urbanisation' that belong to other clusters?

No

One way

73 In your opinion what is the relation between element 'Urbanisation' that belong to the 'Social trends' Cluster and element 'Infrastructure investments' that belong to other clusters?

No

Feedback

One Way

74 In your opinion what is the relation between element 'Infrastructure investments' that belong to the 'Environmental trends' Cluster and element 'Urbanisation' that belong to other clusters?

No

One way

75 In your opinion what is the relation between element 'Urbanisation' that belong to the 'Social trends' Cluster and element 'Charges' that belong to other clusters?

No

Feedback

One Way

76 In your opinion what is the relation between element 'Charges' that belong to the 'Environmental trends' Cluster and element 'Urbanisation' that belong to other clusters?

No

One way

77 In your opinion what is the relation between element 'Urbanisation' that belong to the 'Social trends' Cluster and element 'Financial recession' that belong to other clusters?

No

Feedback

One Way

78 In your opinion what is the relation between element 'Financial recession' that belong to the 'Economy trends' Cluster and element 'Urbanisation' that belong to other clusters?

No

One way

79 In your opinion what is the relation between element 'Urbanisation' that belong to the 'Social trends' Cluster and element 'International Trade' that belong to other clusters?

No

Feedback

One Way

80 In your opinion what is the relation between element 'International Trade' that belong to the 'Economy trends' Cluster and element 'Urbanisation' that belong to other clusters?

No

One way

81 In your opinion what is the relation between element 'Urbanisation' that belong to the 'Social trends' Cluster and element 'Taxation' that belong to other clusters?

No

Feedback

One Way

82 In your opinion what is the relation between element 'Taxation' that belong to the 'Economy trends' Cluster and element 'Urbanisation' that belong to other clusters?

No

One way

83 In your opinion what is the relation between element 'Urbanisation' that belong to the 'Social trends' Cluster and element 'Pricing' that belong to other clusters?

No

Feedback

One Way

84 In your opinion what is the relation between element 'Pricing' that belong to the 'Economy trends' Cluster and element 'Urbanisation' that belong to other clusters?

No

One way

85 In your opinion what is the relation between element 'Unemployment' that belong to the 'Social trends' Cluster and element 'Sustainable development' that belong to other clusters?

No

Feedback

One Way

86 In your opinion what is the relation between element 'Sustainable development' that belong to the 'Environmental trends' Cluster and element 'Unemployment' that belong to other clusters?

No

One way

87 In your opinion what is the relation between element 'Unemployment' that belong to the 'Social trends' Cluster and element 'Renewable energy' that belong to other clusters?

No

Feedback

One Way

88 In your opinion what is the relation between element 'Renewable energy' that belong to the 'Environmental trends' Cluster and element 'Unemployment' that belong to other clusters?

No

One way

89 In your opinion what is the relation between element 'Unemployment' that belong to the 'Social trends' Cluster and element 'Infrastructure investments' that belong to other clusters?

No

Feedback

One Way

90 In your opinion what is the relation between element 'Infrastructure investments' that belong to the 'Environmental trends' Cluster and element 'Unemployment' that belong to other clusters?

No

One way

91 In your opinion what is the relation between element 'Unemployment' that belong to the 'Social trends' Cluster and element 'Charges' that belong to other clusters?

No

Feedback

One Way

92 In your opinion what is the relation between element 'Charges' that belong to the 'Environmental trends' Cluster and element 'Unemployment' that belong to other clusters?

No

One way

93 In your opinion what is the relation between element 'Unemployment' that belong to the 'Social trends' Cluster and element 'Financial recession' that belong to other clusters?

No

Feedback

One Way

94 In your opinion what is the relation between element 'Financial recession' that belong to the 'Economy trends' Cluster and element 'Unemployment' that belong to other clusters?

No

One way

95 In your opinion what is the relation between element 'Unemployment' that belong to the 'Social trends' Cluster and element 'International Trade' that belong to other clusters?

No

Feedback

One Way

96 In your opinion what is the relation between element 'International Trade' that belong to the 'Economy trends' Cluster and element 'Unemployment' that belong to other clusters?

No

One way

97 In your opinion what is the relation between element 'Unemployment' that belong to the 'Social trends' Cluster and element 'Taxation' that belong to other clusters?

No

Feedback

One Way

98 In your opinion what is the relation between element 'Taxation' that belong to the 'Economy trends' Cluster and element 'Unemployment' that belong to other clusters?

No

One way

99 In your opinion what is the relation between element 'Unemployment' that belong to the 'Social trends' Cluster and element 'Pricing' that belong to other clusters?

No

Feedback

One Way

100 In your opinion what is the relation between element 'Pricing' that belong to the 'Economy trends' Cluster and element 'Unemployment' that belong to other clusters?

No

One way

101 In your opinion what is the relation between element 'Sustainable development' that belong to the 'Environmental trends' Cluster and element 'Financial recession' that belong to other clusters?

No

Feedback

One Way

102 In your opinion what is the relation between element 'Financial recession' that belong to the 'Economy trends' Cluster and element 'Sustainable development' that belong to other clusters?

No

One way

103 In your opinion what is the relation between element 'Sustainable development' that belong to the 'Environmental trends' Cluster and element 'International Trade' that belong to other clusters?

No

Feedback

One Way

104 In your opinion what is the relation between element 'International Trade' that belong to the 'Economy trends' Cluster and element 'Sustainable development' that belong to other clusters?

No

One way

105 In your opinion what is the relation between element 'Sustainable development' that belong to the 'Environmental trends' Cluster and element 'Taxation' that belong to other clusters?

No

Feedback

One Way

106 In your opinion what is the relation between element 'Taxation' that belong to the 'Economy trends' Cluster and element 'Sustainable development' that belong to other clusters?

No

One way

107 In your opinion what is the relation between element 'Sustainable development' that belong to the 'Environmental trends' Cluster and element 'Pricing' that belong to other clusters?

No

Feedback

One Way

108 In your opinion what is the relation between element 'Pricing' that belong to the 'Economy trends' Cluster and element 'Sustainable development' that belong to other clusters?

No

One way

109 In your opinion what is the relation between element 'Renewable energy' that belong to the 'Environmental trends' Cluster and element 'Financial recession' that belong to other clusters?

No

Feedback

One Way

110 In your opinion what is the relation between element 'Financial recession' that belong to the 'Economy trends' Cluster and element 'Renewable energy' that belong to other clusters?

No

One way

111 In your opinion what is the relation between element 'Renewable energy' that belong to the 'Environmental trends' Cluster and element 'International Trade' that belong to other clusters?

No

Feedback

One Way

112 In your opinion what is the relation between element 'International Trade' that belong to the 'Economy trends' Cluster and element 'Renewable energy' that belong to other clusters?

No

One way

113 In your opinion what is the relation between element 'Renewable energy' that belong to the 'Environmental trends' Cluster and element 'Taxation' that belong to other clusters?

No

Feedback

One Way

114 In your opinion what is the relation between element 'Taxation' that belong to the 'Economy trends' Cluster and element 'Renewable energy' that belong to other clusters?

No

One way

115 In your opinion what is the relation between element 'Renewable energy' that belong to the 'Environmental trends' Cluster and element 'Pricing' that belong to other clusters?

No

Feedback

One Way

116 In your opinion what is the relation between element 'Pricing' that belong to the 'Economy trends' Cluster and element 'Renewable energy' that belong to other clusters?

No

One way

117 In your opinion what is the relation between element 'Infrastructure investments' that belong to the 'Environmental trends' Cluster and element 'Financial recession' that belong to other clusters?

No

Feedback

One Way

118 In your opinion what is the relation between element 'Financial recession' that belong to the 'Economy trends' Cluster and element 'Infrastructure investments' that belong to other clusters?

No

One way

119 In your opinion what is the relation between element 'Infrastructure investments' that belong to the 'Environmental trends' Cluster and element 'International Trade' that belong to other clusters?

No

Feedback

One Way

120 In your opinion what is the relation between element 'International Trade' that belong to the 'Economy trends' Cluster and element 'Infrastructure investments' that belong to other clusters?

No

One way

121 In your opinion what is the relation between element 'Infrastructure investments' that belong to the 'Environmental trends' Cluster and element 'Taxation' that belong to other clusters?

No

Feedback

One Way

122 In your opinion what is the relation between element 'Taxation' that belong to the 'Economy trends' Cluster and element 'Infrastructure investments' that belong to other clusters?

No

One way

123 In your opinion what is the relation between element 'Infrastructure investments' that belong to the 'Environmental trends' Cluster and element 'Pricing' that belong to other clusters?

No

Feedback

One Way

124 In your opinion what is the relation between element 'Pricing' that belong to the 'Economy trends' Cluster and element 'Infrastructure investments' that belong to other clusters?

Top of Form

No

One way

125 In your opinion what is the relation between element 'Charges' that belong to the 'Environmental trends' Cluster and element 'Financial recession' that belong to other clusters?

No

Feedback

One Way

126 In your opinion what is the relation between element 'Financial recession' that belong to the 'Economy trends' Cluster and element 'Charges' that belong to other clusters?

No

One way

127 In your opinion what is the relation between element 'Charges' that belong to the 'Environmental trends' Cluster and element 'International Trade' that belong to other clusters?

No

Feedback

One Way

128 In your opinion what is the relation between element 'International Trade' that belong to the 'Economy trends' Cluster and element 'Charges' that belong to other clusters?

No

One way

129 In your opinion what is the relation between element 'Charges' that belong to the 'Environmental trends' Cluster and element 'Taxation' that belong to other clusters?

No

Feedback

One Way

130 In your opinion what is the relation between element 'Taxation' that belong to the 'Economy trends' Cluster and element 'Charges' that belong to other clusters?

No

One way

131 In your opinion what is the relation between element 'Charges' that belong to the 'Environmental trends' Cluster and element 'Pricing' that belong to other clusters?

No

Feedback

One Way

132 In your opinion what is the relation between element 'Pricing' that belong to the 'Economy trends' Cluster and element 'Charges' that belong to other clusters?

No

One Way

133 Please indicate the group that you belong:

Academia

Industry

Policy-maker

134 Please, enter the name of the country you are coming from (optional)

Thank you very much for your participation in this research.

E. 2 Second questionnaire

Thank you for agreeing to complete this questionnaire, which will provide important information on future mobility trends. The objective of this questionnaire is to estimate the defined sustainable mobility scenarios. Estimation means overview of the different trends and factors influence on the sustainable mobility scenarios selection. The scenarios reflect the feasibility of social, economic and ecological trends as well as factors on the future sustainable passenger mobility. Your responses will remain anonymous

TRENDS- FACTORS

	ENVIRONMENTAL	**DESCRIPTION**
1	CHARGES	Charges are aligned with the 'polluter-pays' and 'user-pays' principles to influence travel behaviour in a more environmental friedly way
2	INFRASTRUCTURE INVESTMENTS	Well-focused infrastructure expansion will help in avoiding congestion and minimize envirnomental impact. EU has an ambitious policy for the

		development of the TEN-T to ultimately achieve a single multimodal network that is both logistically efficient and environmental friendly
3	RENEWABLE ENERGY	Renewables are currently the cleanest and safest way of producing energy. Along with the technological development they form the backbone of a sustainable composition for the future
4	SUSTAINABLE DEVELOPMENT	Sustainable development is the rational use of natural resources, a use that does not compromise their ability for regeneration. Sustainable mobility is one aspect of sustainable development
	SOCIAL	**DESCRIPTION**
1	AGEING SOCIETY	An actively ageing society with relatively high income may increase mobility. Different mobility needs for elderly people may result in an adaptation process of the transport system to ensure that the needs of the elderly are addressed
2	LAGRE MERTOPOLITAN CITIES	Spatial structures have the greatest influence on the mobility sector and urban sprawl is still increasing in many European agglomerations. From a sustainable mobilit perspective, metropolitan level centralisation is more favourable than decentralized development.
3	UNEMPLOYEMENT	Unemployment may impact the demand of mobility (

		less cars, less use of public transport if it is not cheap enough, less traffic in longer distances)
4	URBANIZATION	Sufficient supply of mobility services is essential for these densely populated commercial centres with high production and service levels
	ECONOMY	**DESCRIPTION**
1	FINANCIAL RECESSION	The current financial recession reasserts the importance of putting budget accounts into a long-term sustainable path, mobility concepts should be adopted but without comprimising sustainability
2	INTERNATIONAL TRADE	Increased international trade and free movement have resulted in an GDP growth but also higher demand for mobility
3	PRICING	Correct pricing (schemes) of externalities can help passengers make the right choice just by opting for the cheaper and solution
4	TAXATION	Taxation based on environmental performance and full internalisation of GHG emission cost for all modes can

lead to sustainability

SCENARIOS	**The scenarios** reflect the harmonization (balance) and feasibility of social, economic and ecological trends. Trends are adjusted in a way to sustain a certain degree of passenger behavior influence on society, economy and environment. Different ways of trends harmonization will be defined as sustainable mobility scenarios. Therefore, we define the following three scenarios:
S1- CONFORMITY OR COHERENCE OR SIMETRY	a well-planned, harmonized and is carried out (the trends are harmonized and lead to the achievement of sustainable mobility, i.e movement, habits and behavior of passengers contribute to reducing the negative effects of transport on society, economy and environment);
S2- INEXHAUSABLE	everything is possible, so that there is uncertainty in carrying out (harmonization of trends exist but distortion of harmonization is also possible and may impact the achievement of sustainable mobility)
S3 -ENTROPY	Disorder, leads to "destruction", the collapse of the system (trends exist independently of each other, so that sustainable mobility cannot be attained).

Analytical Network Process

SCALE FOR ESTIMATION

Degree of Importance	Score
absolutly weak important	0.11
weak to strongly weak important	0.25
weak important	0.30
equally to weak important	0.50
equally important	1
equally to moderately **more** important	2
equally to moderately **more**	2

INSTRUCTIONS

Positive real number rating (0, 1, 2, 3, 4, 5, 6, 7, 8, 9)	When the element on the row is judged to have higher preference than the one in the column.
Negative real number rating (-1,-2,-3,-4,-5,-6,-7,-8,-9)	When the element on the row is judged to have lower preference than the one in the column.

important	
moderately more important	3
moderately to strongly more important	4
strongly more important than	5
strongly to very strongly more important than	6
very strongly more important than	7
very strongly to extremely more important than	8
extremely more important than	9

EXAMPLE

ALTERNATIVES VERSUS CLUSTERS

Please complete the yellow fields only

CLUSTER SOCIAL FACTORS

Ageing society is equally to moderately **more** important than Large metropolitan cities regarding the alernative Scenario 1

Which of the following is considered to be affected the most Scenario 1?						
	Large metropolitan cities	Unemployment	urbanization	Unemployment	urbanization	urbanization
Ageing society	2					
Ageing society		3				
Ageing society			-2			
Large metropolitan cities				-2		
Large metropolitan cities					-2	
Unemployment						2

Ageing society is equally to moderately **less** important than Large metropolitan cities regarding the alernative Scenario 1

SOCIAL FACTORS

What do you consider as the most important factor/trend affecting Scenario 1?

	Large metropolitan cities	Unemployment	Urbanization	Unemployment	Urbanization	Urbanization
Ageing society						
Ageing society						
Ageing society						
Large metropolitan cities						
Large metropolitan cities						
Unemployment						

What do you consider as the most important factor affecting Scenario 2?

	Large metropolitan cities	Unemployment	Urbanization	Unemployment	Urbanization	Urbanization
Ageing society						
Ageing society						
Ageing society						

Large metropolitan cities						
Large metropolitan cities						
Unemployment						

What do you consider as the most important factor/trend affecting Scenario 3?

	Large metropolitan cities	Unemployment	urbanization	Unemployment	Urbanization	Urbanization
Ageing society						
Ageing society						
Ageing society						
Large metropolitan cities						
Large metropolitan cities						
Unemployment						

ECONOMY FACTORS

What do you consider as the most important factor/trend affecting Scenario 1?

	International trade	Pricing	Taxation	Pricing	Taxation	Taxation
Financial recession						
Financial recession						
Financial recession						
International trade						
International trade						
Pricing						

What do you consider as the most important factor/trend affecting Scenario 2?

	International trade	Pricing	Taxation	Pricing	Taxation	Taxation
Financial recession						
Financial recession						
Financial recession						

International trade						
International trade						
Pricing						

What do you consider as the most important factor/trend affecting Scenario 3?

	International trade	Pricing	Taxation	Pricing	Taxation	Taxation
Financial recession						
Financial recession						
Financial recession						
International trade						
International trade						
Pricing						

ENVIRONMENTAL FACTORS

What do you consider as the most important factor/trend affecting Scenario 1?

	infrastructure investment	renewable energy	sustainable development	renewable energy	sustainable development	sustainable development
Charges						
Charges						
Charges						
infrastructure investment						
infrastructure investment						
renewable energy						

What do you consider as the most important factor/trend affecting Scenario 2?

	infrastructure investment	renewable energy	sustainable development	renewable energy	sustainable development	sustainable development
Charges						
Charges						
Charges						
infrastructure investment						

infrastructure investment						
renewable energy						

What do you consider as the most important factor/trend affecting Scenario 3?

	infrastructure investment	renewable energy	sustainable development	renewable energy	sustainable development	sustainable development
Charges						
Charges						
Charges						
infrastructure investment						
infrastructure investment						
renewable energy						

ECONOMY

Which of the scenarios below you believe is more likely to impact sustainable mobility if f**inancial recession** is most important/predominant trend

	S2	S3	S3
S1			
S1			
S2			

Which of the scenarios below you believe is more likely to impact sustainable mobility if **international trade** is most important/predominant trend?

	S2	S3	S3
S1			
S1			
S2			

Which of the scenarios below you believe is more likely to impact sustainable mobility if **pricing** is most important/predominant trend?

	S2	S3	S3
S1			
S1			
S2			

Which of the scenarios below you believe is more likely to impact sustainable mobility if **taxation** is most important/predominant trend?

	S2	S3	S3
S1			
S1			
S2			

ENVIRONMENT

Which of the scenarios below you believe is more likely to impact sustainable mobility if **charge**s is most important/predominant trend

	S2	S3	S3
S1			
S1			
S2			

Which of the scenarios below you believe is more likely to impact sustainable mobility if **infrastructure investment** is most important/predominant trend

	S2	S3	S3
S1			
S1			
S2			

Which of the scenarios below you believe is more likely to impact sustainable mobility if **renewable energy** is most important/predominant trend

	S2	S3	S3
S1			
S1			
S2			

Which of the scenarios below you believe is more likely to impact sustainable mobility if **sustainable development** is most important/predominant trend

	S2	S3	S3
S1			
S1			
S2			

SOCIAL

Which of the scenarios below you believe is more likely to impact sustainable mobility if ageing society is most important/predominant trend

	S2	S3	S3
S1			
S1			
S2			

Which of the scenarios below you believe is more likely to impact sustainable mobility if **large metropolitan cities** is most important/predominant trend

	S2	S3	S3
S1			
S1			
S2			

Which of the scenarios below you believe is more likely to impact sustainable mobility if **unemployment** is most important/predominant trend

	S2	S3	S3
S1			
S1			
S2			

Which of the scenarios below you believe is more likely to impact sustainable mobility if **urbanization** is most important/predominant trend

	S2	S3	S3
S1			
S1			
S2			

CLUSTER SOCIAL

Which of the factors below do you think are most affected by 'financial recession'?

	Large metropolitan cities	Unemployment	urbanization	Unemployment	urbanization	urbanization
Ageing society						
Ageing society						
Ageing society						
Large metropolitan cities						
Large metropolitan cities						
Unemployment						

Which of the factors below do you think are most affected by 'international trade'?

	Large metropolitan cities	Unemployment	urbanization	Unemployment	urbanization	urbanization
Ageing society						

Ageing society						
Ageing society						
Large metropolitan cities						
Large metropolitan cities						
Unemployment						

Which of the factors below do you think are most affected by 'pricing'?

	Large metropolitan cities	Unemployment	urbanization	Unemployment	urbanization	urbanization
Ageing society						
Ageing society						
Ageing society						
Large metropolitan cities						
Large metropolitan cities						

Unemployment						
Which of the factors below do you think are most affected by 'taxation'?						
	Large metropolitan cities	Unemployment	urbanization	Unemployment	urbanization	urbanization
Ageing society						
Ageing society						
Ageing society						
Large metropolitan cities						
Large metropolitan cities						
Unemployment						

Which of the factors below do you think are most affected by 'charges'?

	Large metropolitan cities	Unemployment	urbanization	Unemployment	urbanization	urbanization
Ageing society						
Ageing society						
Ageing society						
Large metropolitan cities						
Large metropolitan cities						
Unemployment						

Which of the factors below do you think are most affected by 'infrastructure investements'?

	Large metropolitan cities	Unemployment	urbanization	Unemployment	urbanization	urbanization
Ageing society						

Ageing society						
Ageing society						
Large metropolitan cities						
Large metropolitan cities						
Unemployment						

Which of the factors below do you think are most affected by 'renewable energy'?

	Large metropolitan cities	Unemployment	urbanization	Unemployment	urbanization	urbanization
Ageing society						
Ageing society						
Ageing society						
Large metropolitan cities						
Large metropolitan cities						
Unemployment						

Which of the factors below do you think are most affected by 'sustainable development'?

	Large metropolitan cities	Unemployment	urbanization	Unemployment	urbanization	urbanization
Ageing society						
Ageing society						
Ageing society						
Large metropolitan cities						
Large metropolitan cities						
Unemployment						

Which of the factors below do you think are most affected by 'ageing society'?

	Unemployment	urbanization	urbanization
Large metropolitan cities			
Large metropolitan cities			
Unemployment			

Which of the factors below do you think are most affected by 'large metropolitan cities'?

	Unemployment	urbanization	urbanization
ageing society			
ageing society			
Unemployment			

Which of the factors below do you think are most affected by 'unempolyment'?

	Large metropolitan cities	urbanization	urbanization
ageing society			
ageing society			
Large metropolitan cities			

Which of the factors below do you think are most affected by 'urbanization'?

	Large metropolitan cities	Unemployment	Unemployment
Ageing society			
Ageing society			
Large metropolitan cities			