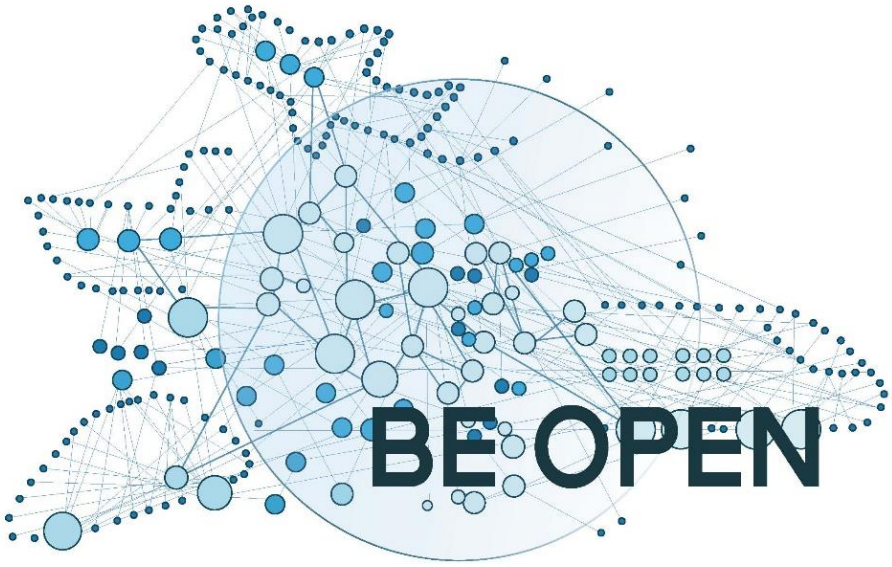

European forum and oBsErvatory for Open Science in transport

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Executive summary

The objectives of the BE OPEN project are to create a common understanding on the practical impact of Open Science and to identify and put in place the mechanisms to make it a reality in transport research. Open Science in transport research can result to several challenges and opportunities for stakeholders with increased societal value. Towards this direction, the main objective of this deliverable is to identify the challenges, opportunities and barriers of Open Science in transport research. On that purpose a two-step methodology was developed:

- A targeted review of literature findings was conducted in order to identify the challenges, opportunities, constraints and bottlenecks of Open Science in transport research at European, national and institutional level. In order to meet these objectives literature review was conducted on documents (papers, reports, deliverables, etc.) discussing Open Science and its impact on the two following categories: (a) Overall research and (b) Transport research. A total of 134 publications were reviewed and the syntheses of the literature findings were prepared.
- A Delphi survey on the challenges, opportunities and barriers of Open Science in the transport sector was also conducted. Based on the results of literature review, a survey was designed and a panel of transport experts were invited to participate. The survey was held in two rounds: in the first round, a questionnaire of 30 questions was disseminated to the experts. The responses of the first round were collected and analysed. In the second round of the Delphi survey, the experts were asked to provide their final responses, by either confirming or adjusting their responses given in the first round, taking also into account the feedback of the Delphi panel. Thus, the variation of answers was reduced and more robust results were achieved.

Concerning the challenges of Open Science in transport research, they could be categorized in the following areas: Resources and organizational issues, skills, capacities and capabilities, data related issues, technical issues, data ownership, legal and ethical issues and data security.

Among the opportunities of Open Science in the transport research were found the advance of the science in the transport field, while further co-operations with other institutions from other countries or disciplines as well as with transport companies are also among the main benefits for the research institutions. Similar were the benefits of opening up for individual researchers, who could gain more co-operations and contacts as well as further recognition, alongside with accessibility to more data. Open Science and open data are also expected to improve transport operations and performance of public transport authorities, foster data-based decisions and increase transparency, while for private companies the reduction of the costs, the improvement of their customer services and the accessibility to more data are among the main benefits of using open data services.

Among the barriers that research institutions should overcome in order to adopt an open data policy are the lack of resources (human and financial) and organizational issues, as well as conflicts concerning data ownership/IPR. Besides these legal and ethical issues, the lack of skilled personnel was identified for public transport authorities, while the commercial competition was identified for private transport companies. However, conflicts regarding ownership/IPR, protection of commercial and confidential data and protection of personal data, alongside with further marketing issues, have been assessed as the most significant barriers and the least likely to be overcome.

The first section of this deliverable discusses the purpose of this document and describes how the corresponding Task was implemented. Then, the literature review methodology is presented in Section 2 and the results of the literature search are provided. In Section 3, the key findings of the literature

review are presented and a synthesis of the main challenges, opportunities and barriers of Open Science in overall research and transport research is presented. The Section 4 discusses the methodology of the Delphi Survey and the design and preparation of this survey, while in Section 5 the final results of the Delphi survey are provided. Finally, the overall results and the main conclusions are drawn in Section 6.

1 Introduction

The objective of the present Deliverable is to identify the main challenges, opportunities, constraints and bottlenecks of Open Science in transport research. More specifically, the knowledge production and exploitation of Open Science in transport research has been analysed. Initially, a literature review was conducted in order to identify the challenges, opportunities, constraints and bottlenecks of Open Science in transport research at European, national and institutional level. Based on the literature results, a Delphi survey was designed and disseminated to a panel of transport experts, representing all transport modes and coming from various types of organizations. The aim of this survey was to better highlight the opportunities and the main problematic areas of Open Science in the transport sector.

The results from both the literature review and the stakeholders survey are expected to:

- provide Task 5.3 with adequate findings on opportunities, challenges, weaknesses and bottlenecks in order to carry out an impact assessment of Open Science in transport research;
- provide Task 5.4 with adequate findings to be taken into account in order to develop existing documents concerning the mapping of governance and operational models;
- assist WP4 in setting up a European Code of Conduct on Open Science in Transport.

2 Literature Review Methodology

2.1 Objectives

The objective of the Literature Review carried out was to conduct a targeted review of literature findings in order to identify the challenges, opportunities, constraints and bottlenecks of Open Science in transport research at European, national and stakeholder level.

In order to meet these objectives literature review was conducted on documents (papers, reports, deliverables, etc.) discussing Open Science and its impact on the two following categories:

- Overall research
- Transport research

2.2 Literature Search

Concerning the Open Science documents, scientific papers, reports, project deliverables etc. were explored, which were divided in the two main categories:

- General: in this category documents concerning Open Science and overall research were included
- Transport: in this category, documents related to Open Science in transport were included. These documents were further categorised based on the transport type they refer to:

  - Road Transport

  - Rail Transport

  - Air Transport

  - Maritime Transport

  - Combined Transport

For each of the aforementioned categories and sub-categories a standardised literature search was conducted.

The main online databases used for the literature search have been the following:

- Scopus - Science Direct
- Google Scholar
- Web of science

In order to identify an adequate and reasonable number of relevant studies for each case, the following search terms and logical operators were used in the online databases:

- Open Access OR
- Open Science OR

- Open Research OR
- Open Data OR
- Science Cloud
- ……..

AND

- Transport OR
- Road OR
- Maritime OR
- Rail OR
- Air
- ……..

AND

- Challenges OR
- Opportunities OR
- Constraints OR
- Bottlenecks OR
- Barriers
- Threats
- Strengths
- Weaknesses
- ……..

The selection of the related publications has been based on specific criteria, like the following:

- Relevance
- Importance
- Most recent studies
- Quality of studies
- Country
- Language
- Peer-reviewed journals

2.3 Organisation of Literature Results

In order to keep track of the number of studies and to avoid their double-coding by different partners with overlapping topics, a literature reference table (Excel Spreadsheet) was developed and updated, in which all partners involved in Task 5.1 recorded all of the studies used for the literature review.

Concerning the Open Science Documents, the coding of the following information and results for each study have been included:

- Study Title

- Issue Date
- Authors
- Publisher
- Country of Publisher
- Language
- Type of publication
- Link/Filename (if available online)

- Category 1 (entries restricted to: General, Road Transport, Rail, Transport, Air Transport, Maritime Transport, Combined Transport);
- Category 2 (concerning entries of Category 1 related to Transport; entries restricted to: Passenger Transport, Freight Transport, Urban Transport, Inter-urban Transport, National Transport, International Transport);
- Keywords (primary, secondary-1, secondary-2 etc.):
  Primary keywords: entries restricted to Challenges, Opportunities, Constraints, Bottlenecks and other synonyms;
  Secondary-1 keywords: Policy issues, Technical issues, Organisational issues;
  Secondary-2 keywords etc.: legal concerns, IPR, security, data protection, social costs, economic costs, governance, cultural barriers, infrastructure, metadata, data quality, skills, stakeholders, collaboration, partnership, data ownership etc.
- Remarks / Interesting Parts: the reviewer will fill in any interesting points that he/she considers useful for the project.
- Review by: the name of the BeOpen partner responsible for the review of the specific study.

2.4 Implementation of Literature Review

In order to identify as many publications related to challenges, opportunities, bottlenecks and constraints, all partners involved in Task 5.1 of the project (i.e. CERTH, DLR, NTUA and UITP) were assigned to explore specific types of documents for the two categories (i.e. Open Science in overall research and Open Science in transport) and record in the reference list those that were related to Open Science. More specifically, the documents and sources explored were divided into the following categories:

- Reports
- Papers (published in scientific journals or conference proceedings)
- Project Deliverables (inside and outside EU)
- Articles
- Policy documents

2.5 Results of Literature Search

A total of 174 publications related to the objectives of the current task were gathered. Most documents collected were papers published either in scientific journals or in proceedings of

conferences and reports. More than 40% of these documents concern open science in general, about 25% of the documents concern transport and a 13% of the gathered documents concern multimodal transport. Furthermore, the documents were classified in terms of importance and quality as low, high and medium, with the majority of those documents being considered as of high or medium importance and quality (Figure 2). The importance of the collected documents was assessed in terms of relevance with the scope of the current deliverable, while some indicative criteria that were taken into account when assessing the quality of the documents were: up-to date material, clearly stated objectives, well-described methodologies, well-drawn conclusions, scientific quality (for scientific papers), etc.

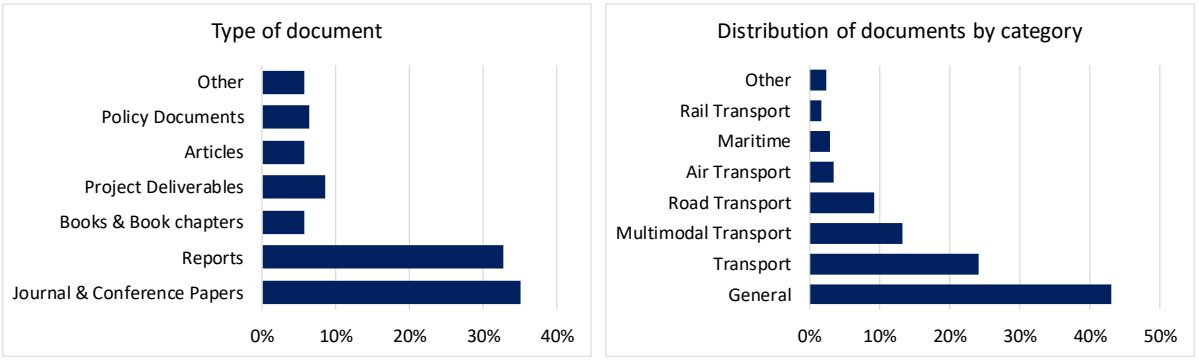


Figure 1. Classification of documents by type and subject category

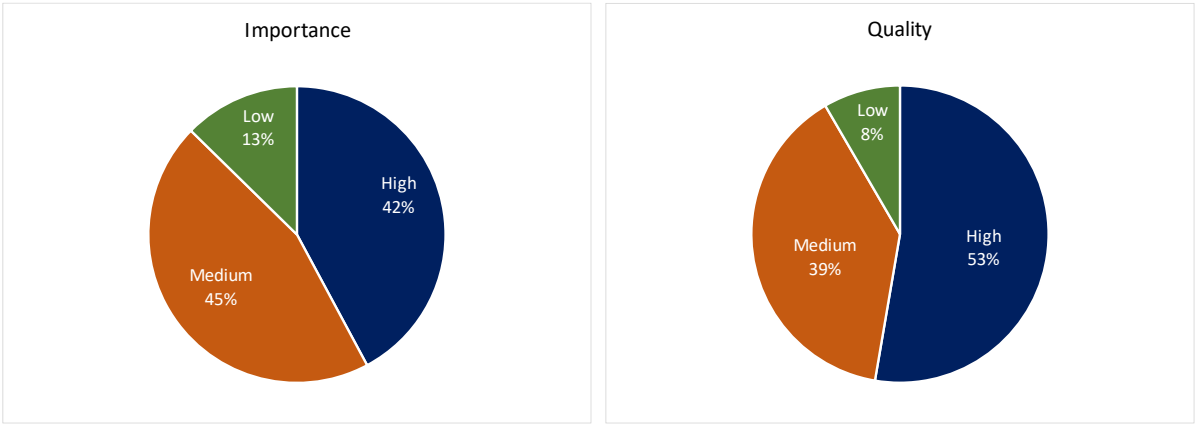


Figure 2. Distribution of documents in terms of importance and quality of the publication

Finally, 134 out of the 174 publications were assessed of both high/medium importance and quality, which were included in the final literature reference table and were taken into account in the thorough literature review, while the remaining documents will be available to project partners and end users through the TOPOS observatory. The detailed results of the literature search are presented in Annex I, in which the gathered publications used for the literature review are presented.

Concerning the literature search on challenges, opportunities and barriers in Open Science in overall research, 66 sources out of 174 were recognized as relevant towards the goal of this deliverable. These sources were scaled by the research team according to their importance and quality. Based on this categorization, the following figure provides the classification of the acquired relevant sources:

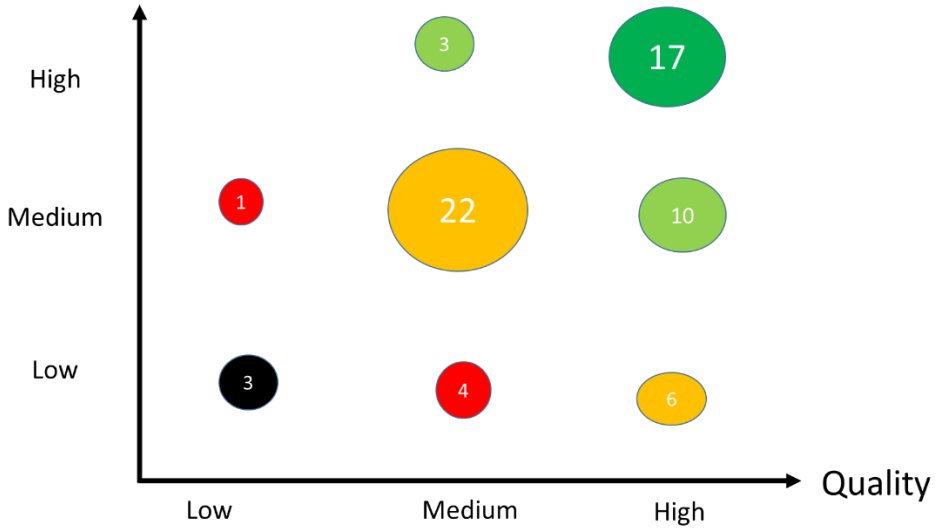


Figure 3. Classification of relevant sources

As far as the publications related to Open Science and transport sector are concerned, 77 documents were gathered and selected as the most relevant to the objectives of this Task. Out of the 98 documents, the majority of them (32) referred to the overall transport sector, 19 referred to multimodal transport, 14 referred to road transport, while the remaining 12 publications concerned maritime, rail and air transport. It is noted that few publications relating Open Science and maritime, air or rail transport were found. The documents referring to the transport sector were further classified ("Category 2") in the following groups based on the subject of the publication: freight transport, passenger transport, public transport, transit, urban transport.

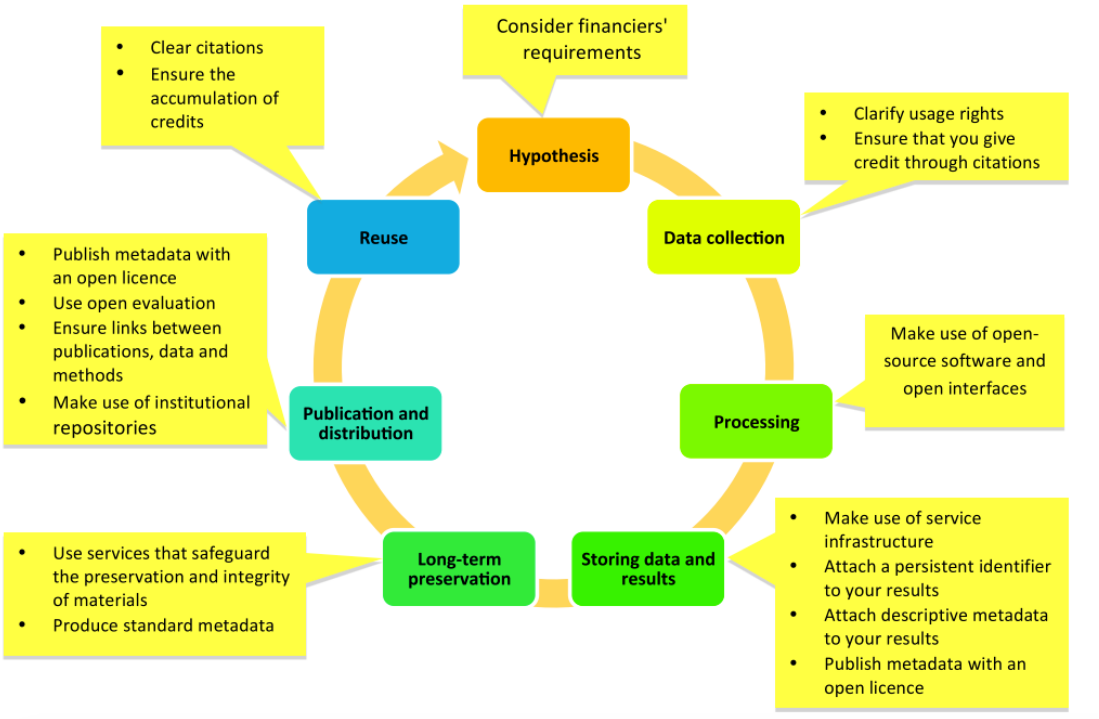
Based on the first keyword recorded by the research team, 36% of publications concerned the identified challenges of Open Science, 36% of the publications concerned the opportunities of Open Science and 28% of the publications concerned barriers and constraints of Open Science. It is noted that in the vast majority of the publications collected, the three key aspects that constitute the main objectives of this Task were discussed.

3 Synthesis of Review Results

3.1 Open Science in reserach

3.1.1 Open Science description

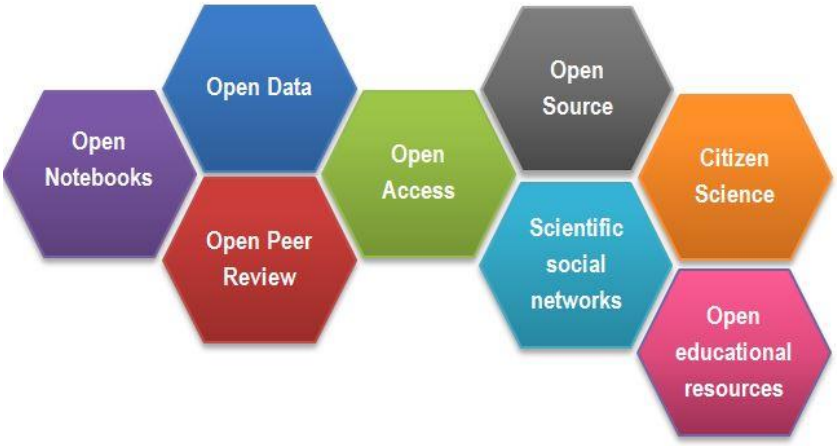
As digital technologies constantly develop and new working methods arise, many sectors have begun to collaborate more and reach out the data/information and knowledge with modernized methods. Scientific community is following this path and has tried, according to OECD, "*to make the primary outputs of publicly funded research results – publications and the research data – publicly accessible in digital format with no or minimal restriction*" (OECD, 2015). This term has been commonly agreed as "Open Science". Open Science focuses on promoting the open access of data to the whole research cycle (see Figure 4) and creating an online collaborative environment that will bring a holistic shift on the existing scientific operations.



Source: https://www.fosteropenscience.eu/content/what-open-science-introduction

Figure 4. Promoting openness at different stages of the research process

Open Science consists of different elements, which can be data-oriented (i.e. open research data, open notebooks, open infrastructure) and process-oriented (open peer review, open access, open software).



Source: https://www.fosteropenscience.eu/content/what-open-science-introduction

Figure 5. Open Science facets as a beehive

Open Science affects both individual research and research organizations scientific work. However, Open Science is not followed by all research organizations to impose proper rules and procedures to their members for adopting Open Science in their research. On the other hand, individual researchers may support Open Science initiatives and actions or not.

Based on the latest developments in information and communication technologies, Open Science has currently been adopted in many countries (at international, European and national level) and institutions even though there are concerns and barriers. These limit the implementation of Open Science initiatives and actions in practice.

3.1.2 Main initiatives and actions of Open Science in Europe

The latest EOSC Strategic Implementation Plan (2018) indicates that 65% of EU member states have prioritized to enhance OS in services and policies in national and international level although currently EU countries have different readiness levels for alignment of their existing national research infrastructures and cloud services with EOSC. Latest data shown that only 23% of some selected European countries (7 out of 31) are ready to implement EOSC practices (DG Research and Innovation, 2018).

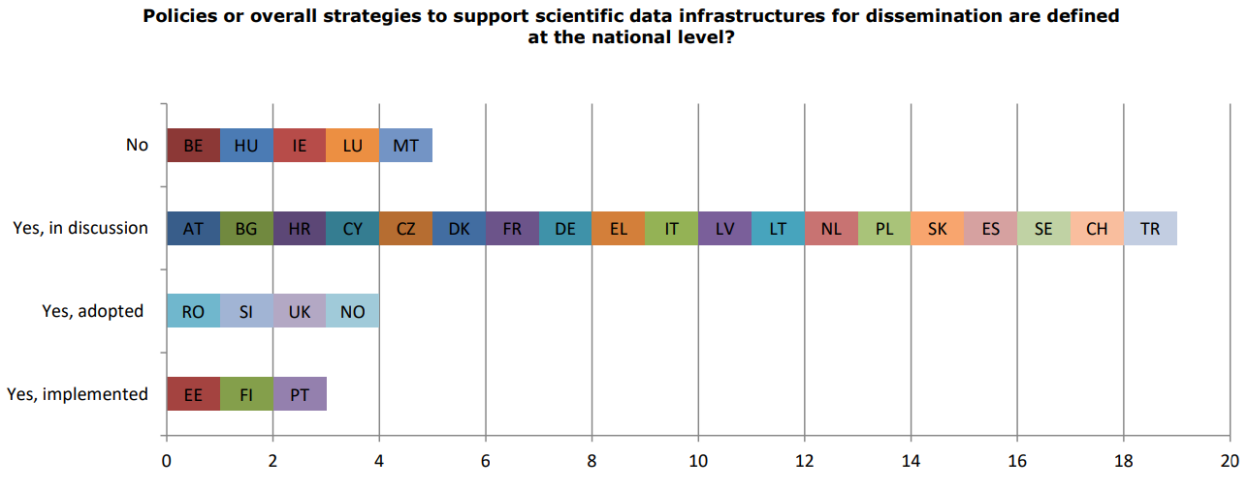


Figure 6. Mapping of supporting Open Science initiatives in European countries (DG Research and Innovation, 2018)

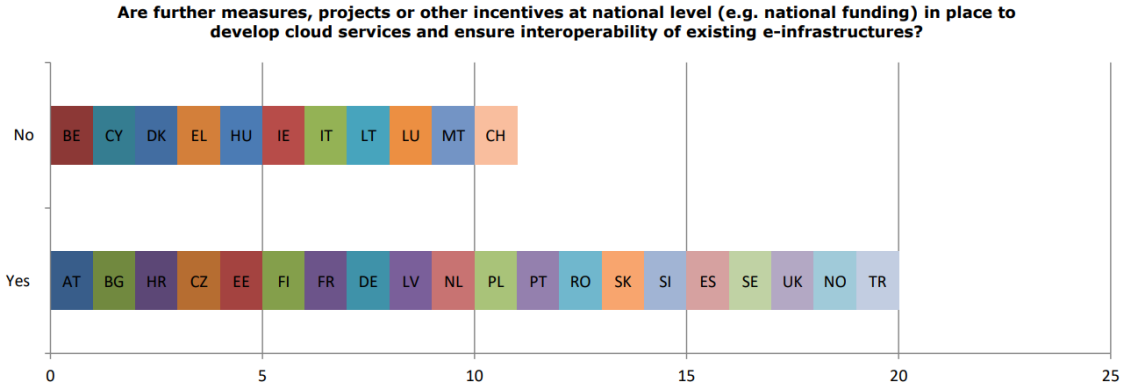


Figure 7. Mapping of supporting Open Science cloud and interoperability actions in European countries (DG Research and Innovation, 2018)

These results indicate the high importance and pressure of European governments and policy-makers to promote Open Science opportunities through different channels, such as EOSC, Strategic Research and Innovation Agendas (SRIAs) of different sectors in which open data sharing is pursued.

More specifically, during the BE OPEN project a study on "Transport Research in the European Open Science Cloud" (BE OPEN, 2020) was conducted identifying the priorities and challenges regarding data and EOSC for seven priority areas defined in Transport Research sector. Some of the key challenges and priorities identified in these areas were:

- Data collection and representation
- Applications of Big Data and Artificial Intelligence
- Skills and Training
- Data sharing principles, guidelines and standards
- Data authorization and accessibility

3.1.3 Challenges, barriers and opportunities of Open Science at International and European level

Interestingly, during the literature review process of main challenges, barriers and opportunities in Open Science it has been observed that the majority of relevant scientific sources (approx. 40%) tackle the "Open Science" topic at international or European level.

During the creation of FOSTER e-learning platform[1] (EU funded project) one of the major objectives was to develop strategies and skills for the implementation of Open Science practices. These proposed strategies came as a result of the identification process of existing list of barriers and challenges in Open Science (Gema Bueno de la Fuente, 2016). More specifically, six dimensions of **challenges** have been considered:

- Socio-cultural *(mainly concerning researchers):*
  - the lack of awareness on the benefits and importance of opening up their research;
  - the reluctance to change their current workflows and data publication practices;
  - the consideration by researchers of being a time and effort-consuming activity adding to their existing workloads;
  - diverse approaches between scientific community research groups;
  - absence of a clear recognition, incentives and rewarding systems towards researchers that promotes Open Science practices;
  - major differentiation on stakeholders' (research institutions, funders, government bodies, libraries) vision and practical approaches.
- Technological: further development of current information and communication technologies and European research e-infrastructures is needed in order to support and enhance culture of openness among research communities.
- Political:
  - major differentiation on stakeholders' policies on Open Science integration strategies;
  - lower priority of Open Science in governmental agendas and resources allocation priority;
  - diversified paces and approaches of countries strategic planning and implementation activities.
- Organizational:
  - potential lack of open research tools, workflows, units and services;
  - available human resources requiring training in Open Science implementation and monitoring processes.
- Economic:
  - high initial investment costs on infrastructure and scientific personnel to support and develop technical, political and organizational ecosystem of Open Science;
  - long-term efficiency of research activities and resource allocation opportunity having insignificant impact to persuade research communities to adapt Open Science initiatives.
- Legal:
  - diversified legislation frameworks at global level;
  - necessity of creating a common international Open Science framework and policy;
  - unclear legal environment on research data privacy, data ownership and data security issues.

[1] https://www.fosteropenscience.eu/

Plus, FOSTER platform project highlights that in order to protect scientific researchers' rights and ideas several barriers for Open Science implementation will arise:

- Commercial interests and economic benefits for researchers: a balance is needed between creating incentives for individuals or groups to exploit new scientific knowledge for financial gain and societal benefits through the products and services that are developed and the macroeconomic benefits that accrue when knowledge is broadly available and can be exploited creatively in a wide variety of ways. In this context, three different levels of data ownership and openness exist with distinct funding mechanisms:
    - Data ownership and the exercise of Intellectual Property rights;
    - Public-private partnerships;
    - Opening up commercial information in the public interest.
- Data Privacy: as research data may contain sensitive personal information such as in medical and social sciences, special attention should be put into the protection of privacy at personal data processing, both from a legal and a technical perspective. Unfortunately, a one-fits-all solution is not suitable, so public benefit and risks to confidentiality need to be assessed and balanced individually.
- Data Security and safety: as sharing confidential, sensitive or proprietary data poses clear challenges for protection against incidents or deliberate attacks, and requires a special effort on building architectures and develop methods and techniques that ensure security of scientific information systems.

In the same context, several research studies have focused on individual elements of Open Science such as open access (OA), open data and open sources (repositories, infrastructures, etc.). As the data origination and infrastructure structure may change from sector to sector (healthcare, transport, social sciences, etc.) it creates more technical, operational and social problems. Thus, hybrid models with both open and closed access publications' schemes have begun to be tested.

In 2019 a Copernicus study showed that approximately 69% of journal articles published globally appeared in journals that charge readers for access. However, there is broad recognition of the benefits of Open Access (OA) publication, making the results of scientific research freely available to everyone. Many publishers have introduced hybrid publishing models, where some articles are published in OA while others are only available to subscribers. These so called Transformative Agreements frequently display the following shortcomings (Copernicus, 2020):

- They lack binding commitments to a full transformation to OA.
- Access is limited to selected parts of a publisher's portfolio.
- Conditions vary across national borders.
- They crowd-out pure OA publishers from institutional or national agreement negotiations

A European Commission report in 2016 investigated existing data storage (cloud) sources to identify the potential bottlenecks towards a data-driven and open data sharing economy. Unfortunately, it has been observed that many European businesses, research communities and public bodies are yet to tap into the full potential of data and of its potentially transformative effect on traditional sectors and on the way research is conducted. Most of data is inaccessible due to (European Commission, 2016):

- commercial reasons and competitiveness;

- a lack of a clear structure of incentives, rewards and recognition for data sharing (mainly for academia);
- an unclear and non-coherent legal basis (mainly for the public sector);
- a shortage of data-related skills between researchers;
- lack of interoperability of data between scientific sectors. This includes:
    - variety in the size of datasets and data formats
    - complexity of required software needed for data processing and analysis
    - deep-routed walls between disciplines
- fragmentation of data infrastructures;
- inefficient high computing capabilities - absence of High Performance Computing (HPC) infrastructure to process "Big data" due to technological and financial limitations.

Additionally, to the afore-mentioned barriers for open research data, the findings of the EU-funded project "RECODE" rely on the Council of European Social Science Data Archives (CESSDA), which states a vital aspect that needs to be tackled today and the upcoming years. A major challenge is the creation of a research infrastructure sustainability framework, which could provide both to research individuals and organizations the proper incentives and rewards. As currently, a large proportion of the existing e-infrastructures and OS projects are short-term funded by different organizations, there is a danger for large datasets to be lost. Uncertainty over the future of datasets submitted to repositories could become a barrier to successfully implementing Open Access to publicly funded research data (University of Sheffield, 2013).

Another European OS related project – the FP7 funded project "Permanent Access to the Records of Science in Europe" (PARSE.Insight) (2008-2010) – conducted major surveys in order to gain insight into the current state of affairs in digital preservation of digital research data (including publications), the outlook of data preservation, data sharing, and the roles & responsibilities of stakeholders in research and funding of research. The key aim was to define the needs for an e-Science infrastructure for long-term availability of research data. A brief summary of findings gives some indication to the perceived barriers:

- Researchers regard the lack of sustainable hardware, software or support of computer environment may make the information inaccessible as the most important threat to digital preservation. 80% believe this to be either important or very important.
- 58% of the research respondents believe that an international infrastructure for data preservation and access should be built to help guard against the impending threats.
- 25% of the researchers already make their data openly available for everyone.
- Major barriers for sharing research data are the fear of researchers regarding legal issues and the misuse of their data.
- Data managers also regard the lack of sustainable hardware, software or support of computer environment may make the information inaccessible as the most important threat to digital preservation. 86% believe this to be either important or very important.
- 59% of the respondents to the data managers' survey don't think that the tools and infra-structure available to them will suffice for the digital preservation objectives they have to achieve.

- 71% of the respondents to the data managers' survey believe that funding for preservation will be an issue now and in five years' time.

Even though many research studies highlight different concerns and issues raised by the implementation of Open Science practices, many entities coming from different sectors of the research industry, policymakers and experts refer to the benefits EOSC could provide in societies globally.

An independent consultation group organized by Science|Business formed an expert group consisted of 11 different organizations coming from industry, policy and academic sector in order to evaluate the potential use of EOSC in an international level. Interestingly, EOSC gains significant support due to the coupling of different sectors' practices and enhancement of collaboration between the international scientific societies. Furthermore, EOSC gives new opportunities to tackle major international problems such as zero-carbon transportation and climate change with cross-disciplinary projects and new EU funding schemes that will target towards the establishment of large-volume, cost-effective research data infrastructures (Science|Business, 2017).

In the same way in April 2016, Leiden University's Centre for Science and Technology Studies (CWTS) and Elsevier embarked on a project to investigate open data practices at the workbench in academic research (CWTS-Elsevier, 2017). For this purpose, a survey has been conducted and, according to 1.162 researchers' responses, the following opportunities have been addressed for both research individuals and organizations:

- Researchers recognize the importance of data sharing.
- Researchers are already sharing data in ways that can be optimized, e.g., defining "data pipelines" in research fields.
- Collaborative practices can be used to further streamline data sharing.
- Cross-disciplinarily provides an opportunity for open data in emerging intensive data-sharing research fields.
- Data sharing practices can be better facilitated by offering training and awareness programs, e.g., in research data management (RDM), Creative Commons (CC) licensing practices, and sharing mandates.
- There is a need for increasing funding of data management activities [...] in perceptions on sharing and reuse.
- The scientific credibility system could reward participation in open data practices, e.g., through publishing in data journals, which is a recent and growing development.
- There is a need for improving standardization.

3.1.4 Challenges, barriers and opportunities of Open Science at national and institutional level

Taking into consideration the high involvement of European scientific communities with Open Science initiatives and the effort of many governmental bodies to promote it in their institution, a set of applied case studies and research studies identifying the applications of open data, open publication or open infrastructure efforts have been made. These studies specifically tackled prospects and limitations that academia experts, institutional organizations or national policy-makers have identified in a form of

surveys or interviews. The studies have been applied in several countries such as United Kingdom, Germany, Denmark and Poland.

However, during this research study institutional Open Science practices and concerns could not be specified on the appropriate level due to the anonymity of survey results in the research studies below. Additionally, due to confidentiality and reliability reasons the institutions are presented in sectorial level; each sector represents one major scientific field (i.e. healthcare, engineering, social sciences, etc.).

Historically some research communities (astronomy, meteorology, natural history, genomics, etc.) have already advocated an open data sharing culture and practices. This creates a public debate on the avoidance of open data adaptation in other scientific fields according to the independent work of Sabina Leonelli – professor of Philosophy and History of Science at the University of Exeter – together with experts from various sectors of European scientific research communities. In this context, this research study has identified eight dimensions which blocks the openness of scientific research data (Sabina Leonelli, 2017):

(1) evaluation and credit systems;
(2) diversity in research cultures;
(3) costs and accountability;
(4) skills and training;
(5) intellectual property regimes;
(6) semantic ambiguity;
(7) ethical and social concerns; and
(8) a high resource bias.

In addition to Leonelli's study (2017), "RECODE" EU funded project approaches practical scientists (data producers) opinions on five case studies from five different disciplines (one case study for each discipline): particle physics and astrophysics, health and clinical research, bioengineering, environmental research and archaeology. Overall, researchers within all fields were positive about openness to data within their respective fields, but remained sceptical about the practicalities. As it was stated also in Gareth Johnson's study (2018), while archaeology was presented as a field with relatively limited sharing of data, bioengineering was very open, in terms of sharing models and methods.

Open access to research data also raises several ethical concerns. As the secondary use of data is increasing, the misinterpretation in the original research data is increasing too. This often results to unintended damage on personal scientific or organizational researchers' work and reputation. In some cases, due to moral obligation and responsibilities to share results especially in social sciences and healthcare scientific work is getting demoralized and vanished due to social or scientific community reactions. As it is stated in many afore-mentioned publications, data privacy, confidentiality and restriction of scientific freedom cannot be absent. Lastly, many research organizations have unequal available resources to utilize for a specific research purpose. In this case, not all research organizations can capitalize the impact of the results from their scientific work in the same way due to limited resource availability (Rachel Finn et al., 2014).

As mentioned in the beginning of this section, some countries have made major efforts to record the different dimensions of barriers that postpone the implementation of Open Access (OA) publications in their national research communities. Specifically, within the UK academia an organized survey study has been made to examine the perception of scientific experts towards OA practices and potential risks. During the semi-structured interviews with academics, the reluctance towards OA practices resulted to be highly correlated with the misinformation received about it. Notably though, STEM scholars lead the charge on OA initiatives rather than more classic scientific fields such as arts, humanities and social science. This could be described due to cultural perception of UK academics that additional effort and personal benefits out of this process are insignificant. Additionally, the marketization of scholarly channels, the competition between research publication productions and current external and internal policy drivers postpone further OA practices. Although a systematic unification of policy terms in national and international level is preferred, greater capital consequences and a perceived separation between practitioners and senior institutional policymakers enhances conceptual issues for OA understanding (Gareth J Johnson, 2018).

The same issue between "open access" initiatives perception of younger and senior researchers has been identified in Fenrich et al.'s latest study (Wojciech Fenrich, 2016). In Poland open access initiatives have been approached as radical and "newcomers" opportunity for PhD students and "fresh" academia staff. Moreover, data sharing approaches and cooperation between the in-house scientific partners in a research entity can promote open data sharing practices and thus make them become a normal working method. On the contrary when it comes to data ownership, scientists that focus on data publication and analysis rather than data production itself tend to require bigger share of the research outcomes' ownership and rewards. Thus, "data ownership" and "data security" policies are considered important future objectives for the Open Science community in Poland. Additionally, senior researchers focus on the commercialization and reputation benefits that could be lost from open publishing their work. In this context, a necessity for national or European funding schemes towards research infrastructures and individual scientific achievements should be pursued.

National and European funding schemes has been a hot topic also in the 9th Plenary Meeting of Research Data Alliance (RDA). A presentation from German Data Forum about the socio-economic impact of Open Access on research data proposed several methods towards the enhancement of data security and Open Science research infrastructures' sustainability. Briefly, the main proposal was the centralization of research data infrastructure in international and European level, plus enhancing federated networks and cooperation on scientific data management procedures. Through this process existing forms of open data access could be implemented and new ones to emerge (RatSWD – German Data Forum, 2017).

Finally, the Danish National Research Foundation (DNRF) conducted a survey among its researchers on open access to data. The purpose of the survey was to clarify how and how much the researchers are using open data and to illuminate the strengths of open data and the barriers to its use. The responders were involved in five science fields: (a) humanities, (b) social sciences, (c) natural sciences, (d) life sciences, (e) technical series with different number of responders amongst each scientific area. The main portion of respondents (45%) made their data available through open access (Danish National Research Foundation, 2017).

The three most important reasons (opportunities) for making data available resulted to be:

1. It enables validation and/or replication of data (81% find it very or extremely important).

2. It is good practice to share research data (77% find it very or extremely important).

3. It enables collaboration and contribution by others (73% find it very or extremely important).

On the other hand, the two most important barriers to making data available have been: “it requires time/effort to prepare data” (46% find this reason very or extremely important) and “loss of publication opportunities” (41% find this reason very or extremely important). Other important barriers were “data contain confidential/sensitive information” (35% find it very or extremely important) and “others may misuse or misinterpret my data” (30% find it very or extremely important).

The majority of respondents (approx. 60%) make their data available to researchers other than those in their research group. When asked how they make the data available, 45% answered as open access. Whether researchers make their data available seems to be associated with scientific area. Half of the researchers within the social sciences do not make their data available.

Validation, good practice, collaboration, and visibility of one’s own data are at the top of the range of reasons for making data available. However, the researchers also find barriers to making data available, including it is time consuming, the data contain sensitive information, someone may misuse the data, or the researcher may lose publication opportunities.

Overall, the main barriers and opportunities of Open Science are summarized in Figure 8 and the most important challenges that should be considered by governments and institutions within a country are presented in Figure 9 in an attempt to provide empirical evidence of how to implement Open Science in practice based on stakeholders’ priorities and demands.

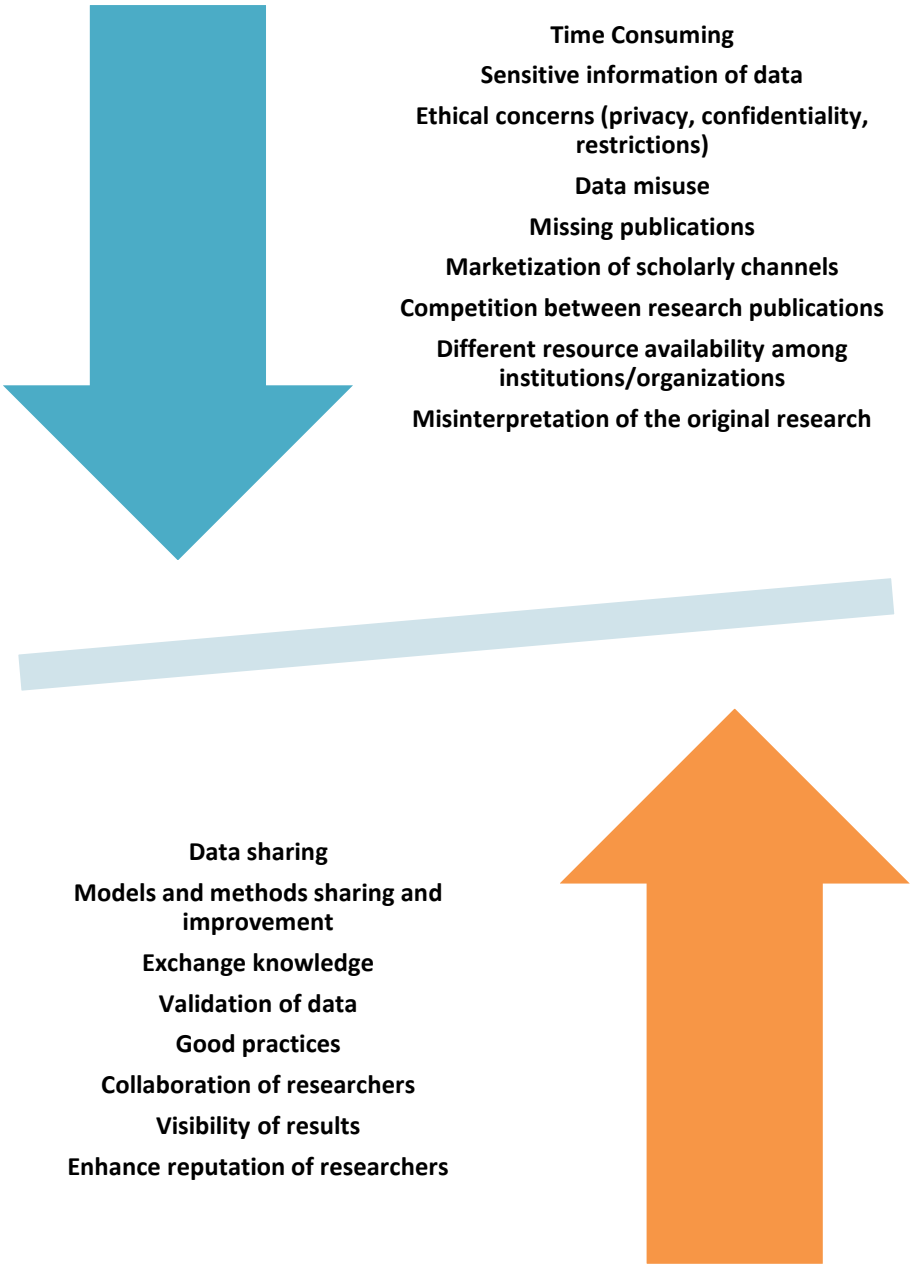


Figure 8. Barriers and opportunities of OS at national and institutional level

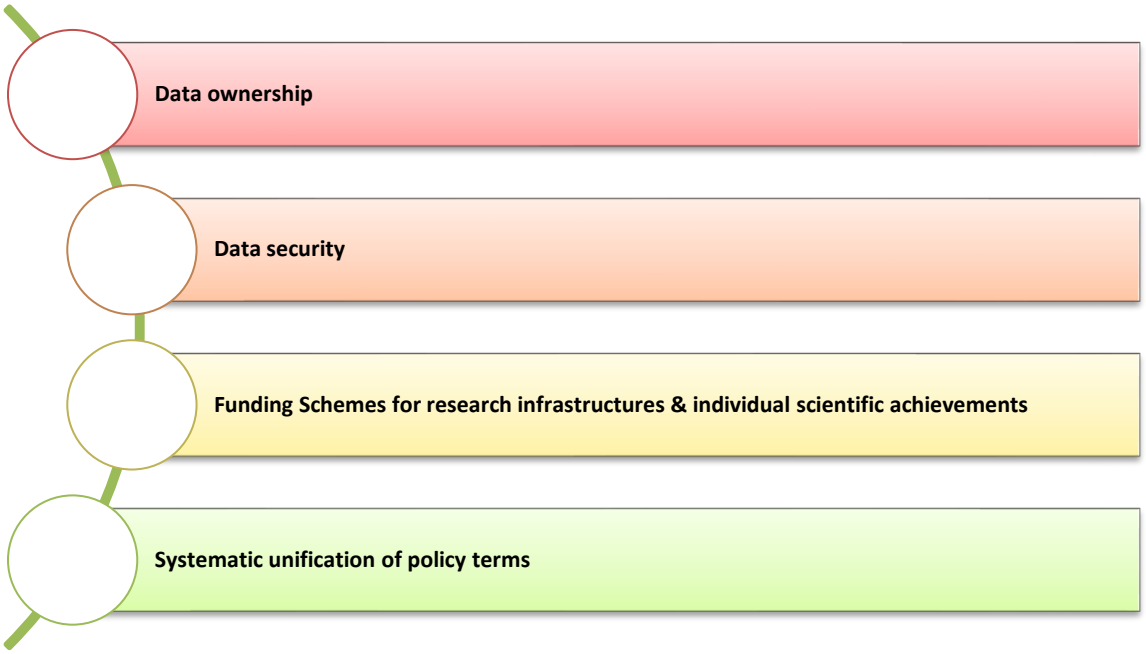


Figure 9. Challenges of OS at national and institutional level

3.2 Open Science in Transport Research

3.2.1 Introduction

A revolution in transport is witnessed over the last years, which is anticipated to grow further in the future. New, smart technologies are transforming not only vehicles, but also mobility choices and travellers' behaviours, which will consequently lead to a necessary upgrade of the transport system and modifications in the way the policymakers and other involved stakeholders at all levels make their decisions.

In road transport sector, certain technological innovations are expected to drive major changes. These innovations concern digitalisation, automation, artificial intelligence (AI), and the decarbonisation of transport. Within this context, (Raposo et al., 2019) have highlighted four fast moving trends that have been affecting the transport sector over the last decade and are expected to radically change the framework of road transport in the future. These factors are automation, connectivity, decarbonisation and sharing, which are expected to minimize the negative impacts of the road transport and to lead to a more efficient, safer and sustainable multimodal transport system. Briefly,

- automation is defined as systems able to perform part or all of the Dynamic Driving Task (DDT) – with different levels of automation existing;
- connectivity refers to the use of technologies enabling road vehicles to communicate with each other and with roadside infrastructure;
- decarbonisation addresses the use of alternative fuels like electricity, hydrogen, biofuels and natural gas instead of fossil fuels;

- sharing is “an innovative transport strategy that enables users to gain short-term access to transport modes on an ‘as-needed basis’” and includes “various forms of car sharing, bike sharing, ride sharing (carpooling and vanpooling), and on-demand ride services” (Raposo et al., 2019).

Moreover, hand held mobile devices are being increasingly used, by people of all age groups for various reasons, e.g. entertainment, business, navigation, education etc. The availability of such enormous amount of data is changing business strategies, creating new ideas and businesses, which is, in turn, generating and releasing more data in the public domain (Rahman et al., 2015). Indeed, over the last years, major technology companies have captured a large part in the field of personal mobility and transport-related data. Organisations such as Google, Microsoft, Ebay, Apple, etc. increasingly control, or cause significant changes, in relation to crowd-sourcing systems disposing data sets of personal movement and location data, the development of large map-based and place-related platforms, common formats for storing transport-related data, as well as new forms of mobility and delivery of goods (Catapult, 2015).

This new framework, that has already formed and rapidly changes the transport sector, affects not only the decision makers in both the public and private sector, but also the research community, which has to be proactive in understanding how the new technologies and trends may affect the transport sector, fully exploit the available data and new tools and efficiently support the decision making process. The need for opening up data and sharing knowledge is thus more imperative than ever. New regulation is therefore needed, including principles and rules in order to ensure a fair access in transport opportunities by addressing challenges that could either contribute to or hinder the transition, such as data governance, infrastructure, communication technologies, cybersecurity, legislation and standardisation.

This chapter discusses the challenges, opportunities and barriers identified in the transport research. Special emphasis is given on challenges encountered at national level by central and local governments in the implementation of an open data policy in the transport sector, as well as on challenges, opportunities and barriers encountered in public and private sector, which comprises a large network of transport stakeholders, including both data providers and users.

3.2.2 Open Science in transport research

According to the literature findings, the main challenges, opportunities and barriers of Open Science in transport research do not differ significantly from those identified in other sectors of science. The most critical issue that must be considered is the nature of transport data, and more specifically the nature of data coming from new, emerging technologies in the transport sector. Additionally, the various data providers and users constitute a rather complex environment, since their different needs, perspectives and interests in transport data lead to different challenges in both sharing and using open data. Overall, the main challenges of opening up data and services identified in the literature can be summarized in the following broad areas.

3.2.2.1 Resources and organizational issues

Both data providers and users need further organisational capabilities in order to better integrate the philosophy of Open Science into their organisations. These organisational capabilities include leadership roles and decision-making groups within the transport related companies and authorities that will make strategic decisions based on the value being derived from the manipulation and exploitation of multiple open datasets. Within these strategic decisions, challenges in both financial and human resources may exist.

Organisational capability is needed to develop so that people undertaking leadership roles and decision-making groups are able to make strategic decisions based on intelligence being derived from the manipulation and aggregation of multiple datasets. On that purpose, organizations should modify their recruiting criteria to take this requirement into account, they will need to develop training programs to increase the capabilities of their current management and analyst team. This challenge is even higher for smaller companies responsible for the delivery of transport services, which are less able to hire the data analysts they need.

(Catapult, 2015) have also identified the main barriers at institutional and commercial level, with various transport organisations:

- Being reluctant to openly share data that may become commercially valuable at a later stage.
- Lacking, or not recognising, the rationale for opening-up data they hold.
- Lacking the in-house skills, they need to create data feeds using common data formats, which often require data conversion and pre-processing effort.
- Lacking the financial resources to maintain and curate a reliable data feed due to uncertainty over the business model/value created for the data owner.
- Being concerned that making data available - even in anonymised and aggregated form - may contravene data protection legislation.

3.2.2.2 Skills, Capacities and Capabilities

Another important challenge in both sharing and using open transport data has been the identified gaps in skills within the transport researchers and practitioners. Areas where skills gaps may be a challenge for using data include (Abrantes & Linton, 2016):

- Analysis
- Information and Communication Technology
- Legal
- Governance
- Commercial and
- Management.

Additionally, a large part of transport data, especially those coming from the emerging new technologies, are big data. This type of data requires new algorithms and approaches to data management, including machine learning algorithms and cloud-based parallel computing. The fact that these approaches are relatively new to the transport sector is also a challenge of using or making available such data. However, the transport sector has historically used and managed large and

complex data sets, and through upskilling and collaborative working, it is expected that opportunities from using emerging data can be arisen for the transport sector (OECD/ITF, 2015).

3.2.2.3 Data issues

Within this area, issues concerning data quality and timeliness are included. Additionally, data inter-operability presents another important challenge, which refers to the standards, including software architecture and data structures, employed to store and transfer relevant data between different parts of the system and between different organisations. Furthermore, developing common data standards in the public transport realm is another important challenge, in part due to the fragmented nature of transport sector and the subsequent need to gather and homogenise information from across a large number of operators. Incompatibilities may also be arisen if different organisations choose to adopt competing standards, which in this case, questions arise around who should hold responsibility for setting data standards.

(Catapult, 2015) has identified the following challenges for evolving transport data creation and sharing:

- Understanding and maintaining open data feeds;
- Developing and adhering to interoperable data standards;
- Ease of data discovery;
- Maximising the collection and archiving of real-time data.

However, the challenges identified above may present also opportunities to accelerate the uptake of intelligent mobility practices, services, and operational approaches through smarter data collection and sharing.

3.2.2.4 Technical issues

The technical challenges to opening up datasets often prove to be relatively trivial. These kinds of challenges typically relate to the use of common formats for sharing the data; and introducing accurate time, location, and date-stamping at the point of collection.

Further technical challenges have also been identified in (Hee et al., 2018), concerning open data and especially big data collected within the transport sector. These challenges concern:

- Poor data quality (a challenge for data cleaning)
- Lack of standards regarding hardware and software
- Data bias (for sample data)
- Lack of expertise in handling big data
- Lack of skills in database design and computer programming

3.2.2.5 Data Ownership

Ambiguity over data ownership and related concerns by individuals over privacy pose a range of challenges for transport authorities, but also creates opportunities. Transport data are owned and generated by a range of organisations, from developers to retailers, telecom companies and individuals, as well as transport authorities and operators. This constitutes a complex environment in

which ownership of data or analysis results needs to be assured in a fair way. Legislation is one way in which ownership can be clarified.

Challenges also exist when transport authorities need to access data sets from other organisations, and there could be an opportunity for collective action in this area. One such example occurs around the use of mobile phone data, which is held by mobile network operators, but could have significant value for transport authorities. Another instance identified in the literature concerns the Bus Services Bill (Abrantes & Linton,2016) in the UK, which requires increased openness and transparency on the part of bus operators working with the Department for Transport and other parties to ensure secondary legislation on open data will be fit for purpose. This is an example where adopting a joint approach is useful and more areas for collaborative working may emerge.

3.2.2.6 Legal and ethical issues

As the value of data to both public and private organisations becomes increasingly clear, the importance of protecting personal privacy also emerges. On that purpose, over the last years, national legislations dedicated to this issue have been either developed or modified, to create or clarify individuals' rights and to create obligations on public and private sector organisations to protect individual data. At EU level, the new EU General Data Protection Regulation (GDPR) came into force in 2018, strengthens data protection regulations, setting accountability obligations on data controllers, requiring them to maintain documentation and conduct data protection impact assessment. For transport authorities, the challenge of adhering to these regulations is arising, since it is considered that compliance is more complicated than previous data protection requirements and needs considerable digital architecture. (Abrantes & Linton,2016)

These challenges are acute and what is at stake is an erosion of personal privacy rights. As mentioned in (OECD/ITF, 2015), these rights in some cases especially within the private sector are considered either as not aligned to current technological developments or irrelevant. Many proponents of this belief highlight the significant improvements in service delivery that could be facilitated by data convergence.

However, technology can offer some solutions to privacy concerns. For example, Abrantes & Linton (2016) suggest that data portability may offer a solution to the management and protection of personal data by giving more control back to the user. This can also provide a solution to some of the challenges concerning data ownership and trust.

3.2.2.7 Data security

The growing importance of network-based information and other connected services in transport poses increased cyber-security risks, especially when networked-based systems interact directly or indirectly with primary control systems of vehicles (OECD/ITF, 2015).

Two recent examples of cyber-attacks (OECD/ITF, 2015) on indirect but mission-critical systems involve spoofing of Global Positioning System (GPS) signals used to pilot ships and aircraft. In the first instance, researchers were able to feed spoofed GPS coordinates to the automatic navigation system of a vessel allowing the attackers to gain full directional control. Although the attack was on an automatic navigation system, the method also fed incorrect GPS coordinates to all on-board GPS receivers. This

meant the crew only received data indicating the vessel was still on-course. In the second instance, an unmanned drone was spoofed into flying off-course.

Another example concerns remote sensor data by a remote and passive hack of unencrypted wireless road sensor data. Manipulating these data could have important and severe consequences for traffic system operations that depend on these data feeds to coordinate emergency services, signal timing and traffic variable messaging systems, among others (OECD/ITF, 2015).

The need for adequate data encryption protocols and practices for handling transport data has, therefore, been highlighted in the literature.

3.2.3 Open Science at national and local level

Central and local governments (e.g. municipalities, regional authorities) encounter also significant challenges in the application of an open data policy within the transport sector, for instance, in the development of a system providing real-time information on various means of transport or in mobility as services (Maas). These challenges can be summarized as follows (Meijer et al, 2014; Catapult, 2015; Hee et al., 2018):

- Complexity of stakeholders number and interconnectedness

  Government organizations and stakeholders have a variety of interests and perspectives on open data. Various actors, government, public transportation companies, providers of information, public transportation lobby groups, and even individual (young) citizens interact in the construction of open data. They have a variety of commercial and public interests.

  All these actors engage in interactions in which they try to influence the socio-political construction of open data. Some companies may try to protect their monopolistic position in the provision of this data, while public authorities may have opposite targets, which are also influenced by the emerging technologies and the new needs in data and information the public and especially young people ask for. Thus, complex multi-actor interactions over time are needed to be analysed in order to understand how open data came to be constructed and reconstructed over time. (Meijer et al, 2014)

- Lack of technical expertise and analytical skills

  In many countries, data that are being published openly or even for free generally at a national, or major city level. In smaller cities and towns, there is little open transport-related data. This is mainly due to the fact that there is a lack of technical expertise, which constitutes the dependency on the private sector significant. However, there are not always the necessary financial resources in order to form the proper and beneficial collaborations.

- Lack of comprehensive data catalogues

  The existence of many different stakeholders has also a direct effect on the open data catalogues developed, in which the various practices and policies are reflected. A significant challenge however is the publication of some data using inconsistent/non machine-readable

formats, e.g. raw transport data feeds are being presented in PDF documents which are may be useful for oversight, but have no direct value. This also means that extra time has to be spent in order to gather open data from multiple sources and homogenising them rather than exploiting them (Catapult, 2015).

Additionally, the lack of a comprehensive catalogue covering all types of transport data (free/open/available at cost) also means that valuable items of transport-related data that are not currently openly available are being overlooked rather than prioritised for release. (Catapult, 2015)

An example of transport sector that presents similar complexities and challenges of Open Science with those encountered at national or local level can be identified through the application of open data policy within the operation of ports. The maritime sector is an example of a traditional industry where integrations of new digital applications into processes and practices have started slowly. The following challenges and barriers have been identified in a study exploring the Open Science in ports of Finland (Inkinen et al., 2019):

- Effective port–hinterland functionality requires interaction and collaboration between numerous businesses (private sector) and public-sector administrative units (e.g., national customs and transport authorities).
- The governance of open data is based on EU directives, principal decisions and programs. However, in the case of municipality owned ports there is a contradiction whether they are regarded as companies or organizations with public interest. In the case of private sector, open data will probably remain scarce as the opening process should bring clear economic or process benefits. On the other hand, publicly owned companies act as forerunners providing evidence of the pros and cons of open data.
- The ports focusing on digitalization are mainly large international sea hubs and their volumes and resources are exceeding the ones of a country. Thus, straightforward best-practices are not easily implemented in smaller scale.
- Cyber-security is one of the key development areas in ports, which is caused by two main factors: first, the overall digitalization trend and change, and second the increasing amount of data related to the transported cargo. These two factors are interlinked and are part of supply-chain management. Transportation documentation also includes valuable agreements and business intelligence vital to the companies conducting international trade with physical products. Cyber-security presents an example of phenomena that is connected to the national supply securities of nations.

3.2.4 Open Science in transport companies and organisations

3.2.4.1 Challenges

Open transport data, especially in the public transport sector, have been a success story for several countries, which have exploited such datasets and have created applications or other tools targeting to more efficient operation of their companies and better customer services. However, this is not always the case for the private transport sector, e.g. transport service providers, technology companies, etc., which are more reluctant to share openly or/and freely the data they create and store.

Only a few major international data companies, such as TomTom and INRIX, have started to differentiate their data policy over the last few years (Catapult, 2015).

In the introduction a picture of the current and future trends in transportation has been provided. Intelligent mobility is one of the upcoming trends in the transport sector, for which there is a lack of proper data. (Catapult, 2015) have identified the challenges met in the collection and sharing of the data needed through a survey among practitioners:

- The appropriate infrastructure (i.e. sensor networks) to gather such data is missing.
- Issues concerning the temporality of the data collection, maintenance and sharing. More precisely, practitioners highlighted the fact that most real-time data collected are not stored by the data owners for time-series analyses of historic trends.
- Most of the datasets that are considered essential to intelligent mobility are owned by private sector enterprises, which exploit them in order to either operate their business (e.g. Uber), to interact with their clients (e.g. rail or bus operator's ticket sales), or as their main product for sale (e.g. INRIX).
- Organisations are developing such business models of sharing datasets with third parties taking into account the maximisation of the profit for the private sector.

Public transport authorities dispose a wealth of data. While these services are partially or fully financed by taxpayers, those companies operate in competitive markets and therefore need their most sensitive data to be kept confidential. The use and boundaries of data for PTOs[2] and PTAs[3] remains an issue for which all benefits and losses should be considered with relation to different stakeholders (UITP, 2018). Within this context, some challenges that should be considered are the following:

- Opening all data could cause strategic and commercial competitive disadvantages in some cases.
- There are some significant costs of producing and disseminating data for operators and these costs should be distributed under a fair context.
- The necessity to preserve proprietary and commercial data, which constitutes alongside with the industrial know-how and expertise, the foundation of business-models, and should be treated as confidential. Opening such data to the public may generate the risk of judicial attacks between transport or digital companies – with high implications to PTOs resources (UITP, 2018).

The National Academies of Sciences, Engineering, and Medicine, in 2015 conducted a wide survey among transit agencies concerning the challenges and opportunities of opening data. The challenges identified were grouped in the following five areas:

- resources and organizational issues;
- data quality and timeliness issues;
- standards and formatting issues;

[2] Public Transport OPerators.
3 Public Transport Agencies.

- marketing issues relating to making the open data known and addressing branding issues;
- technical issues.

Furthermore, opening data under a specific framework includes some additional costs for transport organisations and companies. (Kaufman & Wagner, 2012) have published a guide for transportation agencies for getting started with open data. A key issue highlighted in this guide concerns the costs of producing open data. While the costs of generating open data are modest due to the fact that they mainly come from internal data of the agencies, other essential costs have been identified which are related to:

- Converting data to mainstream formats
- Web service for hosting data
- Personnel time to update and maintain data as needed
- Personnel time to liaise with data users

It is noted, however, that these costs are not the same for all types of transportation agencies and may vary a lot, depending on the size of the transportation agencies and the scale of the services they cover.

The issue of opening data has also been explored for the maritime sector. While the maritime industry is considered a closed ecosystem requiring significant effort to penetrate, there are trends in creating services and applications which are encouraged from the openness of the maritime industry. Such an application is the MarineTraffic, a publicly available map with real-time ship positions, which provides accurate information on ship's location or its expected time of arrival. In 2017, Memos explored the challenges and opportunities of open data and crowdsourcing for the maritime industry (Inkinen et al, 2019). The challenges identified based on this application are the following:

- User diversity: Such applications address simultaneously to both millions of “free” users and relatively few customers from whom revenues are generated. This is a challenge concerning not only the development of the product but also the branding, requiring, thus, additional efforts and specific decisions.
- Data management: focus is given on the upgrade of companies' data warehouses and big data infrastructures, allowing for efficient data processing and delivery of services.
- Quality assurance: technical challenges are arisen during the quality control process of both data collected and data process outputs. Especially, when handling with high volumes of data, intelligent algorithms and machine learning are required for the quality control of the data and their derivatives.
- Growth of the company: the most important challenge that may be faced is the sustainability of the company's growth through a policy of openness, which concerns the growth of market expectations, the growth of the team, the growth of customer and user base and the growth of the product scope. This requires an additional work and redefinition of company culture, systems and processes.

3.2.4.2 Opportunities

The following opportunities in relation to transport companies and organisations have been identified through the literature review:

Customer satisfaction/personalized information

For transport companies, various opportunities arise within a complex framework. Various transport authorities in both public and private sector dispose a wealth of transport data, which develop a new framework for further co-operations and the development of various applications that can be used by the public.

One example of a transport sector that may offer many opportunities through an open data policy is the public transportation. The International Union of Public Transport (UITP) has declared that the public transport sector should support the production and provision of open data, preferably on a cost-free basis. This would lead to the following benefits (Abrantes P. & Linton C., 2016):

- facilitate efficiency and innovation in information diffusion;
- encourage transparency;
- further develop the concept of 'Smarter Cities';
- enhance job creation in the technology sector.

This in turn is also expected to help public transport customers to improve their journey experience, and transport authorities and other stakeholders to improve their operations and transport product services (Abrantes P. & Linton C., 2016; UITP, 2014).

It is evident that through the provision of open and accurate data and their proper exploitation, the public can obtain a variety of applications and multi-modal information, often free of charge, as a guide for the use of public transport. Thus, the users will have the ability to choose the most suitable tools for their needs, often enabling them to 'personalise' information. This 'personalisation' of the information can lead to higher customer satisfaction with transport services (UITP, 2014).

An example of application of open data in the public transport sector is met in some cities, such as London, where the departure times of public transportation are available real time. The availability of these data enabled the development of applications that suggest alternative routes based on information about delays. This example highlights that open data can have a direct value for individual choices of a large group of citizens (Meijer et al., 2014).

On the other hand, the increased use of smartphones and social media has contributed to the higher voluntary provision of personal information on behalf of individuals (e.g. their spatial coordinates) to such applications, with the expectation that the data they provide will improve the quality of service they receive. This exchange constitutes the basis for many services that provide real-time traffic information or personalised recommendations.

Such an example of mining open and crowdsourced data comes from the rail sector. (Rahman et al, 2015) have explored the benefits of utilising open and crowdsourced data related to the UK railway systems. There is enough information generated from data, produced by both industry and social networks, which are openly available in the public domain. Decision makers listen to the messages posted on social networks by passengers or other members of the public and relate these messages to specific trains that are referred to, by fusing information from other open sources. Based on these data, the operational staff and emergency response teams are thus able to better plan and act more

efficiently in a case of emergency. Additionally, train operators may also be able to measure the speed of a specific train using information from the social networks of the passengers and predict the time of arrival of the train more accurately. This use of live data on the state of the rail network can, consequently, further improve customer satisfaction.

Further commercial co-operations and new commercial models

The value of the data disposed by the transport agencies or companies is not limited to the explicitly first-use case. Companies can aggregate and sell these data or the results of the data analysis to other companies or public authorities for re-use, merging with other data and re-analysis (OECD/ITF, 2015), giving thus the opportunity to the companies to open up to further commercial co-operations with third party stakeholders.

Such partnerships can also be developed among transport agencies or companies and developers or other technology companies. Many transport agencies, mainly from the public transport sector, dispose large datasets but lack of expertise or resources (human or financial), which does not allow them to proceed to the development of applications with real-time data and information. However, the availability of open transport data provides the opportunity to third parties to develop such applications. Within this context, more and more transport organisations support their developer community and engage in co-development (UITP, 2014) by providing third parties with high quality and accurate data. Thus, they avoid the considerable costs of developing applications themselves while extending the reach of their information and in parallel saving time.

Furthermore, many of the application developers are small independent individuals or companies. Consequently, a further benefit of transport authorities providing open data is that they stimulate the growth of small and medium enterprises, which in turn creates highly skilled jobs and tax revenue (UITP, 2014).

Additionally, new models of public-private partnership involving data-sharing may be necessary to be developed in order to leverage both public and private benefits. Under existing data ownership rules a significant amount of data pertaining to, for instance, road safety, traffic management and travel behaviour is held by the private sector and could be used by public sector.

(Catapult, 2015) have also highlighted that the trend towards the greater provision and use of open data forces businesses to adopt new commercial models, develop new ways of engaging with stakeholders and ultimately deliver economic and social benefits. According to the study, the following opportunities can be derived from opening up transport data:

- time and money savings for transport operators and service users;
- passenger/customer revenues arising from the use of new forms of mobility;
- payment for strategic planning and operational insights, and advice, derived using transport-related data;
- payment for data itself, which will continue to flow between mobility service providers, organisations, and individuals as they interact;
- revenues from partnerships/sales of tools and applications to major technology companies.

Strengthen capabilities and capacities/gather intelligence

Open data provides a way for organizations, employees, and other private persons to update their data storages and knowledge needs. (UITP, 2018) has highlighted that public transport sector can be further benefited from the process of opening up data, since the operators will have the opportunity to strengthen and expand their capabilities in:

- Human resources: training and hiring staff;
- Procurement: purchasing data services to phone, banking and internet operators;
- Budgeting: including in the annual budgets specific amounts for data management;
- Monitoring and maintenance: both for infrastructures and super-structures;
- Licensing: according to types of data and softwares;
- Privacy: data protection and stewardship for both customer and operational data;
- Risks: identification, assessment and management of risks.

According to (Catapult, 2015), open data policy can also provide the opportunity to transport companies to build capability and capacity, by fulfilling the following requirements:

- Ensure skilled technical personnel capable of handling and analysing very large datasets compiled from multiple sources.
- Organisational capability that ensures decision-makers understand these analytical processes in outline, be able to use actionable insights derived from new data analysis processes to inform strategic company decision-making, and exploit associated creative business models.
- Technological investment to ensure access to data storage capacity and computational processing power.

Transparency and innovation

Furthermore, another key argument for opening up data is that open access to public sector data and information may offer greater economic, social and political benefits compared to the exclusive exploitation of these data (Meijer et al., 2014). Additionally, one of the added values of open data is that the authorities supervising the public transportation companies can use the available data in order to check whether the companies are punctual to their contractual commitments concerning the customer services (Meijer et al., 2014). (National Academies of Sciences, Engineering, and Medicine, 2015) has also shown that transit authorities in the USA have embraced transparency by providing open data, which has led to improve the perception and increase the visibility of transit.

The study (National Academies of Sciences, Engineering, and Medicine, 2015) also showed that the availability of open transit data encourages innovation that could not be accomplished solely by agency staff. Private businesses have been created or expanded to work with open transit data and have developed innovative applications that, in some cases, could not have been developed in a public agency. Additionally, academic institutions and research organizations, have been instrumental in analysing, using and promoting the creation and use of open transit data.

A survey among transit agencies highlighted the top five overall benefits experienced by survey respondents from opening up data (National Academies of Sciences, Engineering, and Medicine, 2015):

- increased awareness of their services;
- empowerment of their customers;
- encouragement of innovation outside of the agency;
- improvement of the perception of their agency (e.g., openness/transparency);
- provision of opportunities for private businesses.

Similar findings have also been found by (Inkinen et al., 2019), who explored the benefits for the use of open data in Finnish ports. The three main benefits identified are the following:

- open data would enable the development of innovative applications needed in daily work;
- open data would help the overall coordination of port operations particularly concerning unexpected events or delays;
- open data would enable more transparent information exchange internally within the port community as well as externally outside the port vicinity.

Data based decisions

Finally, another benefit of opening up data concerns the decision making process. If all data are available to decision makers at all levels in a company, data-based decisions are fostered and backed with evidence. Open data are thus used in order to improve and align customer needs with proactive management of transport networks and modes (UITP, 2018).

3.2.4.3 Barriers

(Catapult, 2015) has identified possible barriers concerning the exploitation of open transport data. These barriers can be categorised in the following areas:

- Data availability and demand: including cost of data collection/purchase, ethical/privacy issues, storage and use of sensitive personal data, incomplete or partial datasets, lack of willingness to share (e.g. Google/Bing, connected vehicle data platforms for each car manufacturing group).
- Data usability: including incompatible data, non-existence of standardised formats and conventions, and proprietary formats, not machine-readable data, non-existence of metadata, poorly structured and curated datasets.
- Data relevance: including scale and feasibility of data samples, lack of precision over where and when data were initially collected (e.g. time intervals, and geospatial granularity).
- Structural impediments: including lack of technical skills to handle and process big-data sets, relationships between organisations (e.g. public/private sector) may prevent data sharing, government willingness/action on opening-up datasets, personal/societal attitudes to data privacy, data storage.
- Market forces: including competing commercial interests disrupt open data sharing and standardisation, rapid pace of technological change – may deter investment due to high costs

involved, lack of incentives to 'add value to data' – expectation that developers will respond to available data could be misguided.

Most of these challenges are considered solvable, but those which relate to market forces are less easy to address.

Making data publicly available can deliver significant benefits, however, there are legitimate concerns associated with making any data publicly available. According to (Williams, 2013), the following barriers have to be considered when opening data:

- Privacy: Public and private organisations are wary of allowing data to be published if it is possible to identify individuals directly from the data or by linking datasets.
- Cost of publishing data: There is a time and financial cost to ensuring data validity before release and presenting the data in a user friendly format.
- Uncertainty over continued availability: In order for organisations to make use of data, some assurance that the data will be updated on a continuing and regular basis is generally required.
- Lack of specific skills: A large amount of skills is required when working with vast amounts of data, particularly when linking various datasets together and presenting this data in a usable format.

Additionally, (UITP, 2014) has also identified several barriers concerning opening data, which are highly associated with transport companies:

- Opening data depends at a large scale on existing contracts in place, that are not necessarily adapted to the new reality.
- Issues concerning the ownership of data may also be arisen. In some cases, e.g. when private firms are used for the delivery of certain services, they may, for 'commercial' reasons, be reluctant to make the data openly available.
- License agreements and charging for data are also considered difficult areas.
- Finally, engagement with developers and other players takes time. Transport organisations have to weigh up the challenges against the benefits of an Open Data approach and to explain their position publicly and transparently.

Finally, local transport authorities may not able to provide a real-time information service to the public, which is more often in small cities or regions. Additionally, small transport companies, in contrast with large or international transport data providers, may face issues that do not allow them to open up their data. The main barriers which prevent both small companies and local transport authorities from making their data open and differentiate their potential from that of bigger players in open data are associated with (DfT, 2018):

- costs in terms of staffing,
- costs of required infrastructure, set up and ongoing maintenance and
- lack of expertise.

4 Delphi Survey

4.1 Introduction

The Delphi method is a structured communication technique, originally developed as a systematic, interactive forecasting method which relies on a panel of experts. The Delphi technique, which has been extensively used in planning, policy analysis, and long-range forecasting, in both the public and private sectors, is named after the ancient Greek oracle at Delphi, who offered visions of the future to those who sought advice. It was originally developed by the RAND Corporation in the 1950s and was applied to assess the direction of long range trends, with emphasis on science and technology and their effects on society; to forecast likely inventions, new technologies and the social and economic impact of technological change (Hjarnø et al., 2007). Nowadays the method is becoming increasingly popular in health and social research.

The main purpose of the Delphi method is to acquire the most reliable consensus of a group of experts' opinions by a series of intensive questionnaires combined with controlled opinion feedback [15] (Habibi & Sarafrazi, 2014). Unlike other planning and forecasting methods, Delphi's goal is not to elicit a single answer or to arrive at a consensus, but simply to obtain as many high-quality responses and opinions as possible on a given issue from a panel of experts to enhance decision making (Gupta & Clarke, 1996). It is also noteworthy to mention that the Delphi method has several advantages, since this type of survey is considered quick, cheap and a relatively efficient way to combine the knowledge and abilities of a group of experts. The key features of the Delphi method are:

- Anonymity of the participants
- Structuring of the information flow
- Regular Feedback
- Role of the Facilitator

There are several types of Delphi, with four of the most widely used being discussed by (van Zolingen & Klaassen, 2003):

- Classical Delphi: In this type of Delphi, data are collected on an individual basis from a panel of experts in a series of rounds. At each stage, the results of the previous stage are fed back to the participants until stability in responses among the experts has been achieved. The feedback usually takes the form of a statistic calculation of the group response, such as the average or the median, while experts' arguments may also completely or partially be included. During the whole process of the survey, the anonymity of the experts is kept, while the aim of the survey is to reach consensus through iteration.
- Policy Delphi: This type of Delphi is mainly used in social and political issues and is more often applied in the social sciences. Policy Delphi also collects data from a panel of experts on an individual basis in a series of rounds and there is a systematic feedback on the results of the preceding rounds, as well. However, it does not have the aim to reach consensus, but generate policy alternatives. In this type of Delphi, selective anonymity is used, since initially, the experts

answer the questionnaires individually, and, subsequently, they exchange views in a group meeting.

- Decision Delphi: Decision Delphi is used for decision making on social developments. A crucial issue of this type of Delphi is that all decision makers involved in the problem examined participate in the survey and they are selected according to their position in the hierarchy of decision makers. The aim is to structure thinking so that consensus can be achieved. Quasi-anonymity is also a characteristic of the Decision Delphi, meaning that experts are known and mentioned by name from the beginning of the study, however the answers to the questionnaires remain anonymous.
- Group Delphi: This type of Delphi concerns a face-to-face meeting or workshop, in which the classical Delphi is applied, aiming to achieve fast results in opinion making. In fact, this type of Delphi differs from the classical Delphi only on the point of anonymity.

As mentioned, the Delphi technique is a research approach to gain consensus using a series of questionnaires and the provision of feedback to participants who have expertise in key areas. The main problem in using the Delphi technique is the lack of a clear theoretical framework for using this technique. Among the most important requirements for the use of the Delphi method are the need for experts' judgment, group consensus to achieve the results, anonymity in data collection, a complex, multidimensional problem, experienced and capable experts, dispersion of experts (Habibi & Sarafrazi, 2014).

Concerning the composition and the size of the panel of the experts, there are several points of view recorded in the literature. However, it has been recommended that the panel size may vary according to the topics covered, the nature of different viewpoints included, and the time and money available (van Zolingen & Klaassen, 2003). It is also recommended to use a combination of individuals with multiple specialties and heterogeneous groups (Habibi & Sarafrazi, 2014).

The aim of the Delphi survey described in this Deliverable was to gather experts' opinions on the challenges, opportunities and barriers of Open Science in the field of transport. On that purpose, a panel of transport experts was invited to participate in the survey which was held in two rounds: a first questionnaire was distributed to the experts, in which their opinions on the challenges, opportunities and barriers of Open Science in transport research were collected. After the first round, the facilitator of the survey provided an anonymised summary of the experts' answers from the previous round and the experts were encouraged to provide their final answers by confirming or revising their previous replies based on the opinions of the other experts.

4.2 Methodology

The starting point for the application of the Delphi survey was to identify the "problem". The aim of the present Deliverable is to identify the challenges, opportunities and barriers of Open Science in transport research. The literature review highlighted that these challenges, opportunities and barriers differ for the various involved players of the transport sector. Thus, focus is given on the research community, but also on public and private transport companies and authorities, who dispose a large amount of transport data.

Then, the panel of the experts was developed. One of the most important phases of Delphi method is the selection of the most appropriate experts for the Delphi panel, since the validity of the results depends greatly on the competence and knowledge of panel members. Thus, the experts were selected based on their expertise in transport research, transport data and their familiarity with Open Science. The aim was to develop a panel of experts representing all transport modes and various areas of the transport sector (e.g. research, public sector, NGOs, etc.). On that purpose, the NTUA's large international network of co-operations (with experts from both inside and outside Europe), as well as the consortium of the BE OPEN project were exploited. A total of 30 experts were selected were invited to participate, with 18 of them accepting the invitation.

A questionnaire was then developed and distributed to the Delphi panel members. The questionnaire was drawn up based on the main findings of the literature review and the key areas identified. Before the distribution of the questionnaire to the panel of the experts, a pilot survey was conducted. The questionnaire was sent to three experts, not belonging to the Delphi panel, who responded to the survey and provided with significant comments and suggestions which contributed to the finalisation of the questionnaire.

The first round of the Delphi survey was conducted through an on-line platform, in which each respondent was invited to fill in a questionnaire of 30 questions (Annex I). After the data collection and analysis, a second round of the survey was conducted. In the second round of the survey, each participant received the questionnaire in an excel file, in which the results based on the panel's responses from the first round of the survey, as well as his/her responses to the questions of the first round were presented. It is noted that some questions were modified by the facilitator based on the responses or the comments of the experts in the first stage of the survey. In this round, the experts were asked to either confirm or adjust their responses by considering the answers of the panel of the experts. During both stages of the Delphi survey, the anonymity of the experts was kept.

Finally, the responses of the second round were analysed and the results of the Delphi survey on the challenges, opportunities and barriers of Open Science in transport research were obtained. The following figure presents the steps followed during the Delphi survey.

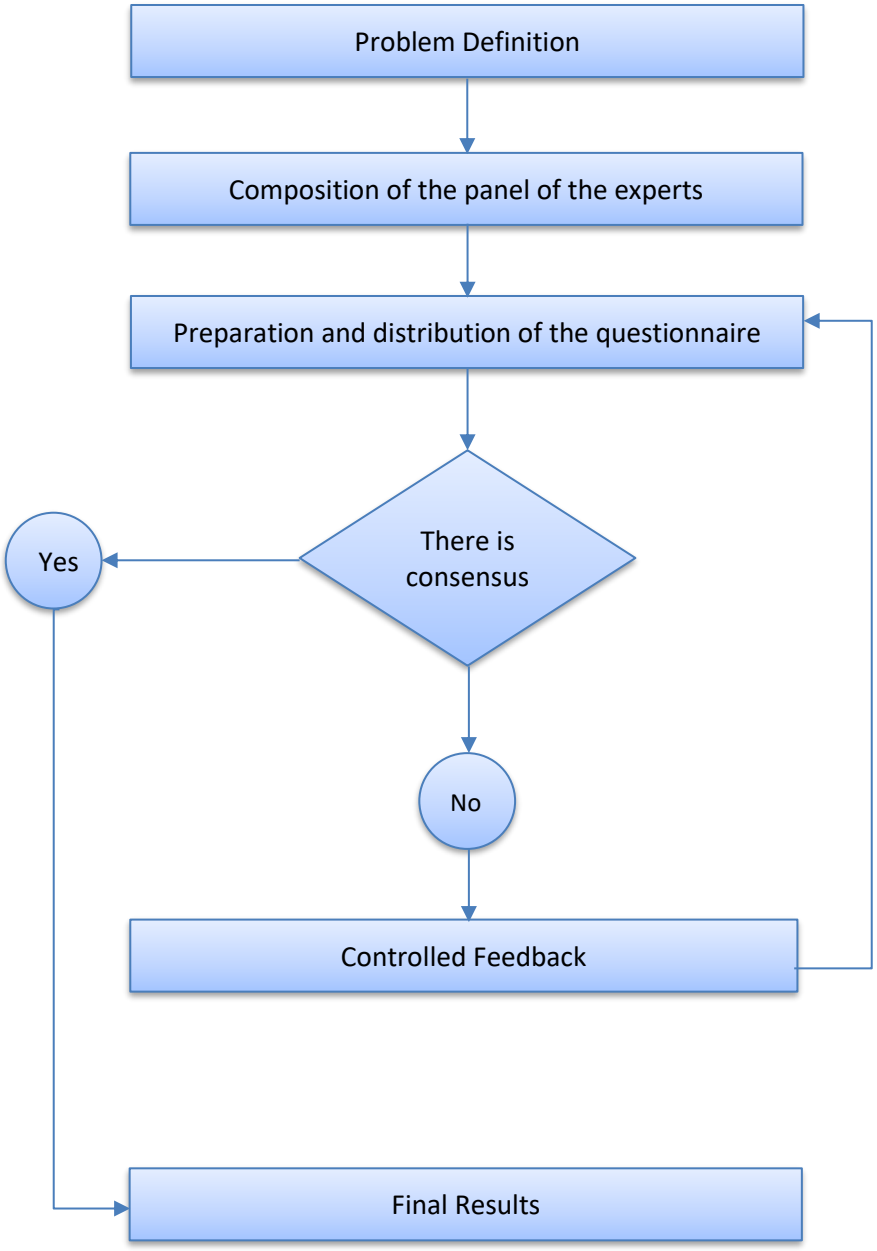


Figure 10. Steps of the Delphi Survey

4.3 Questionnaire Design

The questionnaire for the first round of the Delphi Survey was prepared based on the key areas as found in the literature review conducted within the Task 5.1. The questionnaire was comprised by four sections:

A. General: This section included six questions asking personal information, as well as information related to the background of the expert.

B. Familiarity with Open Science: In this section (four questions), the experts were asked about the use of open data and open infrastructure within their organisations, in order to assess how familiar are with Open Science.

C. Research Community: The experts were asked to assess and opt for the main challenges, opportunities and barriers of Open Science in transport research. The first question included five clear statements and participants were asked to declare how much they agree or disagree with each statement. An agree, disagree scale was opted for, i.e. a range of answer options from "strongly disagree" to "strongly agree". In the second question, the experts were asked to assess the importance of nine challenges for research institutions to share openly data or publications at a scale from "not at all important" to "very important". In the eight remaining questions, experts were asked to choose the most important challenges, opportunities and barriers. The questions were differentiated at the following aspects:

- transport researchers and transport institutions
- openly sharing data and using open data.

D. Public and Private Transport Companies: The experts are asked to assess and opt for the main challenges, opportunities and barriers for transport companies/ authorities to use or share open data and services. The first question included five clear statements and participants were asked to declare how much they agree or disagree with each statement (in a scale from "strongly disagree" to "strongly agree"). In the second question, the experts were asked to assess the importance of eleven challenges for transport companies/ authorities to share openly their data at a scale from "not at all important" to "very important". In the eight remaining questions, experts were asked to choose the most important challenges, opportunities and barriers. The questions were differentiated for public and private transport companies.

Thus, the first questionnaire consisted of a total of 30 questions (Annex II): 24 closed-ended questions (checkboxes), 2 open-ended questions, 2 agreement statements and 2 "Levels of Importance" questions. The questionnaire was designed in a Google form and the link was sent to the Delphi panel. The experts were also able to provide with comments or suggest further options for each question. The comments alongside with the results of the first round were used for the development of the second questionnaire.

The second questionnaire included only the last 2 sections of the first questionnaire. Each participant received an Excel file with the modified questionnaire, in which the results of the experts' answers were provided, as well as his/her responses to the previous round. The expert was asked to fill in again

the questionnaire taking into account the panel's answers. It is noted that in some questions, consensus had been achieved during the first round. However, all questions were included in the second round for the information of the Delphi panel on the results of the first stage. The questionnaires were sent via e-mail.

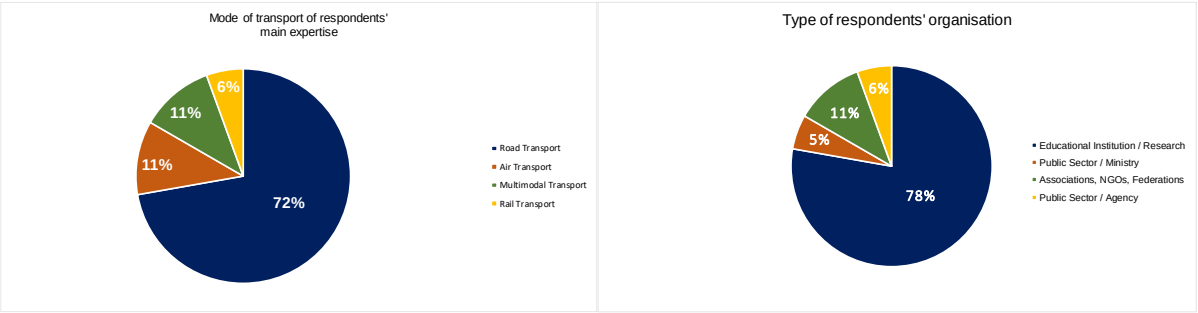
5 Delphi Survey Results

5.1 The Delphi Panel

5.1.1 General characteristics

As referred in the previous chapter, a panel of 18 experts of the transport sector was developed to participate in the Delphi survey. Briefly, the characteristics of the Delphi panel are the following:

- 13 out of the 18 experts are males, while the remaining are females;
- half of the participants are between 35-50 years old, 28% are between 51-65 years old and 22% are older than 65 years old;
- 5 out of the 18 experts have under 20 years professional experience, 8 experts have professional experience of 20-40 years, while 5 experts have more than 40 years experience in the transport field;
- Most of experts (15 out of 18 experts) comes from a European country, 2 experts are from USA, 1 expert from Canada and 1 expert from Australia;
- The main expertise of the majority of the experts participating in the Delphi survey is related to road transport (72%), the next transport modes represented are air transport and multimodal transport (both 11%) and only 6% comes from rail transport;
- About 78% of the experts of the Delphi panel come from the educational/research sector, the organisation of the 11% of the experts belongs to the group of Associations, NGOs and Federations, while another 11% of the experts come from the public sector.



(a) (b)

Figure 11. Distribution of the experts of the Delphi panel by (a) transport mode of their main expertise and (b) type of organisation

5.1.2 Familiarity with Open Science

The practices implemented in the organizations of the respondent concerning Open Science were asked. Concerning the production of open data, most of the respondents declare that their organization produce open data (44%), a 28% of the respondents declares that open data are produced on an ad-hoc basis, while the organizations of the remaining 28% of the experts do not produce open data.

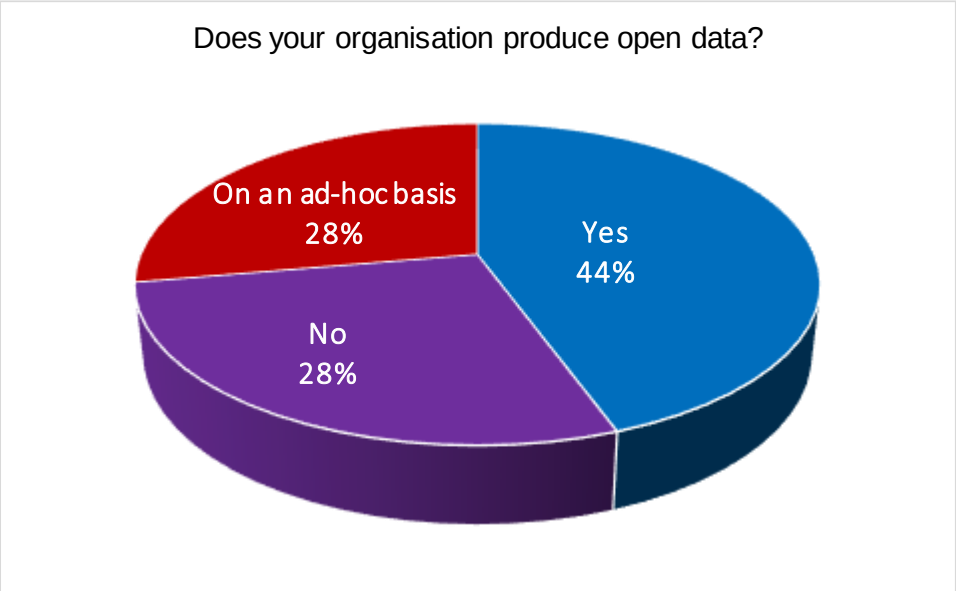


Figure 12. Distribution of responses to "Does your organisation produce open data?"

Respondents were also asked to rate how much of the research conducted at their organisations is based on open data in a 5-point scale (1=not at all - 5=very much).

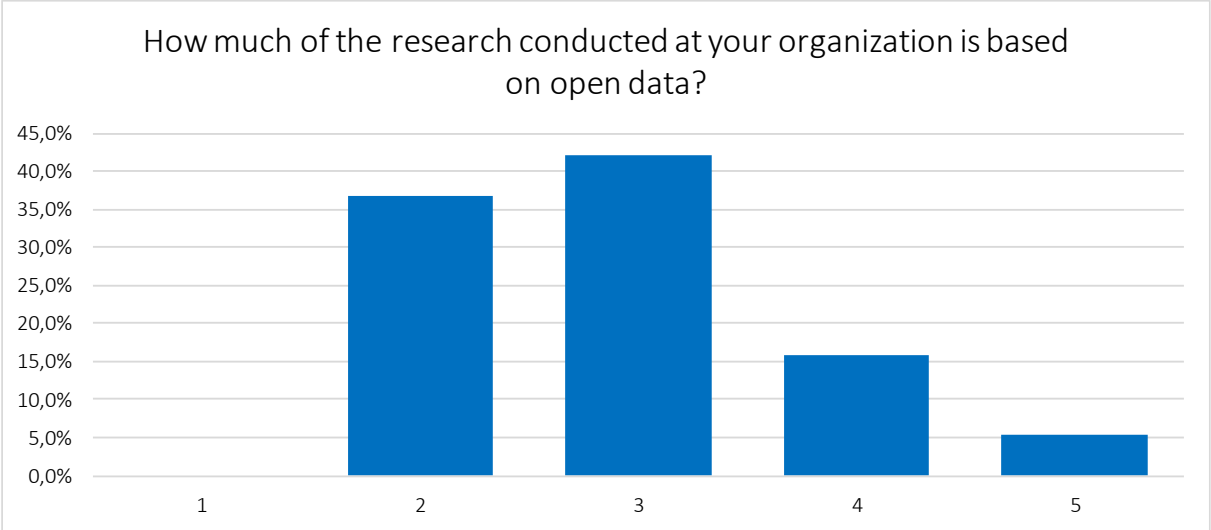


Figure 13. How much of the research conducted at your organization is based on open data? (1=not at all - 5=very much)

However, the picture differs concerning the use of open software, with the vast majority of the experts declaring that the use of open source software is allowed in their organisations. The most widely used open source licences concern data processing software and survey software (both 17%), followed by transport modelling software (15%) and coding and office software (about 14%).

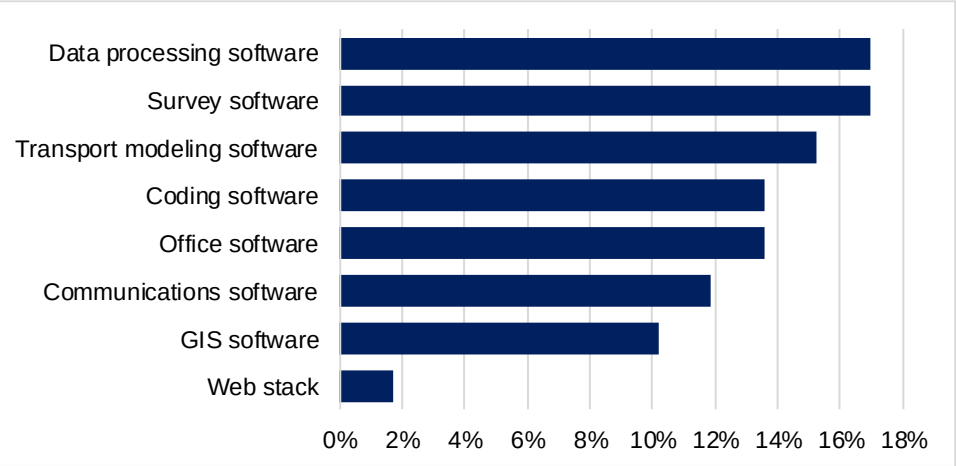


Figure 14. Distribution of responses to " what open source licences are used at your organisation?"

5.2 Transport Research Community

A consensus was reached to three of the five statements concerning Open Science in transport research community, as shown in the following figure. More precisely, about 95% of experts agree that "*sharing data is more beneficial rather than worthless*" and that "access to open research data contributes to the advancement of the science". Concerning the familiarity of researchers with sharing open data or finding easily open data in the web, most experts neither disagree nor agree (40%) with these statements, while more than 35% of experts declare that rather disagree. Consensus is also achieved concerning the training of the researchers on Open Science, with all experts not considering that "*transport researchers have received sufficient training in data sharing*".

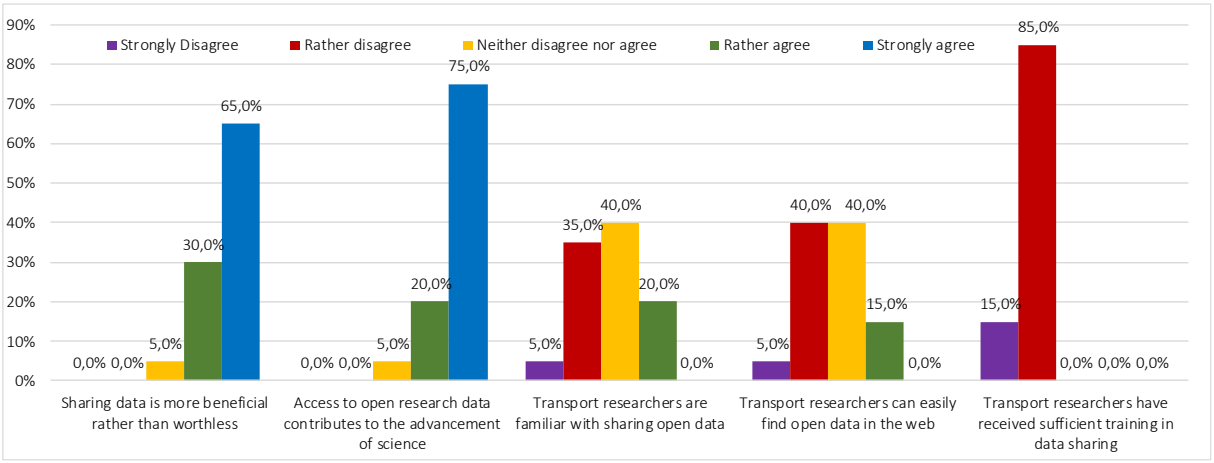


Figure 15. Statement of agreement concerning Open Science in transport research

The experts were asked to assess the importance of the following challenges for research institutions to share data or publications. The most important challenges (assessed as fairly important and very important) were legal restrictions, e.g. GDPR, privacy issues, IPR etc. (80%) as well as contractual restrictions from other partners (75%), followed by the lack of skilled personnel (70%) and the potential of commercial interest for research data (65%). The lack of appropriate hardware or software, the competition with other institutions was assessed as less important than the aforementioned

challenges (only 5%). It should be noted however that data security issues (e.g. access, cyber-security) seem to divide experts' opinions in terms of importance of this challenge.

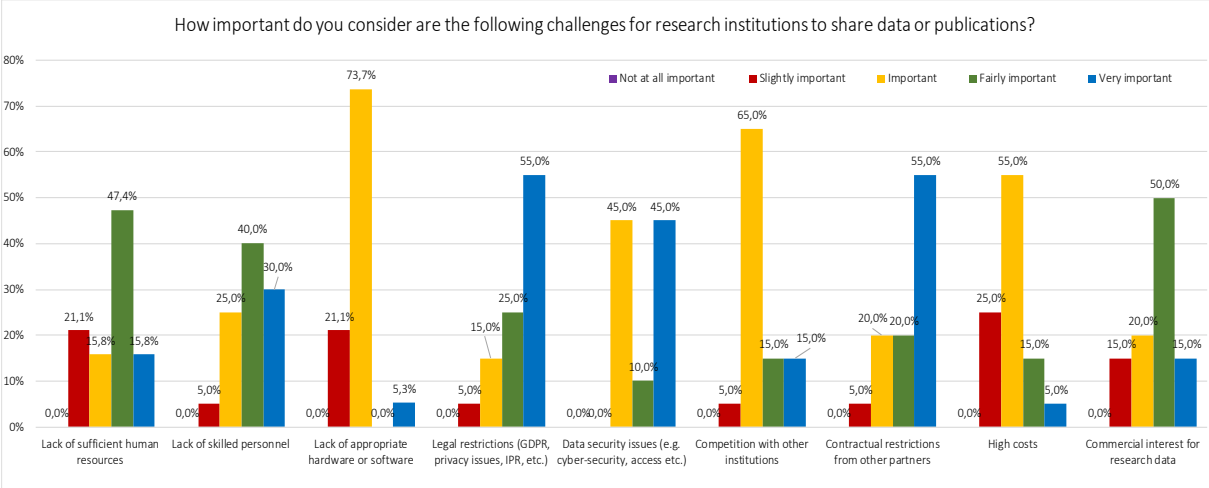


Figure 16. Assessment of importance of challenges for research institutions to share data or publications

As far as data management is considered, the three most important challenges for the research institutions in producing and sharing open data have been identified from the 2nd round of the Delphi survey, which are data quality (24%), data protection and security (24%) and the complex nature of the transport data and information (21%).

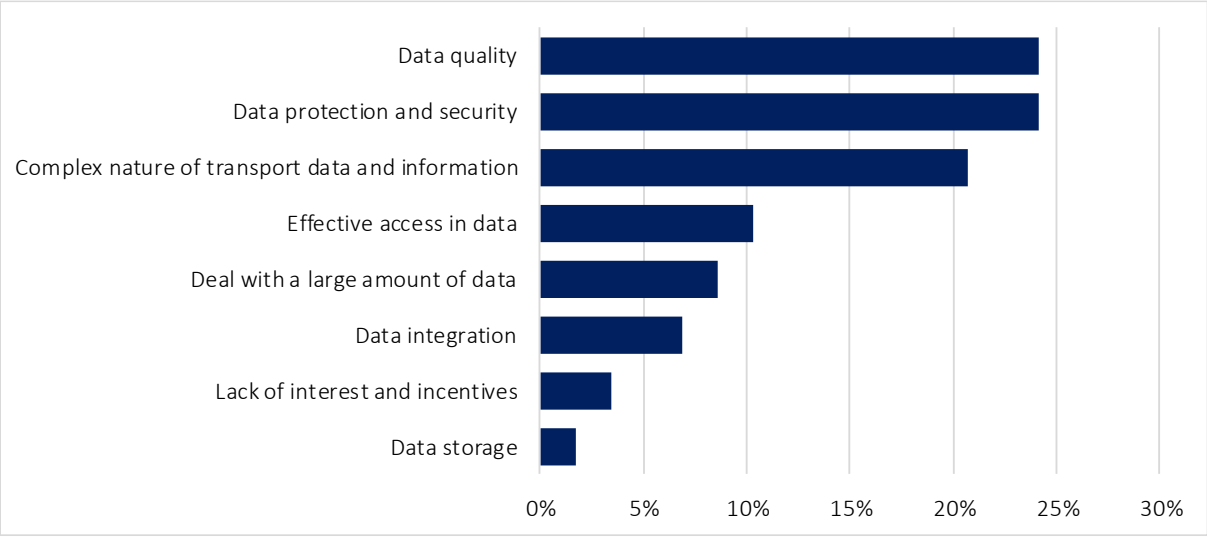


Figure 17. Concerning data management, which are the three most important challenges for the research institutions in producing and sharing open data?

Considering the technical issues, the Delphi panel was asked to choose the three most important challenges for researchers to produce and share open data. The most important challenges that identified in this survey concern technical expertise in data security and privacy (26%) and expertise in data management (22%). It is worth noting that open licence practices and skills on database design

and computer programming seem to be considered challenging issues for the transport research community concerning Open Science.

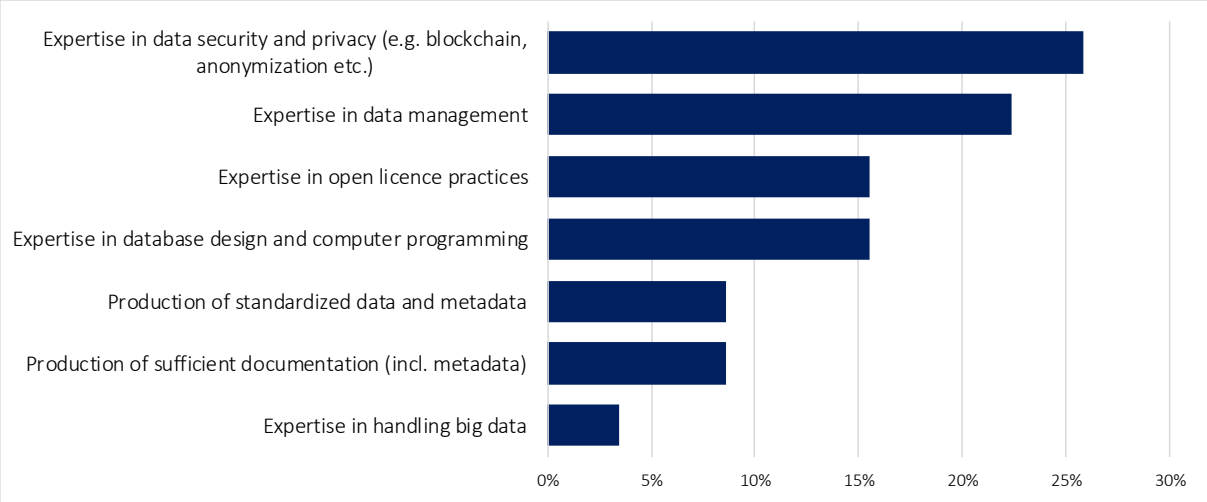


Figure 18. From technical perspective, which of the following requirements are the three most important challenges for researchers to produce and share open data?

The picture is also clear concerning the opportunities that may arise from Open Science for research institutions. The most important opportunity is considered the advance of science that could be achieved in the transport research through the Open Science (32%). Additionally, sharing data and publications is considered as a valid way to increase collaborations not only across institutional, national and disciplinary boundaries, but also between companies and research infrastructures (Figure 19). However, two main barriers for research institutions in sharing open data were identified within this survey, i.e. data ownership issues/IPR (30%) and resources and organizational issues (25%) related to the transport research institutions (Figure 20).

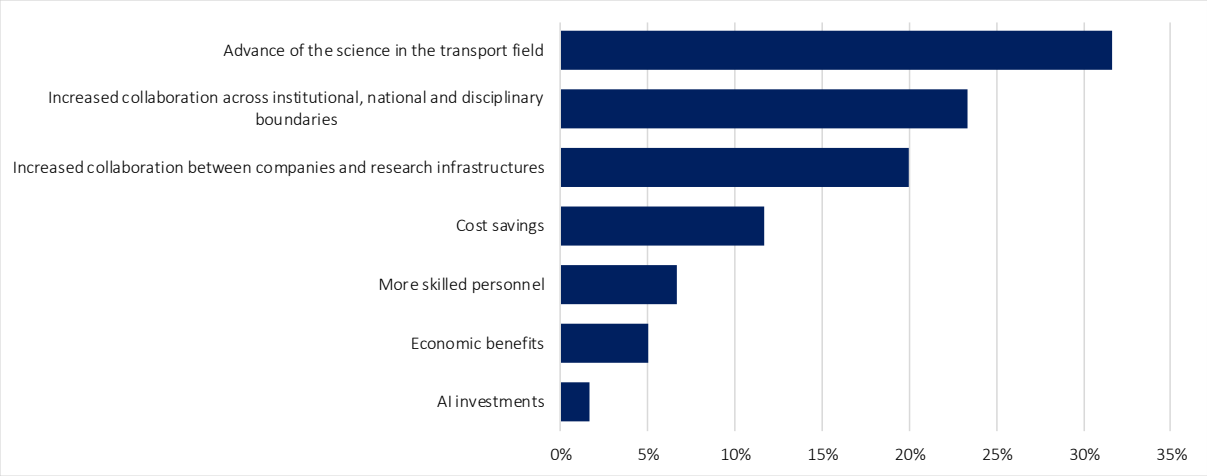


Figure 19. Which are the three most significant opportunities of openly sharing data or publications for research institutions?

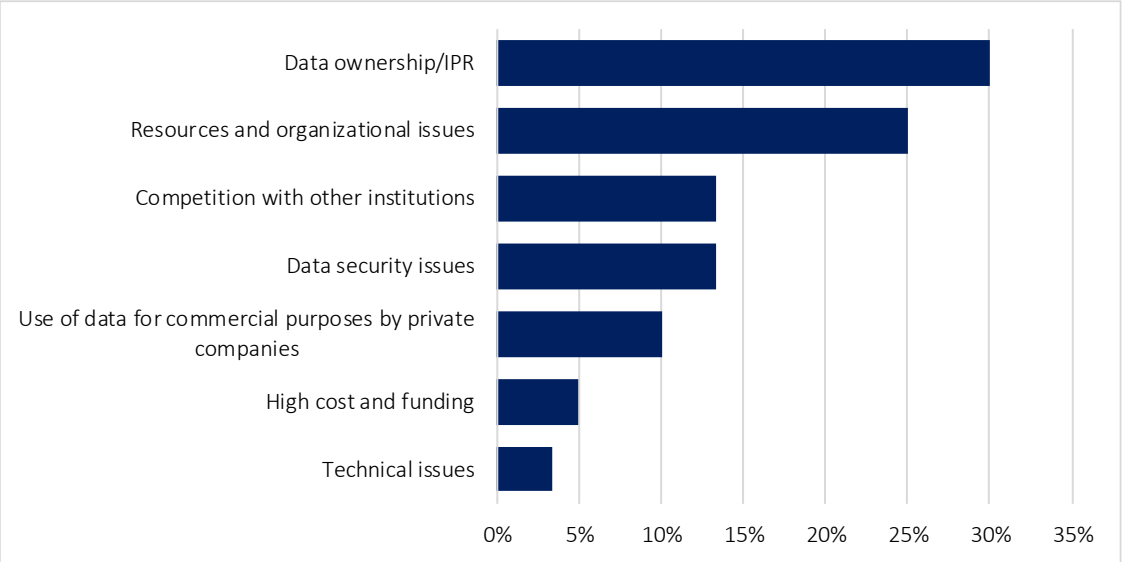


Figure 20. Which are the three main barriers of producing and sharing open data for research institutions?

As far as individual researchers are concerned, the benefits of openly sharing data and using available open data differ. The main incentives for researchers to openly share their data/ research results are the potential of gaining more co-operations/contacts (23%) and recognition in the research community (20%), as well as the opportunity of being co-author to other researchers' publications, who have used their data (20%). On the other hand, the main benefits from using available open data were considered the accessibility to more data (30%) and more cross-disciplinary co-operations (20%), while a significant part of the Delphi panel (about 17%) also believes that using open data will offer more new, original research results and products.

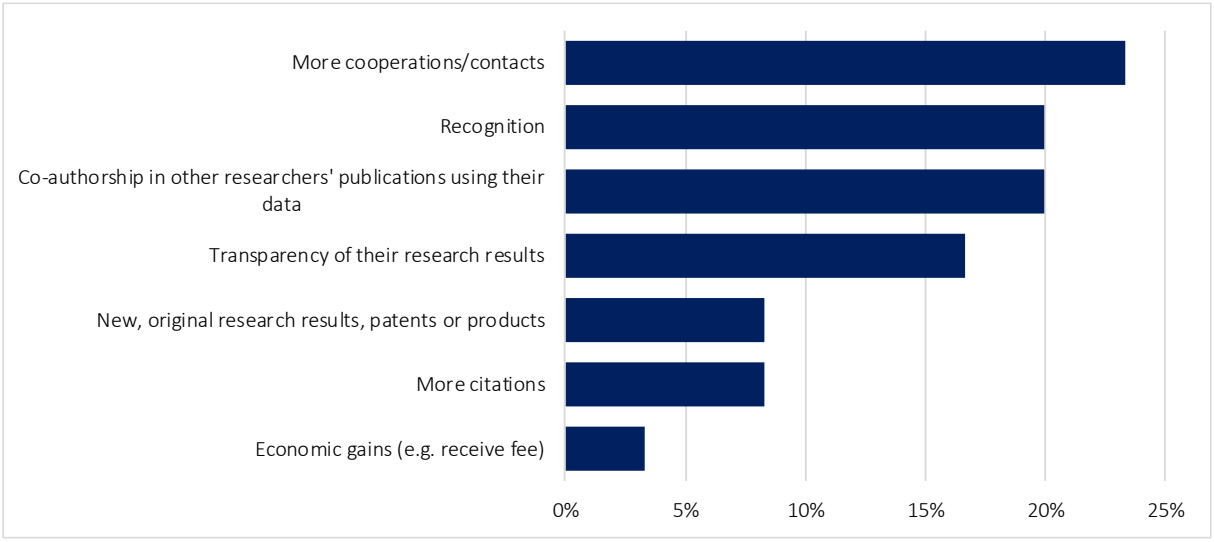


Figure 21. Which are the three most important benefits for individual researchers to share their data?

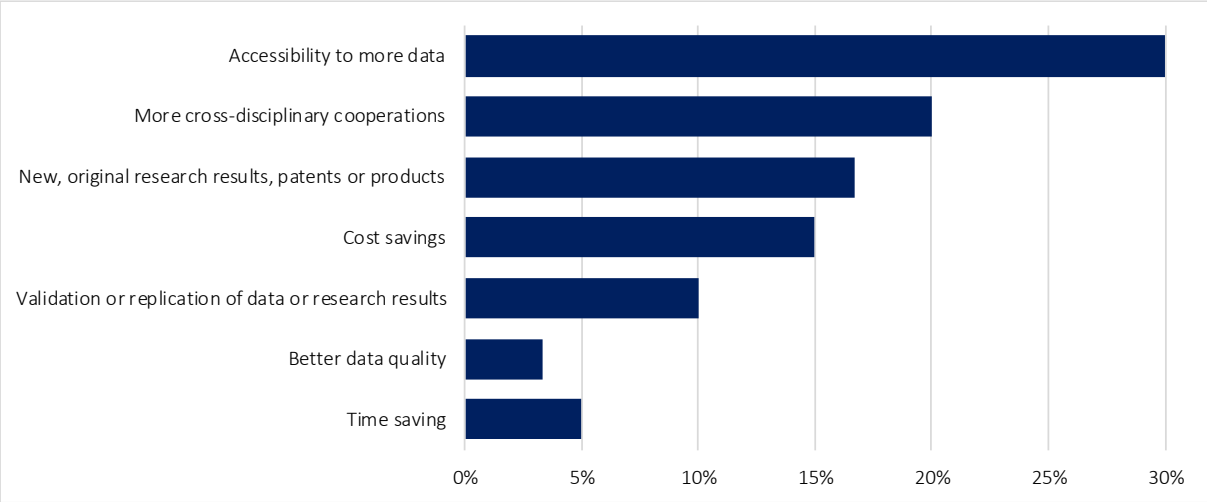


Figure 22. Which are the three main benefits of using open data for individual researchers?

Regarding the barriers of openly sharing their data for individual researchers, the significant effort to produce a dataset and data protection and ethical restrictions were considered as the most significant (Figure 23). On the other hand, the most relevant barriers preventing transport researchers from using available open data were reputed the insufficient documentation of the data (27%) as well as the not easy accessibility (23%) to such data.

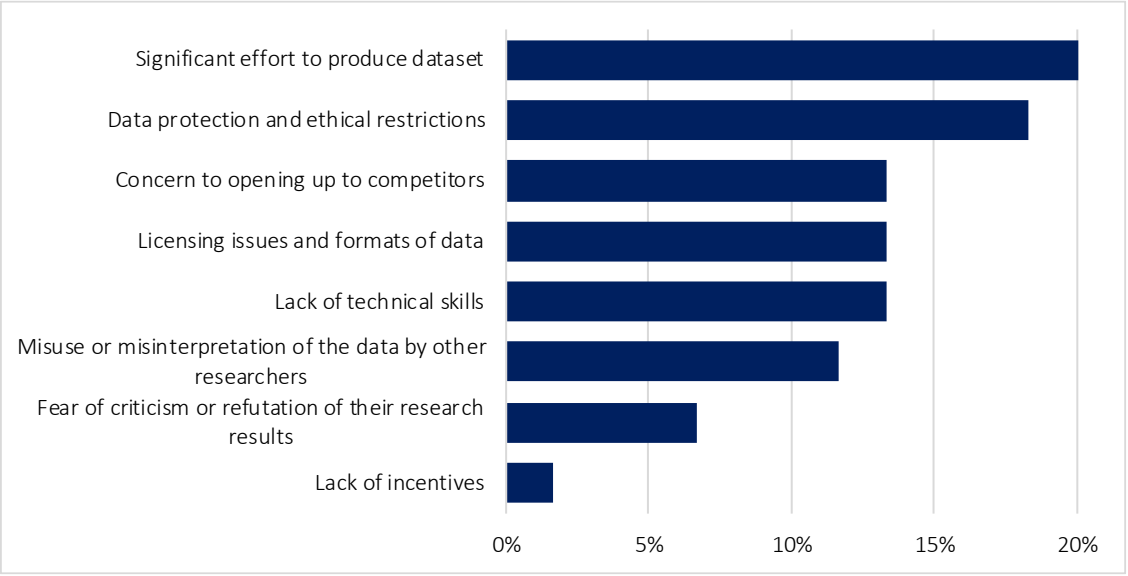


Figure 23. Which are the three main barriers of sharing data or research results for individual researchers?

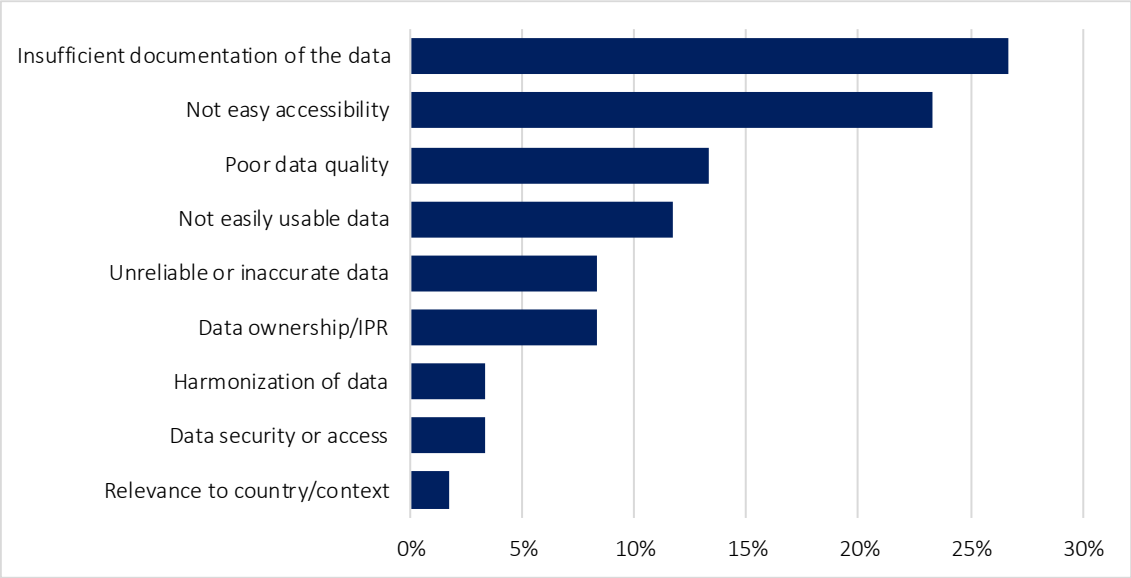


Figure 24. Which are the three main barriers of using open data for individual researchers?

5.3 Public and Private Transport Companies and Authorities

A consensus was reached to four of the five statements concerning Open Science and transport companies, as shown in the following figure. More precisely, about all experts participating in the Delphi panel agree (rather agree and strongly agree) that "*Data is not always considered as a public good, but as something to pay for*", about 90% of experts agree that "exploitation of publicly-funded research should be one of the goals of governments" and "*companies operating in competitive markets are more reluctant to make their data available*". Additionally, 74% of experts recognise that "*Open Science could contribute in the promotion of public-private partnerships*", with 26% of experts being neutral on this statement. On the contrary, consensus was not achieved with the statement "*companies do not benefit enough from participating in open data partnerships with research institutions*" with about 47% of the experts neither disagreeing nor agreeing with this statement.

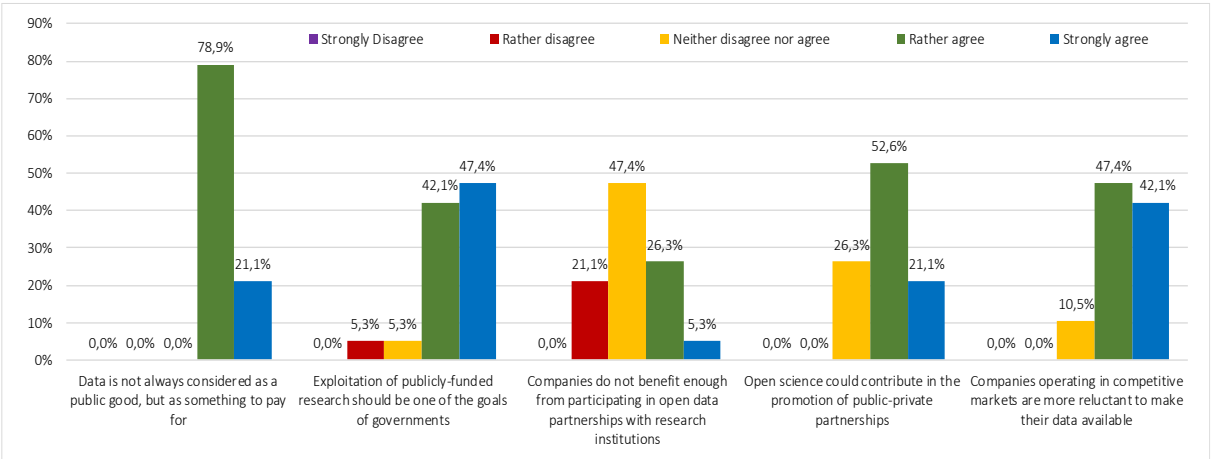


Figure 25. Statement of agreement concerning Open Science and transport companies/authorities

The experts were asked to assess the importance of the following challenges for transport companies and authorities in sharing their data. The most important challenges (assessed as fairly important and very important) were data protection, privacy and ethical issues and data ownership conflicts (94%), followed by complex socio-political interactions among authorities and transport stakeholders (89%), commercial competition (83%) and the different interests and perspectives on open data by transport stakeholders (83%). On the contrary, technical issues, data standards and formatting issues were assessed as less important than the aforementioned challenges.

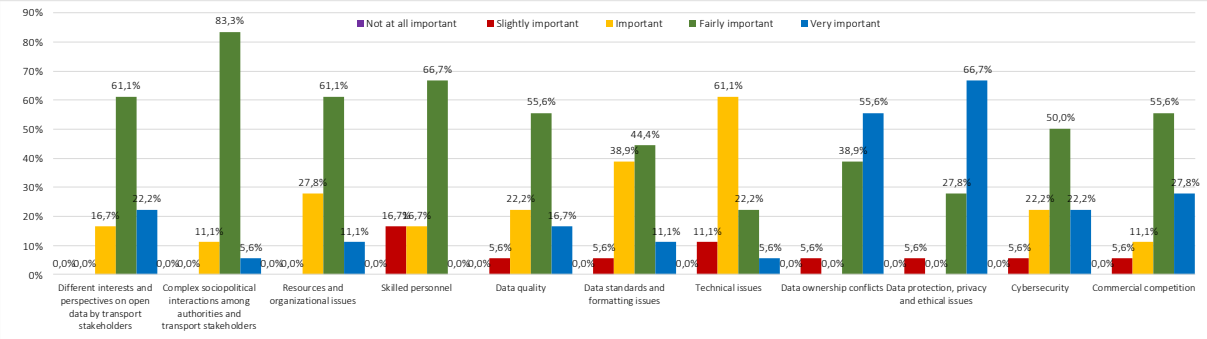


Figure 26. Assessment of importance of challenges for transport companies and authorities in sharing their data

As far as the public transport authorities are concerned, the most significant challenges in opening up their data were found the data ownership conflicts (28%), data protection, privacy and ethical issues (20,5%), followed by the need for skilled personnel (15%). Concerning private transport companies, the first two aforementioned challenges (i.e. data ownership conflicts and data protection, privacy and ethical issues) were also found as the most important (26% and 24% respectively), followed by the commercial competition and the different interests and perspectives on open data by transport stakeholders (about 15%).

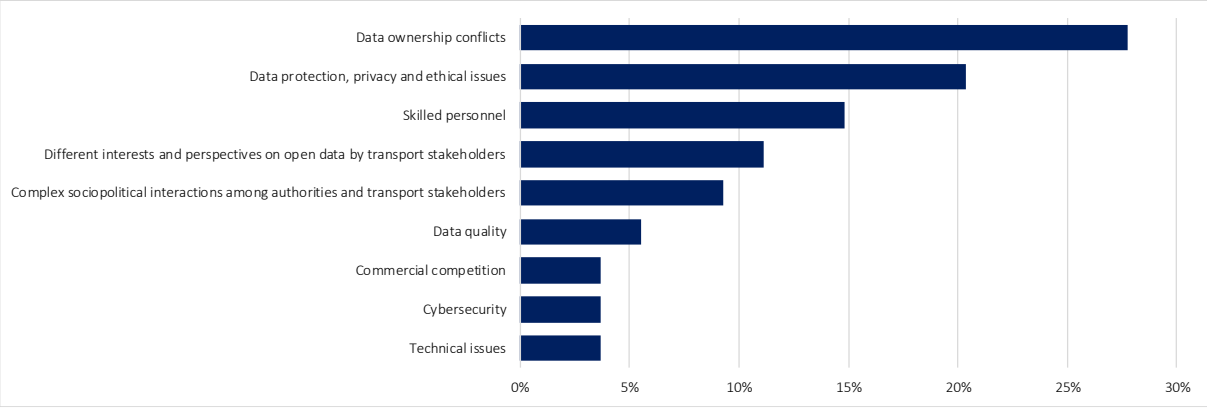


Figure 27. Which are the three main challenges of opening up their data for public transport authorities?

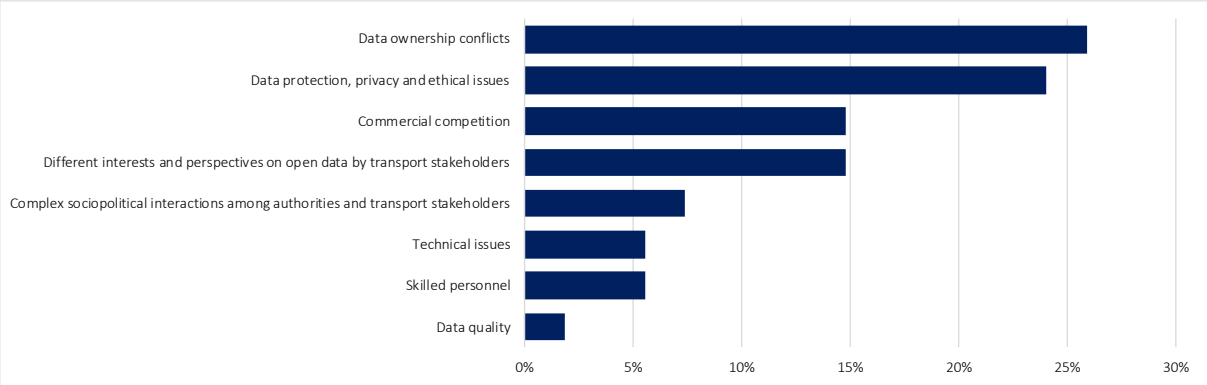


Figure 28. Which are the three main challenges of opening up their data for private transport companies?

Considering the main opportunities arising for public transport authorities from using open data services the most relevant ones resulted to be the improvement of transport operations and performance (26%) and fostering data based decisions (20,4%). The respective opportunities for the private transport companies were the reduction of the costs (26%), the improvement and alignment of customer needs (18,5%) and the accessibility to more data (18,5%).

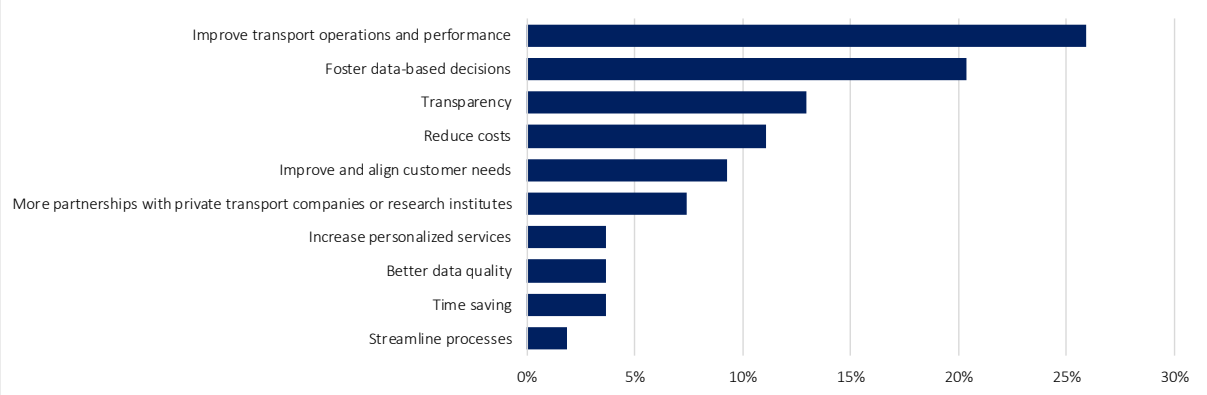


Figure 29. Which are the three main opportunities of using open data services for public transport authorities?

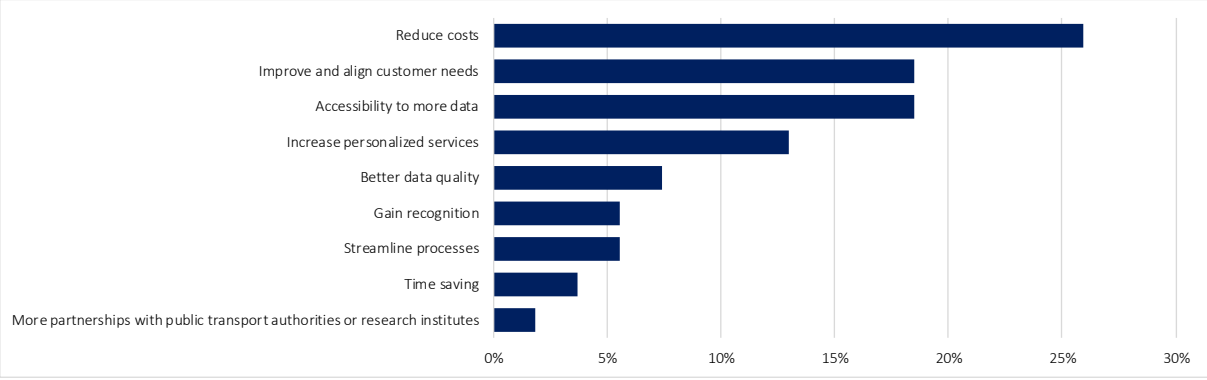


Figure 30. Which are the three main opportunities of using open data services for private transport companies?

Regarding the barriers of sharing data for public transport authorities, the most significant barriers found from the Delphi survey were protection of commercial/confidential data (about 24%) and conflicts regarding ownership/IPR (22%), followed by the protection of personal data (17%). These three barriers were also considered as the least likely to be overcome, with the conflicts regarding data ownership and IPR being identified as the most crucial issue. It is also noted that the limited financial resources were also considered a not easy barrier to be overcome.

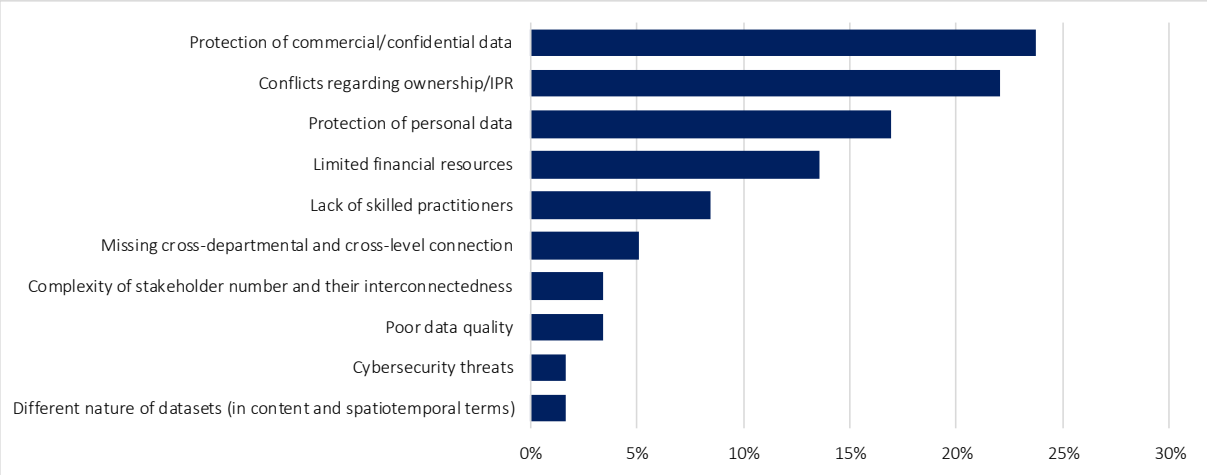


Figure 31. Which are the main barriers of sharing data for public transport authorities?

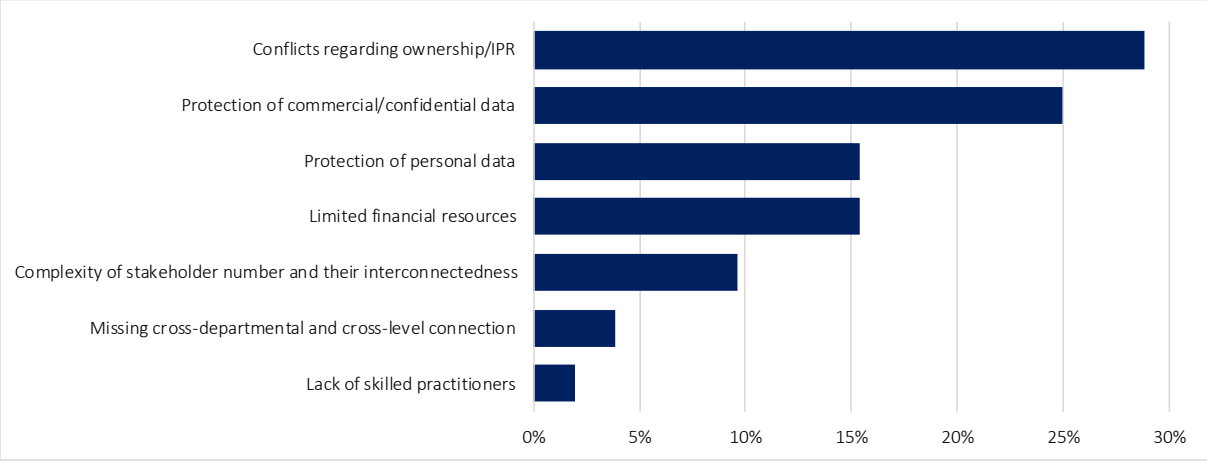


Figure 32. Which of the above barriers of sharing data for public transport authorities are least likely to be overcome?

The same barriers in openly sharing data were identified for the private transport companies (i.e. conflicts regarding ownership/IPR (26%), protection of commercial/confidential data (26%) and protection of personal data (20%)), which were also considered as the least likely to be overcome.

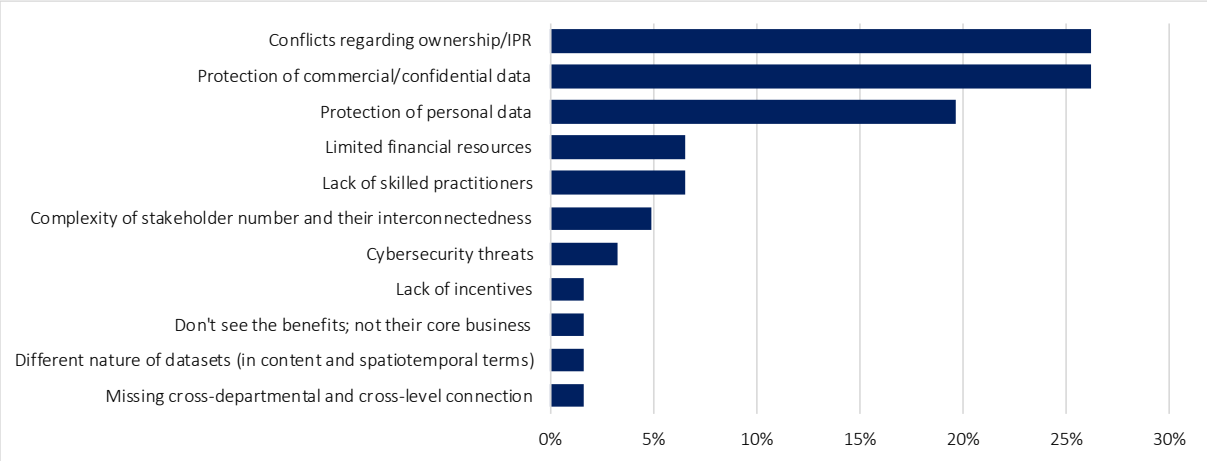


Figure 33. Which are the main barriers of sharing data for private transport companies?

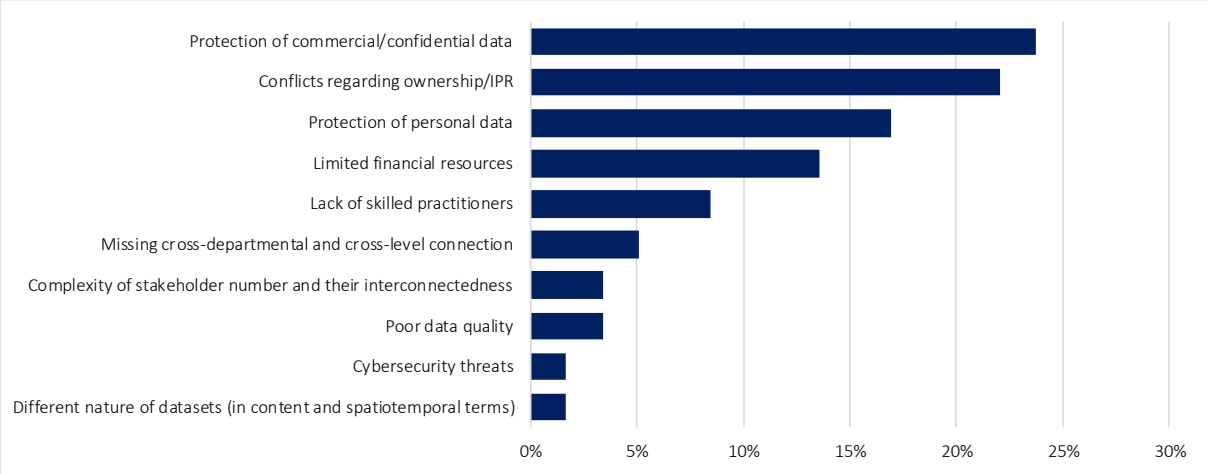


Figure 34. Which of the above barriers of sharing data for private transport are least likely to be overcome?

5.4 Conclusions of the Delphi Survey

The aim of the Delphi survey was to identify the challenges, opportunities and barriers of Open Science in transport research. The Delphi survey was conducted in two rounds, in which a panel of transport experts replied to a questionnaire of 30 questions. The questionnaire was designed based on the literature review results, which led to a series of challenges, opportunities and barriers identified in general (for all disciplines), as well as for the transport sector. The literature also highlighted that these challenges, opportunities and barriers differ for the research community and the transport companies, due to their different interests, needs and profits. Thus, the questionnaire was designed in such a manner to capture these differences, not only between the research community and transport professional sector, but also between public and private sectors.

The Delphi panel formulated for the purposes of this study took advantage from 18 transport sector experts, coming mainly from Europe, but also outside Europe. The main expertise of the panellists was related to a specific transport mode, representing thus all transport modes.

During the first round of the Delphi survey, consensus was achieved in a few questions, while the variation of the responses was higher than that of the second round. In the second round, experts provided their final opinions on the issues asked by taking into account the panel's pooled opinions.

A summary of the main findings of the Delphi survey is presented in Table 1. Based on the results of the Delphi survey, while Open Science is considered as a key contributor in the advancement of science, transport researchers do not receive sufficient training in data sharing. From the side of the research institutions, the most important challenges that should be considered in order to adopt a policy closer to the principles of Open Science are the various legal and ethical restrictions (e.g. GDPR, privacy issues, IPR, etc.) as well as contractual restrictions from their partners. The lack of skilled personnel was also highlighted as a significant challenge, and more precisely the Delphi panel considers that the main technical skills and expertise that researchers do not dispose concern how to ensure data security and privacy during the process of sharing their data, as well as data management and computer programming. Concerning data management, issues regarding the quality of data to be opened up, as well as the complex nature of transport data and information are among the main challenges. Especially the last constrain is associated with the large number of stakeholders involved in the transport research, the various existing data providers and the segmentation of data ownership.

Openness in transport research is expected to lead to the advance of the science in the transport field, while further co-operations with other institutions from other countries or disciplines as well as with transport companies were found among the main benefits for research institutions. Similar are the benefits of opening up for individual researchers, who could gain more co-operations and contacts as well as recognition at a wider scale within their research field. Additionally, their research could be benefited, since they will be able to access more data, by reducing the costs of collecting data and generating from scratch new datasets, which could lead faster and more easily to new, original research results and patents.

Among the barriers that research institutions should overcome in order to adopt an open data policy there are the lack of resources (human and financial) and organizational issues, as well as conflicts concerning data ownership/IPR. For researchers, the main barriers of sharing their data in open platforms are the significant effort needed to produce a standardised dataset, alongside with the proper documentation and metadata. It was also found that if this documentation of data is not sufficient, researchers will be prevented from using open data, possibly due to lack of reliability. Furthermore, not easy accessibility is also considered a barrier in using open data, which could be associated to both the plethora of transport data and sources, without the required standards for their easy identification and acquisition, as well as to the lack of proper training of researchers.

Concerning the challenges, opportunities and barriers of Open Science for transport companies and authorities, greater consensus was achieved in most of the issues asked in the second round of the survey. Similarly to the research institutions, legal and ethical issues referring to data protection and privacy and data ownership/IPR conflicts were assessed as the main challenges for the transport companies. Besides these legal and ethical issues, the lack of skilled personnel was identified for the public transport authorities, while the commercial competition was identified for the private transport

companies, most of which are considered more reluctant to make their data openly available, when operating in highly competitive markets.

On the other side, Open Science and open data are expected to improve the transport operations and performance of the public transport authorities, foster data-based decisions and increase transparency, while for the private companies the reduction of the costs, the improvement of their customer services and the accessibility to more data are among the main benefits of using open data services. However, conflicts regarding ownership/IPR, protection of commercial and confidential data and protection of personal data have been assessed as the most significant barriers and the least likely to be easily overcome.

Table 1. Summary of main findings of Delphi Survey on challenges, opportunities and barriers of open science in transport sector

	Challenges	Opportunities	Barriers
Researchers	**Technical challenges:** • Expertise in data security and privacy • Expertise in data management • Expertise in open licence practices • Expertise in database design and computer programming **Data management:** • Data quality • Data protection and security • Complex nature of transport data and information	**Openly sharing their data:** • More co-operations/contacts • Gain recognition • Co-authorship to other researchers' publications using their data **Using of open data:** • Accessibility to more data • More cross-disciplinary co-operations • New, original research results and products	**Openly sharing their data:** • Significant effort to produce dataset • Data protection and ethical restrictions • Concern to opening up to competitors **Using of open data:** • Insufficient documentation of the data • Not easy accessibility • Poor data quality
Research Institutions	• Legal restrictions (GDPR, privacy issues, IPR, etc.) • Contractual restrictions from other partners • Lack of skilled personnel	• Advance of the science in the transport field • Increased collaborations not only across institutional, national and disciplinary boundaries • Increased collaboration between companies and research infrastructures	• Data ownership/IPR • Resources and organisational issues • Competition with other institutions

	Challenges	Opportunities	Barriers
Public Transport Companies/ Organisations	• Data ownership conflicts • Data protection, privacy and ethical issues • Skilled personnel	• Improve transport operations and performance • Foster data-based decisions • Transparency	• Protection of commercial/ confidential data • Conflicts regarding ownership/IPR • Protection of personal data
Private Transport Companies/ Organisations	• Data ownership conflicts • Data protection, privacy and ethical issues • Commercial competition	• Reduce costs • Improve and align customer needs • Accessibility to more data	• Conflicts regarding ownership/IPR • Protection of commercial/ confidential data • Protection of personal data • Limited financial resources

6 Conclusions

The purpose of the present deliverable is to identify the main challenges, opportunities and constraints of Open Science in transport research. On that purpose, a targeted review of the literature was conducted on the impact of Open Science on the overall research, as well as on transport research. A large number of related publications (scientific papers, articles, reports, project deliverables, policy documents etc.) were gathered and classified in terms of importance and quality. Based on the results of the literature review, the key areas of Open Science were identified and an extensive list with challenges, benefits and constraints of Open Science in research was developed.

Then, the Delphi survey was designed, including the development of the questionnaire, the selection of the transport experts to formulate the Delphi panel, the distribution of the questionnaires and the analysis of the results. The survey was conducted in two stages: in the first stage, the experts provided their opinions on a series of issues, while in the second round experts were asked to either confirm or adjust their answer by taking into account the results from the first round. In both stages of the Delphi survey experts' anonymity was kept. The aim of this procedure was in fact to achieve as high consensus as possible.

Based on the overall results, six dimensions of challenges of Open Science are considered, namely: socio-cultural, technological, political, organizational, economic and legal. Literature on challenges of Open Science in transport research has also identified further dimensions, which are: resources and organizational issues, skills, capacities and capabilities, data related issues, technical issues, data ownership, legal and ethical issues and data security.

The advance of the science is expected through the openness of transport research, while the provision of open data by more and more transport data providers is expected to lead to further new, original research results, patents and products. The implementation Open Science in transport research will also enhance the reputation of both institutions and individual researchers, while the collaborations among research institutions will be expanded. In relation to the transport companies and organizations, the following benefits were identified from both the literature review and the Delphi survey: customer satisfaction/personalized information, further commercial co-operations and new commercial models, strengthening of capabilities and capacities/gathering intelligence, transparency and innovation, and data based decisions.

Both the literature review and the Delphi survey have identified that several barriers arise in the implementation of Open Science in order to protect scientific researchers' rights and ideas, concerning commercial interests and economic benefits, data privacy and data security and safety. These barriers were identified not only for transport research, but also for transport companies and authorities, alongside with the protection of confidential data. However, it is noted that while the literature gives special emphasis on the security of data (e.g. cyber-security), the threat of cyber-attacks was not identified among the main barriers in the Delphi survey. In fact, cybersecurity was assessed as an important challenge, but not among the crucial ones. Additionally, the literature review has indicated that most barriers are considered solvable, with those relating to market forces being less easy to address, while the survey results highlighted the legal and ethical issues as the least likely to be

overcome. Other obstacles in opening up data in transport research resulted to be: data usability, data relevance, lack of technical skills, market forces, privacy, cost of publishing data, existing contracts in place etc.

Concluding, the global transport research and industry are at the forefront of embracing Open Science and the provision of open data and services, a need which is also accelerated by the rapid developments in transport sector. The availability of open transport data delivers net benefits to:

- both transport research community and researchers, by improving data access and promoting the development of new ideas and research results and
- to transport organisations/companies and the customers, by enabling a more efficient operation suitably adjusted to customers' needs and ensuring transparency.

Under these circumstances, transport research should be proactive and support the principles of openness overcoming the barriers.

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8 Annexes

8.1 Annex I. Table of Literature References

a/a	Title	Issue Date	Authors	Publisher	Country of Publisher	Language	Type	Category 1	Primary	Secondary-1	Secondary-2	Secondary-3	Secondary-4
1	The future of Road transpor - Implications of automated, connected, low-carbon and shared mobility	2019	ALONSO RAPOSO Maria, CIUFFO Biagio, et al.	EU Science Hub	Italy	English	Report	Road transport	Opportunities	Challenges	TRIMIS		
2	1st TRIMIS Horizon Scanning Session	2019	Joint Research Centre,Ispra, Italy,	The European Commission's Joint Research Centre (JRC)	Italy	English	Conference and workshop Report	Transport	Opportunities	TRIMIS			
3	A framework for the quality-based selection and retrieval of open data - a use case from the maritime domain	2018	Milena Stróżyna, Gerd Eiden, Witold Abramowicz, Dominik Filipiak, Jacek Małyszko & Krzysztof Węcel	Electronic Markets Journal		English	Journal Article	Maritime	Challenges	Open Science			
4	A fuzzy Delphi-AHP-TOPSIS framework to identify barriers in big data analytics adoption: case of maritime organizations	2019	Xiunian Zhang, Jasmine Siu Lee Lam	Journal Maritime Policy & Management	Indonesia	English	Journal Article	Maritime	Challenges	open data	big data	Fuzzy Delphi-AHP-TOPSIS	
5	A Perspective on the Challenges and Opportunities for Privacy-Aware Big Transportation Data	2019	Godwin Badu-Marfo, Bilal Farooq & Zachary Patterson	Journal of Big Data Analytics in Transportation	Canada	English	Journal Article	Transport	Challenges, opportunities	Big Data	Human travel mobility	Privacy awareness	
6	Action points for the public transport sector, The benefits of open data	2014	UITP, Advancing Public Transport	UITP, Advancing Public Transport	Belgium	English	Report	Road Transport	Benefits	policy issues	efficiency	economy	
7	ADAS&ME , D10.2:ADAS&ME Data Management Plan	2017	CERTH/HIT		Greece	English	Deliverable	Road Transport	Challenges	policy issues	data management	privacy	standards
8	Addressing Barriers and Opportunities Engendered by Big Data in Transport: The LeMO Project	2018	R. AKERKAR	Leveraging Big Data to Manage Transport Operations (LeMO H2020 project)	Norway	English	Deliverable	Transport	Barriers, opportunities	open data	big data		
9	Advancing engagement between HPC Centres of Excellence & EOSC	2020	Drago, Federico, & Ferguson, Nicholas.	EOSCsecretariat.eu	Belgium	English	Report	General	Opportunities	EOSC	High Performance Computing		
10	An action plan for the European Open Science Cloud	2018	Business Network's Cloud	Science Business Publishing Ltd	Belgium	English	Report	General	Opportunity	EOSC	guiding principles		

a/a	Title	Issue Date	Authors	Publisher	Country of Publisher	Language	Type	Category 1	Primary	Secondary-1	Secondary-2	Secondary-3	Secondary-4
			Consultation Group										
11	Analysis of the State of the Art, Barriers, Needs and Opportunities for Setting up a Transport Research Cloud	2018	Bohm, Franklin, Jones, Kovacikova, Nowicka, Yannis	European Commission	Belgium	English	Report	Transport	Barriers	needs	opporunities	challenges	
12	AutoMat,D2.5 Cyber Security Framework	2018	Trialog, EPRC		France, Germany	English	Deliverable	Road Transport	Challenges	privacy	security		
13	Autonomous Open Data Prediction Framework	2019	Janis Peksa	IEEE 7th IEEE Workshop on Advances in Information, Electronic and Electrical Engineering (AIEEE)	Latvia	English	Conference paper	General	challenges	open data	autonomous	prediction	
14	Big Data for Supporting Low-Carbon Road Transport Policies in Europe: Applications, Challenges and Opportunities	2016	Michele De Gennaro, Elena Paffumi, Giorgio Martini	Science Direct - Big Data Research	Italy	English	Journal Article	Road Transport	Challenges, opportunities	open data	Low-carbon road transport	European transport policies	Environmental policies and climate change mitigation
15	Building a Self-Sustaining Science Cloud	2019	Business Network's Cloud Consultation Group	Science Business Publishing Ltd	Belgium	English	Report	General	Benefits	Opportunities	EOSC	benefits	
16	Challenges and opportunities in deploying a mobility platform integrating public transport and car-pooling services	2018	Marco Derboni, Andrea Emilio Rizzoli, Roberto Montemanni, Jafar Jamal, Nikolett Kovacs, Francesca Cellina	18th Swiss Transport Research Conference proceedings (SocialCar H2020 project)	Switzerland	English	Conference paper	Transport	Challenges, opportunities	open data	car-pooling	multi-modal routing algorithms	artificial intelligence
17	Challenges and strategies for the success of Open Science	2016	Gema Bueno de la Fuente	Foster platform	EU	English	Article	General	challenges	boundaries	cultural	technological	political
18	Challenges for data sharing in freight transport	2019	T. Moschovou, E.I. Vlahogianni and A. Rentziou	Advances in Transportation Studies: an international Journal	Greece	English	Journal Article	Transport	Challenges	open data			
19	Computational Intelligence and Optimization for Transportation Big Data: Challenges and Opportunities	2015	Eleni I. Vlahogianni	Computational Methods in Applied Sciences book series	Greece	English	Book chapter	Transport	Challenges, opportunities	open data	big data	Intelligent Transportation System	Modeling Paradigm
20	Container Port Performance Measurement and Comparison	2016	Longbiao Chen; Daqing Zhang; Xiaojuan Ma; Leye	IEEE Transactions on Intelligent	China	English	Journal Article	Maritime	Challenges, opportunities	open data	container port	GPS track	ITS

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	Leveraging Ship GPS Traces and Maritime Open Data		Wang; Shijian Li; Zhaohui Wu; Gang Pan	Transportation Systems									
21	Cultural, ideological and practical barriers to open access adoption within the UK Academy: an ethnographically framed examination	2018	Gareth J Johnson	UKSG Insights	UK	English	Journal Article	General	Barriers	cultural	operational	technological	open access
22	Current Transformative Agreements Are Not Transformative Position Paper – For Full, Immediate and Transparent Open Access	2020	Copernicus, JMRI Publications, MDPI, frontiers	JMIR Publications		English	Position paper	General	Opportunity	Open Access	policy		position paper
23	D2.1 - Analysis Report on Big Data Components, Tools and Methodologies	2016	UNINOVA	BigDataOcean "Exploiting Oceans of Data for Maritime Applications"		English	Deliverable	Maritime	Challenges	open data	big data	value chain	
24	Data sharing of transport research data	2016		Transportation Research Procedia		English	Conference paper	Road Transport	Benefits/challenges	data sharing	metadata	data protection	financial model
25	Dealing with research software: Recommendations for best practices	2019	Kaja Scheliga, Heinz Pampel, Uwe Konrad, Bernadette Fritzsch, Tobias Schlauch, Marco Nolden, Wolfgang zu Castell, Ants Finke, Martin Hammitzsch, Oliver Bertuch, Michael Denker;	(Task Group Access to and Reuse of Research Software) of the Open Science Working Group of the Helmholtz Association	Germany	English		General	Opportunity	Software			
26	Discussing the scope and potential of open urban data from broader perspectives: open government, open data, policy-making, smart cities	2015	Evika Karamagioli, Dimitris Gouscos	PROCEEDINGS OF THE 3RD INTERNATIONAL BIENNIAL CONFERENCE	Greece	English	Conference paper	Transport	Challenges, opportunities	open data			
27	Draft proposal for a European Partnership under Horizon Europe - European Open Science Cloud (EOSC) Partnership	2020	EOSC Executive Board	EOSC		English	Report	General	challenges	opportunities	infrastructure		
28	Effective Data Quality Diagnostic Schema for Big Data	2017	Mejia-Lavalle M., Meusel W., Tavira J. V., Cruz M. C.	2017 International Conference on	USA	English	Conference paper	General	challenges	technical issues	big data	data quality	

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				Mechatronics, Electronics and Automotive Engineering									
29	EOSCpilot-The European Open Science Cloud for Research Pilot Project D6.9: Final report on Data Interoperability	2019	ICOS-ERIC, JISC, ELIXIR - UMAN, CNR, KIT, INAF, UFlorence, BGS/NERC, Athena, ELIXIR - EMBL,CNRS			English	Deliverable	General	challenges	EOSC	Data Interoperability	data resources	Data standards
30	ESFRI cluster projects Position papers on expectations and planned contributions to the EOSC	2019	EOSCSecretariat.eu	European Commission	Belgium	English	Report	General	Opportunities	Challenges	EOSC	ESCAPE	
31	Estimating urban mobility with open data: A case study in Bologna	2016	Valeria Caiati ; Luca Bedogni ; Luciano Bononi ; Francesco Ferrero ; Marco Fiore ; Andrea Vesco	IEEE International Smart Cities Conference (ISC2)	Italy	English	Conference paper	Road Transport	Challenges	open data	urban mobility	Road Traffic Simulation	
32	European Cloud Initiative - Building a competitive data and knowledge economy in Europe	2016		European Commission	Belgium	English	Policy Document	General	barriers	Europe	open data		
33	European Open Science Cloud (EOSC) Strategic Implementation Plan	2019	EOSC Executive Board	RTD-PUBLICATIONS@ec.europa.eu	Belgium	English	Report	General	Opportunities	challenges	EOSC		
34	FAIR Data Maturity ModelSpecification and Guidelines2020	2020	FAIR Data Maturity Model WG,	RDA- alliance		English	Report	General	FAIR				
35	Federated Cloud Analytics Frameworks in Next Generation Transport Oriented Smart Cities (TOSCs) - Applications, Challenges and Future Directions	2017	Md. Muzakkir Hussain, Mohammad Saad Alam , M.M. Sufyan Beg	EAI Endorsed Transactions on Smart Cities	India	English	Journal Article	Transport	Challenges	Cloud of Things (CoT)	Electric Vehicle range Anxiety (EVRA)	Mobility as a service (MaaS)	
36	FTA Open Data Policy Guidelines	2016	Catalá M., University of South Florida, Federal Transit/ Administration			English	Report	Transport	Benefits	challenges	guidelines	transit agencies	best practices
37	Future-proofing the Science Cloud	2018	Business Network's Cloud Consultation Group	Science Business Publishing Ltd	Belgium	English	Report	General		EOSC			
38	Geodata interoperability and harmonization in transport: a case study of open transport net	2017	Carina Veeckman, Karel Jedlička, Dieter De Paepe, Dmitrii Kozhukh,	Open Geospatial Data, Software	Belgium	English	Journal Article	Transport	Constraints	open data	geo data	Data interoperability	

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			Štěpán Kafka, Pieter Colpaert & Otakar Čerba	and Standards Journal									
39	Geoscience Cyberinfrastructure in the Cloud: Data-Proximate Computing to Address Big Data and Open Science Challenges	2017	Mohan Ramamurthy	IEEE 13th International Conference on e-Science (e-Science)	USA	English	Conference paper	General	challenges	Cyberinfrastructure	cloud computing	big data	Open Science
40	Getting Started with Open Data: A Guide for Transportation Agencies	2012	Kaufman S. M. & New York University			English	Report	Road Transport	Benefits	data sharing	passenger information systems	roadmap	
41	Harnessing digital ecosystems through open data – diagnosing the Swedish public transport industry	2019	Daniel Rudmark, Anders Hjalmarsson Jordanius	Proceedings of the 27th European Conference on Information Systems (ECIS)	Sweden	English		Transport	Barriers	open data	Digital Ecosystems		
42	Head in the 'cloud': GÉANT network chief sees opportunities, challenges in EU project	2018	Erik Huizer	Science Business Publishing Ltd	Belgium	English		General	opportunities	Challenges	EOSC		
43	How the Science Cloud could pay its way	2018	Business Network's Cloud Consultation Group	Science Business Publishing Ltd	Belgium	English	Report	General	Opportunity	EOSC	funding principles	EOSC Services	
44	ICT for Transport: Opportunities and Threats	2015	Nikolas Thomopoulos, Moshe Givoni, the late Piet Rietveld	Edward Edgar Publishing	USA	English	Book chapter	Transport	Opportunities, threats	open data	ICT	transport networks	
45	Indicators for monitoring the Strategic Transport Research and Innovation Agenda	2020	Tsakalidis, A., van Balen, M., Gkoumas, K., Ortega Hortelano, A., Grosso, M., Haq, G., Marques dos Santos, F., and Pekár, F.	The European Commission's Joint Research Centre (JRC)	Italy	English	Technical Report	Multimodal transport	Opportunities	challenges	TRIMIS	Transport R&I	
46	Insights from Regional Projects & Infrastructures	2020	Drago, Federico; Ferguson, Nicholas; Tanlongo, Federica; Fuhrmann, Patrick; Götz, Andy; McBirnie, Abigail; Roarty, Kat; Salvat, Daniel; Servan, Sophie; Campos,	EOSCsecretariat.eu	Belgium	English	Report	General	Opportunities	EOSC			

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			Isabel; Cavalli, Valentino EGi; Heikkurinen, Matti; Cauhé, Elisa; Sokartara, Dimple; Arvola, Maijastiina; Lappalainen, Minna; Kotsokali, Dimitra; Prnjat, Ognjen; Toli, Eleni; Fazekas-Paragh, Judit										
47	IPR, technology transfer & Open Science	2017	Emanuele Barbarossa Sergio Grande Jean-Paul Triaille	The European Commission's Joint Research Centre (JRC)	Luxembourg	English	Report	General	Challenges	opportunities	Regulation		
48	Issues, Challenges, and Research Opportunities in Intelligent Transport System for Security and Privacy	2018	Qazi Ejaz Ali,Naveed Ahmad,Abdul Haseeb Malik,Gauhar Ali andWaheed Ur Rehman	MDPI Applied sciences	Pakistan	English	Journal Article	Transport	Challenges	intelligent transport system	security	privacy	
49	Legal aspects of open access to publicly funded research	2015		OECD	Paris	English	Book chapter	General	barriers	policy considerations	legal issues		
50	Legal Interoperability of Research Data: Principles and Implementation Guidelines	2016	RDA-CODATA Legal Interoperability Interest Group	RDA/CODATA Legal Interoperability IG		English	Report	General					
51	LEMO, D2.2 Report on Legal Issues	2018	Bird & Bird		Belgium	English	Deliverable	Transport	Challenges	privacy and data protection	security	anonymisation / pseudonymisation	
52	LEMO, D2.3 Report on Ethical and Social Issues	2018	Bird & Bird		Belgium	English	Deliverable	Transport	Barriers	ethical and social issues	privacy	personal Data Ownership	
53	Linking open data and the crowd for real-time passenger information	2017	David Corsara, Peter Edwards, John Nelson, Chris Baillie, Konstantinos Papangelis, Nagendra Velaga	Journal of Web Semantics	UK	English	Journal Article	Transport	Challenges	Semantic web	QualityProvenance	Citizen-sensing	ontology
54	Major challenges and solutions for utilizing big data in the maritime industry	2015	Sadaharu Koga	World Maritime University library		English	Master Thesis	Maritime	Challenges	Open Science			

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55	Making Open Science a Reality	2015	OECD	OECD Publishing	Paris, France	English	Policy Paper	General	Challenges	Opportunities	Open Access	Open research Data	Open Science
56	Making Open Transportation Data Useful and Accessible: Recommendations for Good Practices in Open Data Standards Management	2017	Sall E., Zorn L., Cooper D., Sana B.,Coe S.	Transportation Research Board	USA	English	Conference Proceedings	Transport	Opportunities	technical issues	Best practices	data standards	standardization
57	Mining Open and Crowdsourced Data to Improve Situational Awareness for Railway	2015	Syed Sadiqur Rahman, John M Easton, Clive Roberts	ASONAM '15: Proceedings of the 2015 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining		English	Conference paper	Rail	Barriers	Open Science			
58	Modeling Transport Accessibility with Open Data: Case Study of St. Petersburg	2016	Anastasia A.	Science Direct - Procedia Computer science	Russia	English	Journal Article	Transport	Challenges, opportunities	open data	transport modelling	urban transportation	mobility
59	Muster-Richtlinie Nachhaltige Forschungssoftwarean den Helmholtz-Zentren / Example guidelines for sustainable Researchsoftware in Helmholtz Center	2019	Helmholtz	Helmholtz	Germany	German	Article	General	Opportunities	Software			
60	Mutual Learning Exercise: Open Science – Altmetrics and Rewards	2017	Prepared by the independent expert: Sabina Leonelli	European Commission	Belgium	English	Report	General	Opportunities	Open Science			
61	Open Access Movement Grows Rapidly in Latin America	2018		Prof. Michael Prieler	USA	English	Article	General	obstacles	infrastrusture	connectivity	financial model	open access
62	Open Access to Data – It's Not That Simple	2017	Danish National Research Foundation	Danish National Research Foundation	Denmark	English	Report	General	opportunities	challenges	technical	data quality	privacy
63	Open access to scientific data and literature and the assessment of research by metrics	2014		ICSU Executive Board/International Council for Science	International	English	Report	General	constraints	challenges	open access	technical issues	legal issues
64	Open Data - The Researcer Perpective	2017		CWTS-Elsevier		English	Report	General	challenges	opportunities	data sharing	research data	
65	Open data: Challenges and opportunities for transit agencies	2015	Schweiger C.	The National Academies Press	USA	English	Report	Transport	Challenges	opportunities	technical issues	organisational issues	transit data

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66	Open Science by Design: Realizing a Vision for 21st Century Research	2018	National Academies of Sciences, Engineering, and Medicine	The National Academies Press	USA	English	Book	General	barriers	opportunities	cost	infrastructure	privacy
67	Open Science challenges, benefits and tips in early career and beyond	2019	Allen C. , Mehler D.	Public Library of Science		English	Journal Article	General	challenges	benefits	early career researchers		
68	Open traffic data for future service innovation - Addressing the privacy challenges of driving data	2014	Rohunen A., Markkula J., Heikkilä M., Heikkilä J.	Journal of Theoretical and Applied Electronic Commerce Research	Chile	English	Journal Article	Road Transport	Challenges	privacy	traffic data		
69	Open Transport Data as an enabler for Multimodal Route Planning	2016	Pieter Colpaert, Mathias Van Compernolle, Nils Walravens, Ruben Verborgh, Peter Mechant, Erik Mannens, Lieven De Marez, Pieter Ballon, Rik Van de Walle	11th ITS European Congress, Glasgow	UK	English	Conference paper	Transport	Challenges, opportunities	open data	multimodal route planning		
70	Open transport data for maximising reuse in multimodal route planners: a study in Flanders	2016	Pieter Colpaert ; Mathias Van Compernolle ; Nils Walravens ; Peter Mechant ; Jan Adriaenssens ; Femke Ongenae; Ruben Verborgh ; Erik Mannens	IET Intelligent Transport Systems	Belgium	English	Journal Article	Transport	Challenges	traffic engineering computing	open systems	decision making	query processing
71	OpenAIRE2020-Open Access Infrastructure for Research in Europe D7.6 The Open Research Data Pilot: Personal Data and PSI Rules	2017				English	Deliverable	General	barriers	legal issues	PSI		
72	OpenAIRE2020-Open Access Infrastructure for Research in Europe D9.1 OPENAIRE PORTAL SERVICES	2016	ARC		Greece	English	Deliverable	General	opportunities	Portal	requirements		
73	Opening Up Scientific Data For Innovation Story 2	2018		International Data Corporation (IDC) and the Lisbon Council		English	Report	General	benefits	disadvantages	research data	case studies	

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74	OpenTransportNet - Spatially Referenced Data Hubs for Innovation in the Transport Sector	2017				English	Final report	Transport	Open data	data visualisation	data harmonisation	Linked Open Data	
75	Port Digitalization with Open Data: Challenges, Opportunities, and Integrations	2019	Tommi Inkinen, Reima Helminen, Janne Saarikoski	MDPI - Journal of Open Innovation: Technology, Market, and Complexity — Open Access Journal	Finalnd	English	Journal Article	Maritime	Challenges, opportunities, barriers	open data	port management	digitalization	open innovation
76	Promoting Open Science in Japan	2015		Government of Japan	Japan	English	Report	General	benefits	roadmap	guiding principles		
77	Prompting an EOSC in practice	2018	European Commission Directorate-General for Research and Innovation	European Commission	Belgium	English	Report	General	Opportunities	EOSC	funding		
78	Putting People on the Map: Protecting Confidentiality with Linked Social-Spatial Data	2007	National Research, Council	National Research, Council	USA	English	Book	Transport	Challenges	policy	legal concerns	protection	spatial data
79	Realising the European Open Science Cloud	2016	Commission High Level Expert Group on the European Open Science Cloud			English	Report	General	Reccomendations	EOSC			
80	Recent applications of big data analytics in railway transportation systems: A survey	2018	Faeze Ghofrani, Qing He, Rob M.P.Goverde, Xiang Liu	Transportation Research Part C: Emerging Technologies		English	Journal Article	Rail Transport	Challenges	open data	big data	Data analytics	
81	RECODE-Policy RECommendations for Open access to research Data in Europe D1.1 Stakeholder Values and Ecosystems	2013	University of Sheffield, Blekinge Institute of Technology, National Documentation Centre, Greece, Amsterdam University Press		UK, Greece etc.	English	Deliverable	General	benefits	barriers	stakeholders	research data	open access
82	RECODE-Policy RECommendations for Open access to research Data in Europe D3.1: Legal and ethical issues in open access and data dissemination and preservation	2014	Trilateral Research & Consulting, University of Sheffield, Royal Netherlands Academy of Arts and Sciences and		UK, the Netherlands etc.	English	Deliverable	General	challenges	legal and ethical issues	data dissemination	data preservation	data protection

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			Amsterdam University Press										
83	Recommendations for Services in a FAIR data ecosystem	2019	Daniel Bangert (RDA Europe), Emilie Hermans (OpenAIRE), René van Horik (EOSC-hub), Maaike de Jong (FREYA), Hylke Koers (FAIRsFAIR), Mustapha Mokrane (FAIRsFAIR)	rd-alliance.org		English	Report	General	Opportunities	Challenges	EOSC	FAIR	
84	Relevance of the EOSC initiative and FAIR principles in the realm of Open Science and implementation phases of the EOSC	2018	Michel Schouppe, Jean-Claude Burgelman	European Commission	Belgium	English	Article	General	FAIR	EOSC			
85	Research Data Centers:Enabling Access to Sensitive Social and Economical Data	2017	Thomas Runge	Research Data Alliance	Germany	English	PlenaryMeeting	General	Challenges	Opportunities	Data Access		
86	SafeClouds.eu-Data-driven research addressing aviation safety intelligence- D5.1 Large Scale Infrastructure v0 development	2018				English	Deliverable	Air transport	Challenges	infrastructure development	privacy	data security	
87	Security of Cooperative Intelligent Transport Systems: Standards, Threats Analysis and Cryptographic Countermeasures	2015	Elyes Ben Hamida, Hassan Noura and Wassim Znaidi	MDPI	Qatar	English	Journal Article	Road	Challenges	cooperative intelligent transport systems (ITS)	threats analysis	V2X communications	cryptographic countermeasures
88	Shaking up the Maritime Industry through Open Data and Crowdsourcing	2017	Demitris Memos	Journal of Continuous and Disruptive Innovation	Greece	English	Journal Article	Maritime	Challenges	open data	big data	, Ship Tracking	
89	Smart Airports: Review and Open Research Issues	2019	Zainab Alansari, Safeeullah Soomro, Mohammad Riyaz Belgaum	International Conference for Emerging Technologies in Computing		English	Conference paper	Air Transport	Constraints	open research	Smart airport	Internet of Things	
90	The case for the Cloud	2017		Science Business Publishing Ltd	Belgium	English	Report	General	SWOT analysis	EOSC	obstacles	opportunities	
91	The Cloud Computing Technology for Future Digital Transport in Europe	2016	Joszczuk-Januszewska, J.	Problemy Transportu i Logistyki	Poland	English	Journal Article	Transport	Opportunities	Open Science	digital transport	cloud computing	big data

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92	The Economic Impacts of Open Science: A Rapid Evidence Assessment	2019	Michael J. Fell	UCL Energy Institute, University College London	UK	English	Journal Article	General	challenges	Open Science	open data	economic impacts	
93	The European Open Science Cloud: Who pays for what?	2018		Science Business Publishing Ltd	Belgium	English	Report	General	benefits	costs	EOSC	funding	
94	The Fourth Wave of Digitalization and Public Transport: Opportunities and Challenges	2016	Paul Davidsson *,Banafsheh Hajinasab,Johan Holmgren,Åse Jevinger andJan A. Persson	MDPI Sustainability	Sweden	English	Journal Article	Transport	Challenges	opportuinities	digitalization	Internet of Things	
95	The Impact of Data Complexity on Privacy Management in Vehicle to Infrastructure Applications	2013	Zierfuss A., Sendag R., IEEE	2013 International Conference on Connected Vehicles and Expo (ICCVE)	USA	English	Conference Paper	Road Transport	Constraints	technical issues	policy issues	data privacy	
96	The making of a mega-region: evaluating and proposing long-term transport planning strategies with open-source data and transport accessibility tools	2020	Oliver Lock, Simon Pinnegar, Simone Z. Leao and Christopher Pettit	Handbook of Planning Support Science	USA	English	Book chapter	Transport	Constraints	open data			
97	The role of open data in driving sustainable mobility in nine smart cities	2017	Yadav, Piyush; Hasan, Souleiman; Ojo, Adegboyega; and Curry, Edward	Proceedings of the 25th European Conference on Information Systems (ECIS)	Portugal	English	Conference paper	Road Transport	Challenges	mobility	sustainability	open data	
98	The TRUST Principles for digital repositories	2020	Dawei Lin, Jonathan Crabtree, Ingrid Dillo, Robert R. Downs, Rorie Edmunds, David Giaretta, Marisa De Giusti, Hervé L'Hours, Wim Hugo, Reyna Jenkyns, Varsha Khodiyar, Maryann E. Martone, Mustapha Mokrane, Vivek Navale, Jonathan Petters, Barbara Sierman, Dina V.	Springer Nature	USA	English	Journal Article	General	opportunity	digital repositories			

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			Sokolova, Martina Stockhause & John Westbrook										
99	The use of Open Data for estimating rail accessibility in Europe	2015	Ing. Lorenzo Vannacci, Dott. Ing. Mario Tartaglia, Ing. Elena Navajas Cawood, Dott. Ing. Francesco Rotoli	INGEGNERIA FERROVIARIA	Italy	Italian, English	Journal Article	Rail Transport	Challenges	open data	big data		
100	The value of data for the public transport sector	2018	UITP, Advancing Public Transport	UITP, Advancing Public Transport	Belgium	English	Report	Transport	Benefits	challenges	collaboration	cost	commercial data
101	Top 10 FAIR Data & Software Things	2019	Australian Research Data Commons	Zenodo		English	Report	General	Opportunities	FAIR data			
102	Towards Early Prototyping of Services based on Open Transport Data: A Feasibility Study	2019	Nicolas Ferry, Aida Omerovic, Marit Kjøsnes Natvig	schemantic scholar - CLOSER 2019 Computer Science	USA	English	Journal Article	Transport	Challenges, opportunities	open data	service prototyping		
103	Towards Open Research Data in Poland	2016	Wojciech Fenrich, Krzysztof Siewicz, Jakub Szprot	Open Science Platform/University of Warsaw	Poland	English	Report	General	obstacles	benefits	challenges	legal issues	Case studies
104	Towards sustainable mobility behavior: research challenges for location-aware information and communication technology	2016	Paul Weiser, Simon Scheider, Dominik Bucher, Peter Kiefer & Martin Raubal	SpringerLink Geoinformatica	Switzerland	English	Journal Article	Transport	Challenges	mobility	sustainability	ICT	
105	Transportation: An Overview from Open Data Approach	2018	Yussef Parcianello ; Nádia P. Kozievitch ; Keiko V. O. Fonseca ; Marcelo de O. Rosa ; Tatiana M. C. Gadda	IEEE International Smart Cities Conference (ISC2)	USA	English	Conference paper	Transport	Challenges	transportation	open data	data integration	smart cities
106	Turning FAIR Into reality	2018	European Commission Expert Group on FAIR Data	European Commission	Belgium	English	Report/ Action Plan	General	Opportunities	challenges	FAIR		
107	Understanding the dynamics of open data: From sweeping statements to complex contextual interactions	2014	Meijer A., de Hoog J., van Twist M., van der Steen M., Scherpenisse J.			English	Book Chapter	Transport	Challenges	organisational issues	stakeholders	sociopolitical issues	
108	Unicorn-Open Science for assessing environmental state,	2016	Neittaanmäki, P., Huttula, T.,	Research Ideas and	Finland	English	Journal Article	General	challenges	environment	health	financial assessment	

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	human health and regional economy		Karvanen, J., Frisk, T., Tuomisto, J., Simola, A., Ropponen, J.	Outcomes, University of Jyväskylä | JYX Digital Repository								
109	What is being done with open government data? An exploratory analysis of public uses of New York City open data	2016	Okamoto K.	Webology		English	Journal Article	Road Transport	Benefits	government data	case studies		
110	Why Open Science is the Future	2019	Business Network's Cloud Consultation Group	Science Business Publishing Ltd	Belgium	English	Report	General					
111	A European strategy for data	2020		European Commission	Belgium	English	Policy Document	General	opportunities	challenges	data	EC strategy	
112	Creating value through open data: Study on the Impact of Re-use of Public Data Resources	2015	European Commission	European Data Portal		English	Report	General	Opportunity	Smart cities			
113	Mobilitty x Data - towards a wiin-win model	2019	Marie-Claude Dupuis, RATP Group	UITP		English	Conference presentation	Multimodal transport	Opportunities				
114	Open data since 2010 - swedish success factors and lessons learnt	2019	Ulf Bjersing	UITP		English	Conference presentation	Multimodal transport	Opportunities	governance model	Open data	stakeholders	lessons learnt
115	Action Points: Stakeholder cooperation on data in public transport	2017	UITP	UITP		English	Position paper	Multimodal transport	Opportunities	stakeholders	governance	collaboration	
116	Open data - innovation and performance with liquid information	2013	McKinsey	McKinsey		English	Report	General	Opportunity	Open data	Innovation	governance	
117	From serving to consuming open data	2017	Torbjørn Barslett	UITP		English	Conference presentation	Multimodal transport	Challenges	Strategy	infrastructure	organisation	governance model
118	The Transport Data Revolution, Investigation into the data required to support and drive intelligent mobility	2015	Neil Taylor, Ian Stott, Jon Parker, Jim Bradley, Andy Graham, Chris Tuppen, Jeremy Morley	CATAPULT	United Kingdom	English	Report	Multimodal transport	Opportunity	Strategy	governance model	Stakeholders	skills
119	Mobility Data Sharing: Challenges and Policy Recommendations	2019	D'Agostino, Mollie; Pellaton, Paige; Brown, Austin	UC Davies	United State	English	Policy Paper	Multimodal transport	Bottlenecks	Standardisation	Data quality	metadata	Open data
120	Analytical Report 4: Open Data in Cities	2016	Wendy Carrara, Wander Engbers, Margriet Nieuwenhuis, Eva van Steenbergen	European Data Portal		English	Deliverable	Multimodal transport	Opportunities	Strategy	governance model		Open data
121	Big Data and Transport: Understanding and assessing options	2016		ITF	France	English	Report	Multimodal transport	Opportunities	governance model	Data quality	stakeholders	Skills

a/a	Title	Issue Date	Authors	Publisher	Country of Publisher	Language	Type	Category 1	Primary	Secondary-1	Secondary-2	Secondary-3	Secondary-4
122	Big and Open Data in Transport	2014		House of Parliament	United Kingdom	English	Summary	Multimodal transport	Challenges	Open data			
123	The (Hidden) Cost of Open Data	2015	TOD NEWCOMBE	Governing	United State	English	News article	Multimodal transport	Bottlenecks	economic costs	infrastructure		Open data
124	State of the Practice on Data Access, Sharing, and Integration		Anita Vandervalk, Krista Jeanotte, Dena Snyder, and Jocelyn Bauer	Federal Highway Administration	United State	English	Report	Road Transport	Opportunities	data sharing	data ownership	staakeholders	Open data
125	Rebooting public service delivery: How can open government data help to drive innovation?	2016	Barbara Ubaldi	OECD	United State	English	Report	General	Opportunities	Strategy	Governance	stakeholders	Open data
126	Using Open & Big Data for a better Customer Experience	2015	Michelle Dix	UITP		English	Presentation	Multimodal transport	Opportunities	Open data	Big Data	London	
127	Making public transport accessible: through open data + storytelling		Sung	Remix	United State	English	Presentation	Multimodal transport	Challenges	Data access	Partnerships	Data quality	story telling
128	Data Management and Governance Practices	2017	Nasir Gharaibeh, Isaac Oti, David Schrank, and Johanna Zmud	TRB	United State	English	Report	Multimodal transport	Opportunities	Data management	Strategy	Governance	
129	open data in public transport	207	Carina Trofast, Elias Arnestrand	UITP		English	Seminar presentation	Multimodal transport	Opportunities	Open data	Data access	stakeholders	
130	Getting Smart on Data: Challenges and Opportunities for Transport Authorities from Emerging Data Sources	2016	Pedro Abrantes and Clare Linton	UTG	United Kingdom	English	Report	Multimodal transport	Opportunities	Open data	Governance	Strategy	Data quality
131	Open Data Publishing transport data on the Web	2019	Pieter Colpaert	UITP		English	Training material	Multimodal transport	Opportunities	Open data	Technical	metadata	data quality
132	the Asian data revolution	2018	UITP	UITP		English	Article	Multimodal transport	Challenges	Big data	Asia	Data sharing	
133	Open Data	2018	Alok Jain	UITP		English	Training material	Multimodal transport	Opportunities	Open data	Strategy	Data sharing	
134	Innovation by opening data: Helsinki's strategy favouring Open [Everything]: data, governance, platforms and "trialling culture"	2017	Kerkko Vanhanen, Helsinki Region Transport	UITP		English	Conference presentation	General	Opportunities	Open data	data sharing	funding	Data quality

8.2 Annex II. Questionnaire of the Delphi Survey

Survey on challenges, opportunities, constraints and bottlenecks of open science in transport

Dear Colleagues,

Given your high level expertise in transport science, we would like to invite you at a short but important Delphi Survey on challenges, opportunities, constraints and bottlenecks of open science in transport research conducted within the BE OPEN Horizon 2020 project, which aims to create a common understanding of the practical implementation of Open Science in transport research and to develop a code of conduct for the entire research family.

The objective of this survey is the identification and assessment of main challenges, opportunities, constraints and bottlenecks related to open science in the field of transport. On that purpose, a panel of transport experts has been invited to participate in the current survey which will be held in two rounds: A first questionnaire is distributed to the experts, in which their opinions on the challenges, opportunities and barriers of Open Science in transport research will be collected. After the first round, the facilitator of the survey will provide an anonymised summary of the experts' answers from the previous round and the experts will be encouraged to revise their replies based on the opinions of the other experts.

It is noted that "Open Science" refers to the practice of science where research data, lab notes and other research processes are freely available, under terms that enable reuse, redistribution and reproduction of the research and its underlying data and methods; "Open Data" are research data that can be freely used, reused and redistributed by anyone; and "Open Access" refers to the published research outputs that are made available online, free of charge, and free of most copyright and licensing restrictions.

Participation in this survey is voluntary and you can withdraw at any point during the study. Your contact data will be retained for the duration of the BE OPEN project, but it will neither be disclosed nor passed on to any third parties. The survey is composed of 30 questions and should not take more than 15 minutes to fill in and submit.

We thank you a lot for your highly valuable contribution.

A. General

Please provide some personal information

A1. Gender

- ◯ Male
- ◯ Female

A2. Age Group

- ◯ Under 35 years
- ◯ 35-50 years
- ◯ 51-65 years
- ◯ More than 65 years

A3. Years of professional experience

A4. Please choose mode of transport of your main expertise

- ◯ Road transport
- ◯ Air transport
- ◯ Maritime transport
- ◯ Rail transport
- ◯ Multimodal transport
- ◯ Αλλο:

A5. Please choose the type of your organisation

- ◯ Educational Institution / Research
- ◯ Air transport
- ◯ Private Firm / Sector
- ◯ Public Sector / Ministry
- ◯ Public Sector / Agency
- ◯ Associations, NGOs, Federations

A6. Country of organisation

B. Familiarity with open science

B1. Does your organisation produce open data? *

- ◯ No
- ◯ On an ad-hoc basis
- ◯ Yes
- ◯ Άλλο: _____

B2. How much of the research conducted at your organization is based on open data? (1=not at all - 5=very much) *

1	2	3	4	5
◯	◯	◯	◯	◯

B3. Does your organisation allow the use of open source software? *

- ◯ Yes
- ◯ No

B4. If yes, what open source licences are used at your organisation? Please check all that apply. *

- ☐ Office software
- ☐ Transport modeling software
- ☐ GIS software
- ☐ Communications software
- ☐ Survey software
- ☐ Data processing software
- ☐ Coding software

C. Research Community

C1. Please declare if you agree with the following statements: *

	Strongly Disagree	Rather disagree	Neither disagree nor agree	Rather agree	Strongly agree
Sharing data is more beneficial rather than worthless	☐	☐	☐	☐	☐
Access to open research data contributes to the advancement of science	☐	☐	☐	☐	☐
Transport researchers are familiar with sharing open data	☐	☐	☐	☐	☐
Transport researchers can easily find open data in the web	☐	☐	☐	☐	☐
Transport researchers have received sufficient training in data sharing	☐	☐	☐	☐	☐

C2. How important do you consider are the following challenges for research institutions to share data or publications? *

	Not at all important	Slightly important	Important	Fairly important	Very important
Lack of sufficient human resources	☐	☐	☐	☐	☐
Lack of skilled personnel	☐	☐	☐	☐	☐
Lack of appropriate hardware or software	☐	☐	☐	☐	☐
Legal restrictions (GDPR, privacy issues, IPR, etc.)	☐	☐	☐	☐	☐
Data security issues (e.g. cyber-security, access etc.)	☐	☐	☐	☐	☐
Competition with other institutions	☐	☐	☐	☐	☐
Contractual restrictions from other partners	☐	☐	☐	☐	☐
High costs	☐	☐	☐	☐	☐
Commercial interest for research data	☐	☐	☐	☐	☐

C3. Concerning data management, which are the three most important challenges for the research institutions in producing and sharing open data? *

- [ ] Complex nature of transport data and information
- [ ] Deal with a large amount of data
- [ ] Data storage
- [ ] Data quality
- [ ] Data integration
- [ ] Effective access in data
- [ ] Data protection and security
- [ ] Άλλο:

C4. From technical perspective, which of the following requirements are the three most important challenges for researchers to produce and share open data? *

- [ ] Expertise in data management
- [ ] Expertise in handling big data
- [ ] Expertise in database design and computer programming
- [ ] Expertise in open licence practices
- [ ] Expertise in data security and privacy (e.g. blockchain, anonymization etc.)
- [ ] Production of sufficient documentation (incl. metadata)
- [ ] Production of standardized data and metadata
- [ ] Production of machine-readable data
- [ ] Άλλο:

C5. Which are the three most significant opportunities of openly sharing data or publications for research institutions? *

- [ ] Advance of the science in the transport field
- [ ] Cost savings
- [ ] More skilled personnel
- [ ] AI investments
- [ ] Economic benefits
- [ ] Increased collaboration between companies and research infrastructures
- [ ] Increased collaboration across institutional, national and disciplinary boundaries
- [ ] Άλλο:

C6. Which are the three main barriers of producing and sharing open data for research institutions? *

- [ ] Resources and organizational issues
- [ ] High cost and funding
- [ ] Technical issues
- [ ] Data ownership/IPR
- [ ] Data security issues
- [ ] Competition with other institutions
- [ ] Use of data for commercial purposes by private companies
- [ ] Άλλο:

C7. Which are the three most important benefits for individual researchers to share their data? *

- [ ] More cooperations/contacts
- [ ] Economic gains (e.g. receive fee)
- [ ] New, original research results, patents or products
- [ ] Transparency of their research results
- [ ] More citations
- [ ] Co-authorship in other researchers' publications using their data
- [ ] Recognition
- [ ] Άλλο:

C8. Which are the three main benefits of using open data for individual researchers? *

- [ ] Accessibility to more data
- [ ] Time saving
- [ ] Cost savings
- [ ] New, original research results, patents or products
- [ ] Better data quality
- [ ] More cross-disciplinary cooperations
- [ ] Validation or replication of data or research results
- [ ] Άλλο:

C9. Which are the three main barriers of sharing data or research results for individual researchers? *

- [ ] Significant effort to produce dataset
- [ ] Lack of technical skills
- [ ] Licensing issues and formats of data
- [ ] Lack of technical support from insitutions
- [ ] Data protection and ethical restrictions
- [ ] Concern to opening up to competitors
- [ ] Fear of criticism or refutation of their research results
- [ ] Misuse or misinterpretation of the data by other researchers
- [ ] Commercial use of data
- [ ] Άλλο:

C10. Which are the three main barriers of using open data for individual researchers? *

- [ ] Not easy accessibility
- [ ] Unreliable or inaccurate data
- [ ] Poor data quality
- [ ] Insufficient documentation of the data
- [ ] Harmonization of data
- [ ] Not easily usable data
- [ ] Data ownership/IPR
- [ ] Data security or access
- [ ] High cost
- [ ] Άλλο:

D. Public and Private Transport Companies

D1. Please declare if you agree with the following statements:

	Strongly Disagree	Rather disagree	Neither disagree nor agree	Rather agree	Strongly agree
Data is not always considered as a public good, but as something to pay for	○	○	○	○	○
Exploitation of publicly-funded research should be one of the goals of governments	○	○	○	○	○
Companies do not benefit enough from participating in open data partnerships with research institutions	○	○	○	○	○
Open science could contribute in the promotion of public-private partnerships	○	○	○	○	○
Companies operating in competitive markets are more reluctant to make their data available	○	○	○	○	○

D2. How important are the following challenges for transport authorities and companies to share their data?

	Not at all important	Slightly important	Important	Fairly important	Very important
Different interests and perpsectives on open data by transport stakeholders	○	○	○	○	○
Complex sociopolitical interactions among authorities and transport stakeholders	○	○	○	○	○
Resources and organizational issues	○	○	○	○	○
Skilled personnel	○	○	○	○	○
Data quality	○	○	○	○	○
Data standards and formatting issues	○	○	○	○	○
Technical issues	○	○	○	○	○
Data ownership conflicts	○	○	○	○	○
Data protection, privacy and ethical issues	○	○	○	○	○
Cybersecurity	○	○	○	○	○
Commercial competition	○	○	○	○	○

D3. Which are the three main challenges of opening up their data for pubic transport authorities?

- [ ] Different interests and perspectives on open data by transport stakeholders
- [ ] Complex sociopolitical interactions among authorities and transport stakeholders
- [ ] Skilled personnel
- [ ] Data quality
- [ ] Data standards and formatting issues
- [ ] Technical issues
- [ ] Data ownership conflicts
- [ ] Data protection, privacy and ethical issues
- [ ] Cybersecurity
- [ ] Commercial competition

D4. Which are the three main challenges of opening up their data for private transport companies?

- [ ] Different interests and perpsectives on open data by transport stakeholders
- [ ] Complex sociopolitical interactions among authorities and transport stakeholders
- [ ] Skilled personnel
- [ ] Data quality
- [ ] Data standards and formatting issues
- [ ] Technical issues
- [ ] Data ownership conflicts
- [ ] Data protection, privacy and ethical issues
- [ ] Cybersecurity
- [ ] Commercial competition

D5. Which are the three main opportunities of using open data services for public transport authorities?

- [ ] Foster data-based decisions
- [ ] Improve transport operations and performance
- [ ] Reduce costs
- [ ] Time saving
- [ ] Transparency
- [ ] Better data quality
- [ ] Streamline processes
- [ ] Improve and align customer needs
- [ ] Increase personalized services
- [ ] More partnerships with private transport companies or research institutes
- [ ] Άλλο: _____

D6. Which are the three main opportunities of using open data services for private transport companies?

- [ ] Accessibility to more data
- [ ] Reduce costs
- [ ] Time saving
- [ ] Better data quality
- [ ] Streamline processes
- [ ] Improve and align customer needs
- [ ] Increase personalized services
- [ ] Gain recognition
- [ ] More partnerships with private transport companies or research institutes
- [ ] Άλλο: _____

D7. Which are the main barriers of sharing data for public transport authorities? Please check all that apply.

- [ ] Complexity of stakeholder number and their interconnectedness
- [ ] Missing cross-departmental and cross-level connection
- [ ] Limited financial resources
- [ ] Lack of skilled practitioners
- [ ] Different nature of datasets (in content and spatiotemporal terms)
- [ ] Poor data quality
- [ ] Protection of personal data
- [ ] Protection of commercial/confidential data
- [ ] Conflicts regarding ownership/IPR
- [ ] Cybersecurity threats
- [ ] Άλλο: _____

D8. Which of the above barriers of sharing data for public transport authorities are least likely to be overcome? Please select up to three choices.

- [ ] Complexity of stakeholder number and their interconnectedness
- [ ] Missing cross-departmental and cross-level connection
- [ ] Limited financial resources
- [ ] Lack of skilled practitioners
- [ ] Different nature of datasets (in content and spatiotemporal terms)
- [ ] Poor data quality
- [ ] Protection of personal data
- [ ] Protection of commercial/confidential data
- [ ] Conflicts regarding ownership/IPR
- [ ] Cybersecurity threats
- [ ] Άλλο: _____

D9. Which are the main barriers of sharing data for private transport companies? Please check all that apply.

- [ ] Complexity of stakeholder number and their interconnectedness
- [ ] Missing cross-departmental and cross-level connection
- [ ] Limited financial resources
- [ ] Lack of skilled practitioners
- [ ] Different nature of datasets (in content and spatiotemporal terms)
- [ ] Poor data quality
- [ ] Protection of personal data
- [ ] Protection of commercial/confidential data
- [ ] Conflicts regarding ownership/IPR
- [ ] Cybersecurity threats
- [ ] Άλλο: _____

D10. Which of the above barriers of sharing data for private transport are least likely to be overcome? Please select up to three choices.

- [ ] Complexity of stakeholder number and their interconnectedness
- [ ] Missing cross-departmental and cross-level connection
- [ ] Limited financial resources
- [ ] Lack of skilled practitioners
- [ ] Different nature of datasets (in content and spatiotemporal terms)
- [ ] Poor data quality
- [ ] Protection of personal data
- [ ] Protection of commercial/confidential data
- [ ] Conflicts regarding ownership/IPR
- [ ] Cybersecurity threats
- [ ] Άλλο: _____