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BE OPEN

European forum and oBsErvatory for OPEN science in transport

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D5.3 Impact assessment of Open Science in Transport

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Abbreviations and Terminology

QoL	Quality of Life
OSS	Open Source Software
OS	Open Science
CS	Citizen Science
OD	Open Data
OA	Open Access

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.

The deliverable D5.3 Impact assessment of Open Science in Transport is produced within WP5, Guidance for promoting Open Science in Transport research, Task 5.3 Impact assessment of Open Science in transport The aim of the task is to carry out an impact assessment of Open Science (OS) in transport to describe the potential environmental, social and economic impacts and define explicitly who will be affected by this initiative and how. By identifying potential positive and negative impacts OS will have, the implementation of OS in transport will be more efficient and more responsive to societal and economic expectations.

A workshop was carried out with about 20 OS transport experts in Europe, using the Future Wheel methodology to identify potential positive and negative impacts of OS in transport. The following main findings were identified:

Economic impacts:

- economic saving due to more efficient transport systems, more efficient research, more efficient legislation, faster access of publications and reduction of investment costs as well as costs for operational, maintenance and upgrading purposes.
- negative economic impact due to more expenses for infrastructure and data management, slowing down decision and planning processes due to involvement of more people/new stakeholders (may increase the level of conflict related to transport research and solutions).

Social impacts:

- improved social impacts due to safer transport systems, better air quality/environment, quicker travel time, new jobs, improved quality of life, increased equality (access to publications and free software),stimulation of citizens' contributions to make their own city or municipality more liveable, increased awareness in the general public.;
- negative social impacts from loss of jobs due to loss of competitive advantages and/or artificial intelligence taking over some jobs and potentially strengthening lobbying interests at the cost of citizens with less resources.

Environmental impacts:

- improved environment due to better legislation, less emissions, etc.
- faster acceptance of transport solutions/politics due to increased awareness - making it e.g. easier to implement environmentally friendly politics.

- creation of liveable cities due to better applicability of results into real-life solutions.
- increased energy consumption due to need for new infrastructure.

Multilevel impacts:

- Increased efficiency and collaboration among research organizations and private companies.
- Linking global transport experts allows cross sectoral information exchange and enables solving complex transport issues.
- More active public participation in the transport research sector. Co-creation of knowledge in a bottom-up approach of science may increase the understanding and acceptance of scientific research and this may ease implementation of political measures in the transport area.
- Negative social and economic impact due to reduced quality of publications, limiting OS promotion and reducing funding for Open Access (OA.).
- Negative multilevel impact in OA, as result of legal barriers while working with industry. leading to closed access and lack of cultural change where the main concern is data protection.
- Increased involvements may also have a negative effect by increasing the amount of data and provide more complex and heterogeneous data which may be difficult to interpret and use (AI may partially resolve this problem).

1 Introduction

1.1 Purpose of the document

Brainstorming with different stakeholders in the transport industry in Europe, this document identifies economic, social and environmental impacts Open Science will have in transport - both in research, industry and for the general public. Identifying problematic areas as well as beneficial impacts of OS will be crucial for building a sustainable OS transport community.

1.2 Methodology

Objective: The "Future Wheel" has been used as a methodology for measuring the impact Open Science will have on transport research in terms of **environmental, social and economic impacts** and hence try to define explicitly who will be affected by this initiative and how.

Open Science

Open Science is the movement of making science more accessible to all levels of society – both amateurs and professionals. Openness should be attempted on several different areas such as data, infrastructure, methodology etc. (see figure 1).

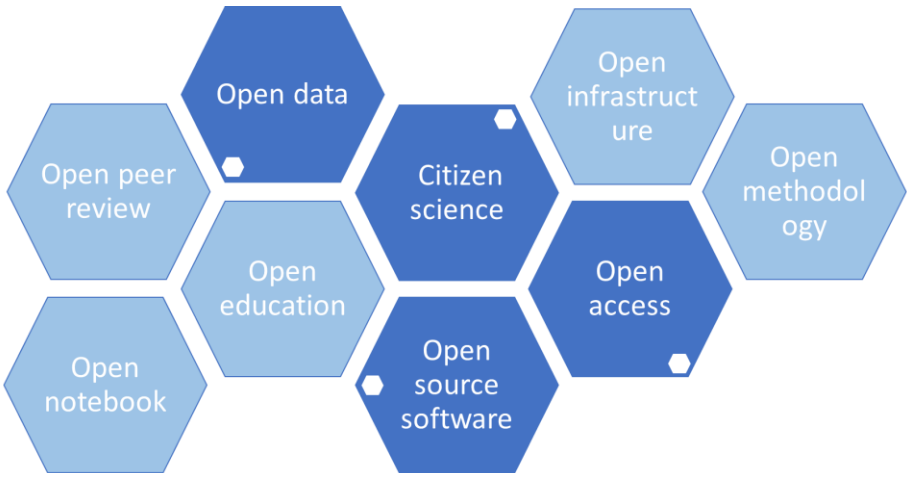

Figure 1 Open Science consist of openness in several different areas

Based on the former work packages findings and the nature of transport research the focus has been put on four areas: Open Data, Open Access, Open source software and Citizen Science:

1. **Open access:** There has been an increase in the share of open access articles the last decade (BEOPEN, D 2.1) and open access publishing has been highly prioritized politically in several countries. However, in the transport research community open access journals have a lot of

issues related to quality (BEOPEN, D 2.4). Also, the models for open access publishing created by coalition S[1], may have implications for the development of Open Access – causing non-equal opportunities on a country level (BEOPEN, D 2.4).

2. **Open data** – There is a large potential for open data and the importance is increasing. Open Data is possibly more problematic for transport than other fields due to large data generation outside the traditional research community (BEOPEN D 2.4, D 2.2).
3. **Open source software** – OSS is still not used a lot in transport research, but there is a large potential as attitudes are increasingly positive especially in the last 1-2 years (BEOPEN WP2.2).
4. **Open citizen science** – this is especially relevant in transport research as interactive maps of mobility are getting more common (Open Maps), together with apps for tracking (bikes etc.).

One future wheel has then been developed for each of the four above mentioned areas, which have then been analysed in relation to society, economy and environment (as mentioned in the GA).

The baseline for the discussion is that all areas of open science are increasing (in terms of use and sharing), and how a future increase in these areas impact society, economy and environment in a positive or negative way.

Future Wheel

The Future Wheel is a methodology used for structuralising brainstorming in order to use it for futuristic analysing of trends impact on society at different levels. It was originally invented by Jerome C. Glenn in 1971 (Glenn 2009), and is used for identifying and packaging primary, secondary, and tertiary consequences of trends (see figure 2), events, emerging issues, and future possible decisions.

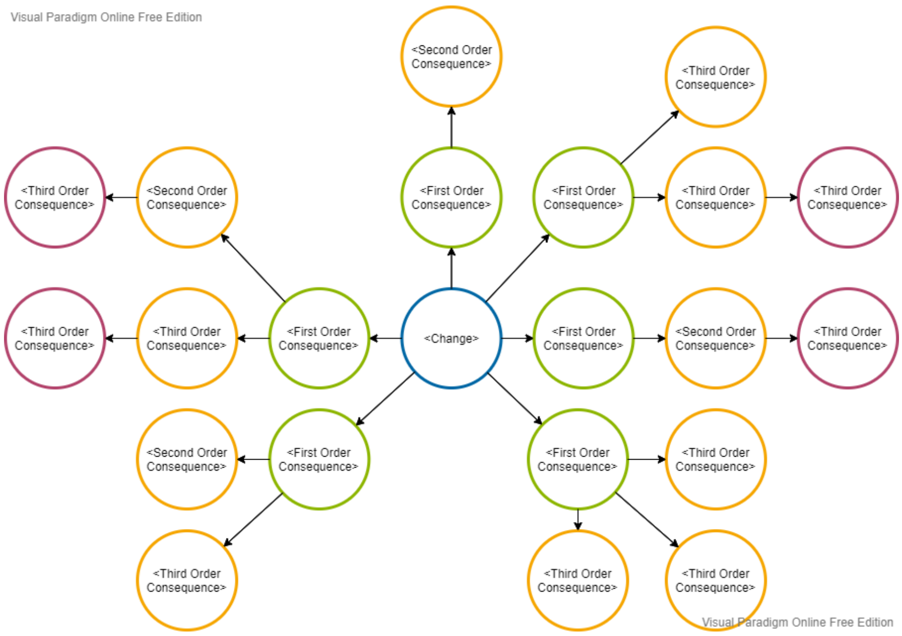

Figure 2 Future Wheel

[1] cOAlition S is an initiative to make full and immediate Open Access to research publications a reality (https://www.coalition-s.org/).

There are several different ways of using the future wheel. In the workshop the methodology described hereafter has been used. An example for Open Science in transport was provided to make it easier to understand (see figure 3 for reference).

1) In the middle of the wheel (figure 3) is the trend that you want to analyse: *Increased use of open source software.* The group of experts then brainstormed on how this will possibly affect society, both negative and positive: i.e. *more flexible and quicker in terms of innovations (positive), lower level of security when handling data (negative), higher availability of software (positive). The experts were asked* this with the aim to list both social, economic and environmental impacts of the trend.

2) In the next round it has been looked away from the original trend, and the primary impact (green circles on figure 3) became the level of analysis. How will *more flexible and quick innovation* impact society? How will *lower security when handling data* impact society? Again, both positive and negative impacts were listed, and both social, economic and environmental impacts were included.

3) When the secondary impacts are established: *Smarter solutions for better analysing, harmful effects for individuals if GDPR data is hacked, malicious users creating bugs i.e. to infect hardware.* etc., a last step using the secondary impacts (yellow circles on figure 3) as the basis of analysis is made. How will *Smarter solutions for better analysing* impact society? How will *malicious users creating bugs i.e. to infect hardware* impact society? Again, both positive and negative impacts were listed, and both social, economic and environmental impacts should be included.

4) Based on the analysis of secondary impacts a third and final circle of tertiary impacts (red circles on figure 3) was listed. The brainstorming session ended here with a list of economic, social and environmental impacts on the trend.

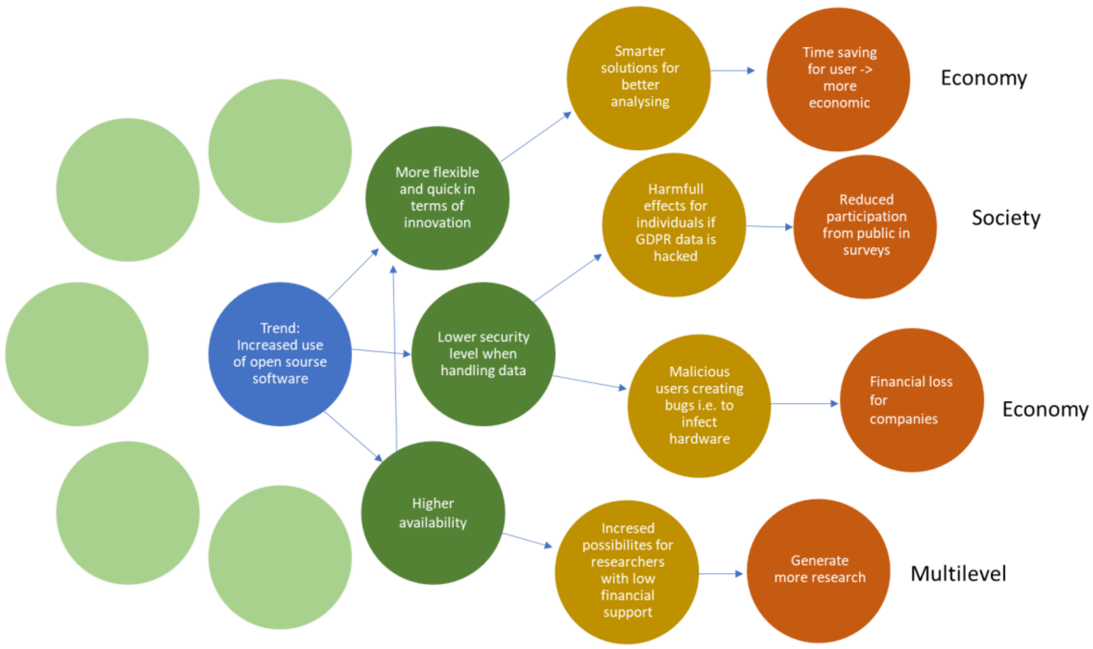

Figure 3 Future Wheel: Increased use of open source software

Instructions about the methodology was sent out to all participants before the workshop. After the workshop the participants also got a chance to comment on the text and wheels of their own group, as a quality control.

2 Literature

Open Data

Open data, especially open government data, is considered an unused recourse that could add a lot of value to the society. How and what values will be created in the future is impossible to predict, however, there are some value creation that is already possible to point to (Open Knowledge Foundation 2021): transparency, democratic control, participation, self-empowerment, improved or new private products and services, innovation, efficiency and effectiveness of services and new knowledge through combining data sources in large volumes.

Some innovation examples increasing social value through participation and self-empowerment are (Open Knowledge Foundation 2021):

- Denmark: Findtoilet.dk, a woman created an app that shows people where all the public toilets are, so that people with bladder issues can move more freely.
- The Netherlands: Vervuilingsalarm.nl, an app that shows the air-quality in your vicinity.
- New York: finding where to walk your dog and people who use the same park.

Other social benefits than empowerment of citizens are increased societal participation, collaboration, and inclusion of marginalized groups (European Dataportal 2020).

Several studies have estimated the economic value of open data at several tens of billions of Euros annually in the EU alone. In the Netherlands, the Ministry of Education publishes education-related data for reuse, which has in turn reduced the number of questions they receive, reducing workload and costs (European Dataportal 2020). Open data is also seen as a driver for economic growth, contributing to innovation and creation of new business models. Businesses re-use data to gather meaningful insights and develop and improve products and services (European Dataportal 2020).

Open Source Software

Open Source Software (OSS) is a software with a source code that anyone can inspect, modify, and enhance. OSS applications have been increasing over the last decades and expanding in new key areas, such as transportation, tourism, health, etc. (BE OPEN, D2.2). OSS applications follow the general principles of "open source" and embrace all principles of open exchange, collaborative participation, rapid prototyping, transparency, meritocracy, and community-oriented development (EC, 2020).

Since early 2000, OSS has been identified as a promising strategy to support the efficiency and quality of software developments (Lakhani & Von Hippel, 2004). Specifically, Linux and Apache were successful case studies that revealed the potential of OSS (Fuggetta, 2003). Many companies adopted OSS due to its adjustability in order to develop customized applications (Von Hippel, 2001). More recently, OSS has been adopted in several sciences such as engineering (Fingerhuth et al., 2018), architecture (Le et al., 2018), physics (Keilegavlen et al., 2021), biology (Geijtenbeek, 2019), etc. In this context, latest EC's strategies focus on the increase of digital transformation schemes in various sectors to achieve a research-friendly environment through the usage of ICT services and existing open-source data infrastructures.

In general, according to the OpenForum Europe (OFE) organization, OSS is a powerful tool offering valuable societal and economic benefits to support innovation. OSS can benefit all users with control options, training opportunities, system's security and stability. On the other hand, OSS initiatives produce problems related to software patents and their regulatory framework (Opensource.com). At the same time, Free Software Foundation Europe (FSFE) highlights the problematic relationship between OSS tools and current legal framework. Existing regulations at national and international level leave significant blind spots for the exploitation of data production and outputs. More specifically, various legal risks and problems with OSS products patenting and commercialisation bring other direct and indirect societal and economic effects on the scientific research communities and general public subsequently.

In this context, Ellis & Van Belle (2009) have studied the barriers and adapters that influence the adoption of OSS by SMEs in South Africa. In general, developing countries primarily focus on cost-efficient alternatives to become competitive against the developed markets (Europe, US, China, Japan, etc.). These researchers highlighted several significant impacts of the usage of OSS tools replacing commercial software solutions for text editing (MS Office), geographical and meteorological representation (ArcGIS, etc.) and other similar software categories. These factors are presented below according to the investigated impact clusters used in our research in this deliverable:

- **Economic:** hardware & software cost, cost of ownership (including training schemes and indirect costs for operation and maintenance of software products),
- **Societal:** complexity on administration and OSS establishment, change management adaptation of employees within an organization.
- **Environmental:** energy savings from the re-use of older computer units (with Linux OS) and other free-open access OSS tools.

In the same principle, Rahud De (2009) studied the economic impact of OSS tools in various organizations in India. According to his study the 70% replacement of office tools from commercial ones (MS Office) to OSS office tools, could have accumulated cost savings of almost 400 million dollars in a 4-year period. Additionally, savings could be achieved from anti-virus software purchases (760 million dollars' market volume on anti-virus licenses).

A good innovative best practice was introduced by Albano et al. (2017), which developed a free and open-source GIS software, called *FloodRisk*, to operatively support stakeholders in their compliance with risk map delineation and the management of current and future flood risk based on their needs for multi-purpose applications. This model creates a risk impact assessment framework in order to effectively mitigate socio-economic damages coming from natural disasters. Similar innovative open source projects have been developed for energy management industry and potentially for transportation in urban and trans-national levels.

Open Access

Open Access (OA) is in general known as the process of removing barriers such as price (including subscriptions, licensing fees, pay-per-view fees) and permission (e.g. copyright and licensing restrictions), in order to enable free, online access to full-text information.

Rising prices for scientific publications while budgets for libraries stagnated or shrank led to the formation of an international OA movement in the early 1990s[2]. The central demand of this movement was: scientific publications, as the results of publicly funded research, should be made available to the public free of charge, to counteract the privatization of knowledge which was financed by the general public and had to be bought back via licenses from the publishers.

There are different types of Open access, e.g. the "green" OA – authors publish in a journal and self-archive a freely available version of the manuscript in available repository – and the "gold" OA –

[2] https://blogs.harvard.edu/openaccess101/what-is-open-access/what-is-open-access/;
https://cyber.harvard.edu/~psuber/wiki/History_of_open_access;
https://www.qualitative-research.net/index.php/fqs/article/view/624/1352

authors publish in **journals** that provide free, immediate access to the articles via publisher web site[3]. Open Access has become a global issue and is considered critical for everybody involved in scholar publishing, such as policymakers, publishers, research funders etc. [4] The benefits of OA are widely recognizable across all sections of society and provide economic and societal impact.

Citizen Science

Citizen science is a way to connect professional scientists and the public in which the public directly contributes to the production of knowledge, sometimes restricted to data collection or simple analysis but also involving more substantial activities. Citizen science has been on the increase since the 1990s and it is also known as community science or described as public participation in scientific research. The purpose of citizen science could be to improve the scientific communities' capacity, to increase the public's understanding of science, and to democratize scientific processes by including common sense (European Commission 2020).

Strasser and Hayclay (2018) define citizen science the following way:

"Citizen science" refers to a broad range of activities where people produce scientific knowledge outside of traditional scientific institutions. From mapping natural phenomena to analyzing scientific data, sharing health information, and making new technologies, citizen science occurs across all the disciplines of science and involves a number of different methods of inquiry, both orthodox and alternative. It includes projects directed by scientists and by grassroots organizations as well as projects where power over the design, implementation, and the use of outputs is shared among participants and organizers".

Citizen science deals with public participation in scientific research, it often results in advancements in scientific research by improving the scientific community's capacity, as well as increasing the public's understanding of science to some extend (Bonney 2015). Below a few contributions to society, economy and environmental issues in science are listed:

Environmental impacts: Citizen Science can support research on environmental developments or impacts of certain ecologic factors, such as monitoring the ecologic conditions of areas. (Pocock et al. 2018).

Societal impacts: Citizen Science can utilize creativity of citizens to react to challenges and in monitoring and designing cities (e.g. . Citizen Science can deliver data to decision-making in policy (Newman 2012), e.g. in making cities safer (Rodriguez, N et. al.. 2019)

Economic impacts: Citizen Science can contribute to the design of new solutions through emerging technologies and making transport more efficient (Creutzig et al. 2019).

[3] https://guides.library.appstate.edu/c.php?g=220070&p=1456674
[4] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4837983/

3 Results

The workshop included transport experts within both Open Data, Open Source Software, Open Access and Citizen science. The experts were both representing research organisations, industry (PTAs, librarians etc.), and transport research umbrella organisations among others. Bellow are the results from all four categories.

3.1 Open Data

Trend	1st order consequence	2nd order consequence	3rd order consequence	Area of implication
Increased use of Open Data in transport industry	Availability of more data will help prove/test theories	Faster innovation and improved theories and methodology	Faster testing and deployment of processes and products (+)	Multilevel (+)
			Cost saving (+)	Financial (+)
		Falcyfi theories faster	Increase costs because using false input for desitions (-)	Financial (-)
	Companies sharing data might lose competitive advantage to other companies / countries.	Jobs disappearing if competitors benefit from shared information	Sosioeconomic damages (-)	Financial (-) Social (-)
			Relocating resourses to other jobs/industries (+)	Financial (+)
		Uneven playing field (if some are obliged to share, while others not)		
	More data could enable more research and provide better input for legislation and regulation for environmental consequences.	Quicker regulations in place	Saves lives and the environment (+)	Envirnomental (+) Social (+)
	More data improves intelligence for automatic transport	More efficient and intelligent mobility	Better mobility with less traffic jams and faster commutes (+)	Multilevel (+)
			Increased need for procedures and infrastructure (+/-)	Financial (+/-) Environmental (+/-)
			Potensial for catastrophic system failure (intended or not) (-)	Multilevel (-)
		People loosing their jobs	Socialeconomic damages	Social (-) Financial (-)
		Higher traffic safety	Saving lifes and money (+)	Finacial (+) Social (+)
	More data improves map and journey planning	Lower emissions	Better air quality / improved enviroment (+)	Envirnomental (+) Social (+)
			Improved quality of life (+)	Envirnomental (+) Social (+)
		Quicker travel time	Better competitiveness of cities (+)	Social (+) Financial (+)
			Resourse savings (+)	Financial (+)
			Improved quality of life (+)	Social (+)
	1. More data gives increased data management costs. 2. Increased need for monitoring use of data	Establisment of risk management and policy for datamanagement	Updated legislation on data sharing (+)	Social (+)
			More costs (-)	Financial (-)
			Fair competition (+)	Financial (+)
		Investment in infrastructure, software and human resourses	More jobs (+)	Social (+)
			More energy consumtion (-)	Environment (-)
			More costs (-)	Financial (-)
			Reliable services (+)	Social (+)

Figure 4 Impacts of Open Data in the Transport Sector

Availability of more data will help **prove/test theories quicker** as a better analysis can be performed with more data available. This will lead to faster innovation and everything will be more efficient, i.e. products may enter the market quicker. But also, more errors can be made faster as the efficiency increases – possibly making a negative impact. In the transport industry (not academia) the availability of more data already leads to changing models with faster testing and faster deployment. The processes are becoming more trial and error and they do the changes on the go. Quicker innovations also could lead to economic benefits as you spend less time on the tasks at hand.

Companies sharing data might **lose competitive advantage to other companies or countries**. I.e. ship building used to be mainly done in Europe, then it moved to Japan and Korea, currently China has the main market. The loss of competitive advantage may cause jobs disappearing if competitors benefit from the shared information. The consequences could be quite large, if for example the Port of Rotterdam lost its competitive advantage to Port of Lisbon, then a lot of other industries around the transport industry would also be affected. In terms of data sharing in the transport industry/urban mobility, this would further be amplified by a possible uneven playing field, if some are obliged to share, while others not – causing companies losing contracts. The end consequence could be socioeconomic damages for the businesses and/or countries affected. However, loss of jobs could also cause a relocation of resources, having a positive effect generating more resources for other industries. To avoid losing the competitive advantage, the development of new business models will emerge, again affecting everything down to the types of jobs available. If you must put your data open in the market (i.e. all EU projects demand open sharing of results) – new business models will emerge consequently to deal with this.

Access to more data could enable more research and **provide better input for legislation and regulation** for environmental consequences. I.e. it is easier to show the consequences of environmental data and how it will impact different countries and thereby give better input for regulations both globally and nationally. One of the experts mentioned a specific example from a project where they did not have data from all countries involved, and thereby the process of giving input to the decision-making process was slower. If data was shared, better decisions can be made from the start and faster input to the decision-making process is possible. This will have huge effects on the environment, if you put a regulation in earlier you save lives and the environment. Earlier solutions to the problems we have.

More data **improves intelligence for automatic transport** and makes us less reliant on people. This will lead to the possibility to increase traffic safety as machines react faster than people. Again, this will lead to saving lives and financial costs. However, it will also have the disadvantage of people losing jobs to automatic processes. Another consequence of more use of automatic transport systems is the potential of catastrophic system failure (intended cyber-attacks or unintended errors). To avoid this there is also an increased need for appropriate procedures and infrastructure for this new landscape. Improved intelligence for automatic transport could also lead to more efficient mobility, but in order to get a better system with less traffic jams, less time commuting to work, it also depends a lot on the strategies put in place by the authorities. You can have open data for all the Übers, but it does not remove cars. However, making the system more efficient could lead to better mobility in combination with the type of policy the city will put in place.

Increased use of open data could also lead to **better journey planning** with improved maps and applications. This will again reduce travel times, giving people an enhanced quality of life since they can allocate travel time into more leisure time. Reducing travel times also reduces costs for the society as travel time could also be allocated to working hours. All in all, this will be giving the cities a more competitive advantage (economic development). Better journey planning could also give less emission if it leads to reduced travel. This will give us a healthier environment, improved quality of life and also improved health of people.

In terms of data there is a distinction of what type of data we are talking about. Some data, companies are happy to share, and some data sharing will give them a disadvantage as mentioned above. The data has value, depending on whom it is given to. What kind of framework does companies have in mind, and what kind of infrastructure does companies have to share with stakeholders. There are two elements – whom you are sharing with and what type of framework and conditions do you have to share? Do companies openly share, and then everyone has access? Or do you have to ask for access and pay for getting the data? It entails a transaction cost. The second point is what type of format, and how to put it in a way that's accessible to others? Solving these types of questions will both lead to a **need for establishment of policies and risk management** related to open data and a **need for investments in infrastructure**, software and human resources. This will again increase data management cost. The amount of data available could also lead to trouble if you cannot handle them. Which again leads to increased need for infrastructure – again generating more data management costs. Investments in infrastructure, software and human resources will possibly generate more jobs and more reliable services as a positive outcome, but it will also lead to an increase in energy consumption for the establishment phase, having a negative environmental impact. The establishment of policies and risk management can lead to fair competition and updated legislation on data sharing.

3.2 Open Source Software

Trend	1st order consequence	2nd order consequence	3rd order consequence	Area of implication
Increased use of Open Source Software in transport industry	reduction of costs / Economic growth	reduction in operational costs	more efficient services for end-users (+)	Multilevel (+)
		reduction of costs focused on OSS licensing	reduction of barriers in public tendering (+)	Social (+)
			higher educational opportunities (+)	Economic (+) Social (+)
	lower security when handling data	harmful effects if GDPR data are hacked	reduced participation for general public in surveys (-)	Social (-)
			lower number of patented scientific products (-)	Economic (-) Social (-)
		malicious users creating bugs	Economic losses (-)	Economic (-)
	higher availability of OSS	better services for end-users	increased efficiency (+)	Multilevel (+)
			higher speed (+)	Multilevel (+)
		share benfitis of OSS to companies and workers	generate more transport research projects (+)	Multilevel (+)
	adaptation of business models for commercial software companies	collaboration amongst companies	more efficient services for end-users (+)	Multilevel (+)
			equal opportunities to create OSS products (+)	Multilevel (+)
	increase reproducibility of transport research	collaboration amongst research organizations	promote open innovation (+)	Economic (+) Social (+)
			equal opportunities to create OSS products (+)	Multilevel (+)
			higher quality of interdisciplinary transport research (+)	Multilevel (+)
	improve quality of OSS products through peer-review process	improved functionalities & working methods	new skills required (+)	Economic (+/-) Social (+)
			proper documentation (+)	Economic (+) Social (+)
			more efficient feedback loop from communities (+)	Economic (+) Social (+)
	insufficient marketing plans	growth is driven primarily by word of mouth	slow or stall growth of OSS products (-)	Multilevel (-)
	increase transparency of data production	increase of trust for OSS products amongst end-users	higher acceptance of OSS solutions (+)	Economic (+) Social (+)
		share benefits of OSS to citizens & end-users	active participation of citizens in decision-making (+)	Social (+)
	promotion of Citizen Science	Plurality of point-of-view and equal dissemination of OSS products	more proposals for new OSS services (+)	Multilevel (+)
			proper communities to support software development (+)	Social (+)
		attract talented people to transport research sector	competitive advantage in transport solutions (+)	Multilevel (+)
			innovative OSS solutions (+)	Multilevel (+)

Figure 5 Impacts of Open Source Software in the Transport Sector

Investment costs can be divided in two main categories, i.e., the hardware-related expenses (*computer units and expendables, specific machinery, etc.*) and the software-related expenses *(licenses, customer support, maintenance, etc.*). Utilization of OSS applications could significantly **reduce investment costs** as well as costs for operational, maintenance and upgrading purposes by mainly **eliminating the cost of licensing** of software products. As such, both scientific research communities and private transport industry stakeholders could benefit, and **economic growth opportunities** could be increased by using

OSS. In more detail, OSS products and applications could be patented reducing the existing barriers in public tendering. In addition, OSS products could provide a higher number of educational opportunities for students/researchers enabling them to capitalize new skills and knowledge.

In this context, an increase in usage of OSS products will **provide higher availability** of software solutions for the research communities and could also **increase the reproducibility of transport research outcomes**. Thus, published results could be evaluated to reflect true findings or false positives. This also supports transparency and allows reviewers or other researchers to validate the published results. Additionally, new collaborative schemes between companies and research organizations could be promoted and the awareness and knowledge of OSS benefits towards the public (citizens & end-users) could be increased. New collaborative schemes and public engagement could further support OSS to provide more efficient services, innovative products and tools that could actively engage the general public in decision-making processes for transport research planning or related activities.

Analysing the current tools (e.g., scenario-based optimization, simulation software, modelling applications) for urban transport planning, it is observed that OSS applications and products could **promote Citizen Science** by achieving a higher involvement of general public and engaging them into the scientific research world. They could offer valuable information and real-time data about the urban transportation network which could result in a competitive and innovative research environment. The engagement of certain communities or citizens could also generate alternative transportation solutions or new transport planning initiatives based on their personal experiences by utilizing and exploiting OSS. Hence, **improved quality of OSS products** could be also achieved through peer-review processes by testing OSS products for defects. Finally, it is worth mentioning that collaboration among the transport research community and general public could set the basis for creating proper documentation of existing OSS tools.

Since OSS tools can be used by everyone, the steps followed for gaining the final results are freely available **offering a more transparent framework** that allows a more trustworthy **provision and handling process of data** to end-users. On the other hand, these lower security standards fail to follow GDPR and avoid cyberattacks and hacking. Mitigation actions are necessary to enhance general public participation in OSS products in an attempt to ensure qualitative data and their participation at a long-term horizon so as to achieve increased patents and profits. Towards an increased use of OSS, **private software providers will be forced to properly adapt their business models** in order to enhance the competitiveness between the research community and industry. As such, more advanced tools and solutions could be developed offering more effective and efficient tools, applications and solution approaches.

However, no one organisation owns OSS and there is no one to provide sufficient marketing. It is mainly promoted via a “word of mouth” approach that could be insufficient on some occasions. Many OSS initiatives created from public research organizations have failed or delayed to reach the market due to the slow growth of their product or lack of end-users engagement to test their services, even though they are strongly supported by research communities (e.g. Python, R, QGIS, etc.).

3.3 Open Access

Trend	1st order consequence	2nd order consequence	3rd consequence	Area of implication
Increased use of Open Access	Equal access to publications	publishing of and access to research results for developing countries	higher impacts (also on their own issues) (+)	Social (+) Economic (+)
			reduced economic difference (+)	Social (+) Economic (+)
		higher quality (produce and use)		
	Quick access to publications	reduce duplication	Saving cost (+)	Economic (+)
		reduce time for new innovation		
		access to up-to date research data	faster solutions for complex problems (+)	Multilevel (+)
	Introduction of standardization and methods	increase quality of research	enables global analysis as the state of the art (+)	Multilevel (+)
		leads to better presentation of results		
	Higher visibility of the author	increase of citations	better job opportunities, more funding (+)	Social (+) Economic (+)
		creating cross-sectoral communities		
			enhances (project) cooperation (+)	Social (+) Economic (+)
	Higher cost for OA publications	decreasing publishing activities with OA	gap between OA results and actual knowledge (-)	Social (-)
		decreasing number of small authoring entities	unbalance in visibility for institutions and countries (-)	Social (-)
			small diversification of research topics in transport (-)	Social (-)
	Legal barriers when working with industry	guidelines/ regulations for OA needed	developing new/changed business models in transport area (+)	Social (+) Economic (+)
		risk of infringement due to copyrights, IPRs	economic risk leads to closed access ( )	Economic (-)
			no culture change - focus on data protection (-)	Multilevel (-)
	Linking global transport experts	solving transport issues	better life, better cities (+)	Multilevel (+)
		cross sectoral information exchange	removes barriers between transport modes (+)	Multilevel (+)
			better use of economic resources (+)	Social (+) Economic (+)
		transferability of solutions		
	Reduced quality of publications	DOAJ SEAL for Open Access publications	recognize peer-reviewed OA journals (+)	Social (+) Economic (+)
		lack of trust in OS	limited OS promotion and reduced funding (-)	Social (-) Economic (-)

Figure 6 Impacts of Open Access in the Transport Sector

Increased usage of Open Access (OA) creates several opportunities as well as exposes the weaknesses which are important to address in order to move towards "Open Research". The goal of the workshop was to gather stakeholders' experience with usage of Open Access, to find out positive and negative aspects and to find the impact – societal, economic or multilevel.

Usage of Open Access enables **equal access to publications** as everybody, independent from the social status, monetary possibilities, country – developed or developing have a possibility to access the research results. This leads to better and broader publishing and using research results concluding higher quality of the research. It could create better awareness in the society by pinpointing strategically important areas where actions need to be taken to reduce economic differences.

Broader use of Open Access in the transport sector enables stakeholders a **quick access to publication** in miscellaneous areas and helps to reduce duplications in the database as more information is available and there is no need to “reinvent the wheel”. The information from other transport sectors is accessible for fast analyses and this reduces time for new innovation. The probability that the research data is up-to-date is higher as it is more used from various stakeholders. Consequently, solutions for complex problems could be found faster and by re-using research data, cost can be saved.

Open Access is a challenge in the transport whereas the amount and complexity of data needs to be accommodated. In order to enable Open Access in the sector and to broaden the use, **introduction of standardization and methods** are important factors. Therefore, guidelines and recommendations at the European level need to be developed for Open Access in the transport sector and supportive infrastructure need to put in place. This increases the quality of research and leads to better presentation of the results, paving the way for an analysis of issues or challenges on a global level as the state of the art.

A well-known factor is that Open Access is increasing the visibility of the publication as the publications are freely available to a broader audience, which also gives **higher visibility for the author**. This could be measured, using the growth of citations, making the author more popular and famous - and therefore supporting the researcher's scientific career. This could trigger better job opportunities resulting in more funding. On the other hand, the creation of the new international communities could lead to more projects, enhancing cooperation in Horizon Europe for example and therefore enable international funding.

The increasing request for free-of-charge access to full-text information affects the pricing formula for journal publications. Raising Article Publishing Charges (APC) leads to **higher cost for OA publications** on the author side. Due to limited budgets for publishing the overall publishing activities with OA could decrease, which could lead to a gap between OA results and the actual knowledge available in the research domain. This trend could be intensified by the fact that small authoring entities might not be in the position to pay higher APCs so that OA publication would represent less diversification of the research topics in transport. For example, institutes from third world countries with lower research budgets can only publish their results at high cost and thus lose opportunities for perception. In the most extreme case, this can lead to an even stronger unbalance in the visibility of institutions and countries.

In the context of publishing results in general, there are several **legal barriers when working with industry** partners, which gets even more critical if OA is involved. There is the risk of infringement due to copyrights and IPRs leading to a focus on data protection, in case of doubt, and preventing a cultural change. Furthermore, even if publication is an option, «closed access» could be preferred to minimize a possible economic risk in the highly competitive transport area.
To pre-empt those consequences by legal barriers, clear guidelines and regulations for OA in transport are needed. It would introduce a framework which allows to develop new/changed business models in the transport area, based on sharing information via OA publications.

A free-of-charge, online access to full-text information provides new opportunities **to link global transport experts**. It allows a cross-sectoral information exchange due to removed pay-walls and easier accessibility. An example could be that scientists from the field of aeronautics can benefit from similar problems on fluid dynamics in the field of shipping. Barriers between the transport modes can be lowered or even fully removed. It could lead to a transferability of solutions beyond transport modes, so that beside the increasing information exchange existing economic resources can be used better/more effectively. Profiting from the linking of global transport export, there is a higher chance to solve transport issues in a common approach to improve cities, e.g. challenges in interaction of different transport modes in urban transport scenarios, and consequently life aspects.

There is the fear that an increased use of OA would lead to a **reduced quality of the publications**. If confirmed, the risk increases that the transport community will lose the trust in Open Science in general and the number of OS activities could decrease. That leads to limited OS promotion in general, ending in reduced funding for transport research as more funding agencies indicate OA as a funding condition. To prevent a quality reduction of publications, the DOAJ Seal was established which is awarded to journals that demonstrate best practice in open access publishing and simplifies to recognize peer-reviewed OA journals[5].

[5] https://doaj.org/apply/seal/

3.4 Citizen science

Trend	1rst Order Consequence	2nd Order Consequence	3rd Order Consequence	Area of implication
Citizen Science in Transport Research	Potential exclusion of Citizens with less resources	Less Understanding / Acceptance by excluded groups	More research on how to include excluded groups	Social (+/-)
			More exclusion in the usage of certain solutions	Social (-)
		Data Bias in biased results	Wrong Decisions	Social (-) Economic (-)
			Manipulation of results by different stakeholders	Social (-) Economic (-)
			Wrong results mislead the research community	Social (-)
	Potential security lacks	Sensitive Information is available to third parties	Discouragement of citizens in future citizens science	Social (-)
			Lack of trust in data handling	Social (-)
	Increased awareness for research in Europe	Increased understanding by citizen (e.g. Funding Budget for Transport)	Acceptance of transport solutions	Social (+)
			Faster changes in perceptions and behaviours	Social (+/-)
		Raise awareness to specific transport issues (safety, energy consumption)	Bring citizens closer to policy-making	Social (+)
		Raise understanding for policies	Increase acceptance for new transport policies	Social (+) Environmental (+)
	Involvement of citizen in scientific interactive processes in a bottom-up approach of science	Better applicability of results in to real-life solutions	Liveable cities	Social (+) Environmental (+)
		More democratic, transparent participation in policy-making	More conflicts, less optimal results	Social (-)
			More time and less effective planning to each social env. goals & delays in projects	Social (-)
			Decisions become more beneficiary (e.g. access in public transport, priority to road safety in local areas, eco-friendly)	Social (+) Environmental (+)
			More liveable solutions provided in transport and cities	Social (+)
	Citizens understand scientific processes/objectives & can give feedback	Results will be accepted	Smooth processes in policy-making and implementation	Social (+)
	Increase diversity and amount of people involved, and data	Find white spots through additional data that were not expected	Validation/falsification through complementary/adverse results	Social (+/-)
			Economic benefit for companies	Economic (+)
			Socially beneficiary solutions	Social (+)
		Too complex heterogeneous data	Hard to combine the citizen data (lack of standards) and scientific data	Multilevel (-)
			Arise of AI methods	Multilevel (+/-)
	Citizen science increase outreach of funding projects in transport	Understanding the money flow/budgeting for funding in transport research	More money in transport research	Multilevel (+)
			More efficient use of budgeting because of the transparency	Multilevel (+)
		A new method for dissemination increases capacity for dissemination	Better acceptance of transport research results and/or their application in real life	Economic (+) Social (+)

Figure 7 Impacts of Citizen Science in the Transport Sector

The practice of citizen science fosters the **involvement of citizens in scientific interactive processes in a bottom-up approach of science.** This could improve the applicability of results in the real life of citizens, e.g. through simplifying sustainable transport solutions by the help of the input of citizens testing prototypes in real-life laboratories. Thereby, citizens can contribute to make their own city or municipality more liveable. The involvement and participation lead to more transparency of policy decisions and democratizes the process. A plausible consequence would be that the solutions could become more beneficial to citizens since they co-create, co-implement and/or co-evaluate solutions making those safer and eco-friendlier. A negative impact would be that the democratization slows down decision processes e.g. in city planning and thereby slows down the implementation of new transport solutions. Further, through participation conflicts can occur leading to less optimal results through compromises. In contrast, results could also be optimized through constructive decisions leading to more liveable cities for all.

Through involving citizens in scientific processes, they can **understand and give feedback on applied methodologies** and research objectives directly. This can increase the acceptance of the applied methodology and the results. By this, policy decisions for the implementation of derived solutions from research projects will be better acceptable for the users and society.

On the one hand, the involvement of citizens in science can **increase the diversity of people providing a coherent data set to the research project**. Science can benefit from this because they can detect white spots through additional data they would not have gained if they had selected only certain target groups. This could potentially impact the validation or falsification practice in research through the complementary or adverse results and thereby work as an accelerator for new research to improve findings. Above that, white spots in research can also be market white spots companies could exploit. The society will benefit through better science because new transport solutions can be designed in a way to solve the newly identified problems. On the other hand, data sets gained through citizen science can be complex or heterogeneous. This could impact the possibilities to combine data with other existing data sets coming from other citizens science due to a lack in standards or with scientific data due to quality differences. To cope with the complexity of data, AI methods could be further developed consequently.

The practice of citizen science can potentially **exclude citizens with less resources**, e.g. professionals or families with young children having less time in evening hours, etc. The exclusion could result in less or no understanding or acceptance of research outcomes. This could lead to wrong political decisions. Following that, excluded groups could not benefit from differently designed transport solutions being not relevant to them or designed in a way they exclude groups, e.g. with special needs. Consequently, more research on how to address and include diverse groups must be undertaken. The occurring data bias and biased results could mislead the research community trying to reuse open data sets. Further, stakeholders could use the biased data to prove solutions in agenda-setting and lobby work.

Potential **security lacks** could make sensitive information available to third parties leading on the one hand to the discouragement of citizens in taking part in citizen science projects. On the other hand, it could heat up the debate on the security of data handling in Europe.

Taking part in citizen science can **raise the awareness for (funded) research activities** in Europe, so citizens can benefit from a greater transparency, e.g. they can gain a better understanding on research results or the budget flows for research and innovation in transport. This could possibly impact their acceptance as well as their perception of new transport solutions and even their mobility behaviour itself. Secondly, attending citizen science projects can help to raise the awareness of citizens for specific transport issues, such as safety, energy consumption, design of new mobility solutions, etc. This allows citizens to contribute to policy making. At last, the increased awareness for research in Europe can help citizens to understand and thereby accept new policies in transport, even if this means uncomfortable regulations for them that should tackle ecologic challenges for instance.

Citizen science in practice **increases the outreach of funded projects in transport research**. The understanding of money flows and budgets and outcomes of funding in transport research can thereby be raised. This could lead to the demand of citizens for more public research in how transport is funded. Citizen science can even be used as a means of dissemination leading to higher acceptance of transport research results and their application in transport.

4 Findings and discussion

Even though the groups have been divided into four different themes in the workshop, most of the outputs are true for all areas of OS even though the focus was slightly different in the different working groups. Therefore, a common table for Open Science has been created to sum up the findings (see figure 8).

The results from the workshop gave more insight to social and economic impacts. However, the environment specific impacts could potentially have large consequences: lower emission, quicker regulations, and faster acceptance of transport politics from the general public are crucial to meet the UN goals of reducing emission rates. Also, the multilevel impacts cover all the three areas (social, economic, environmental). Some of the inputs are placed in the area where it has the largest impacts, however most impacts will affect all other areas to some extent.

Open Science in Transport

Social	Economic	Environmental	Multilevel
Positive impact			
More jobs (OD) due to need of new resources.	Saving cost through faster innovation (OA, OD, OSS)	Saving environment due to quicker regulations in place (OD).	Solving complex problems faster (OA, OD, CS)
Reduced inequality due to equal knowledge access (OA)	Reduced economic inequality due to equal knowledge access (OA)	Better air quality due to lower emission (OD).	Increased quality due to standardization (OA)
Better social solutions due to	Better use of economic resources due to knowledge exchange (OA)	Acceptance of transport solutions/politics due	Improved competition of cities due to lower travel time (OD).

knowledge exchange (OA)		to increased awareness (CS)	
Updated legislation for sharing (OD)	Saving cost through reduced duplications (OA)	Creating more livable cities due to better applicability of results into real-life solutions (CS)	Better mobility and faster commutes due to AI systems (OD).
Better job opportunities due more marketing of research (OA)	More funding due to more marketing of research. (OA)		More efficient services for end-users due to reduction in operational cost (OSS).
Better services due to infrastructure investment (OD)	More equal competition due to new policies for data management (OD)		Decisions become more beneficiary due to more participation in policy making CS
Improved QoL due to quicker travel time (OD)	Cost saving due to lower travel time (OD)		Acceptance of transport solutions/politics due to increased awareness (CS)
Improved QoL due to lower emission (OD)	Relocating resources to other industries due to jobs disappearing (OD).		Faster changes in perceptions and behavior due to increased awareness (CS)
Saving lives through better traffic safety (OD).	Better educational opportunities due to reduced cost for OSS licensing		Increased efficiency through new collaboration (OSS)
Saving lives due to quicker regulations in place (OD).	Competitive advantage through white spots (additional data) (CS)		Equal opportunities to create OSS products
Reduced barriers in public tendering due to reduced cost for OSS licensing	More money in transport research and generation of new projects (CS, OSS)		Higher quality of interdisciplinary research (OSS)
Better educational opportunities due to reduced cost for OSS licensing	More efficient use of budgeting because of transparency (CS)		Innovation of OSS solutions
More research on how to include excluded groups (CS)			Competitive advantage for transport research due to attracting talented people to transport research (OSS)
Bringing citizens closer to policy-making (CS, OSS)			

Higher acceptance of OSS solutions			
Negative impact			
Gap between OA results and actual knowledge due to less publishing.	Reduced funding due to quality issues (OA).	Increased energy consumption due to need of new infrastructure (OD).	Potential catastrophic system failures in AI systems (OD)
Unbalance in visibility for institutions and countries (OA).	Increase cost due to need for investment in infrastructure (OD)		Increased conflicts due to involvement of more people (CS)
Risk of infringement causing TR to chose 'closed access' (OA).	Job loss due to loss of competitive advantage (OD).		Less effective planning/time delays due to involvement of more people (CS).
Job loss due to increased use of AI (OD)	Job loss due to increased use of AI (OD)		Hard to combine citizen data (lack of standardization)
Reduced participation of general public in surveys due to GDPR issues (OSS, CS)	Increase cost due to wrong input when making decisions (OD, CS).		
Solutions based on exclusion of people with less resources (CS).	Economic losses due to malicious users creating bugs in software (OSS)		
Manipulation of results by different stakeholders due to data bias (exclusion of some people). CS			
Wrong results mislead research community (data bias). CS			

Figure 8 Impacts of Open Science in the Transport Sector

Future Impacts of OS in Transport

Supporting and confirming former sources (Open Knowledge Foundation 2021, European Dataportal 2020, Open Forum Europe (OFE) organization, Bonney 2015) we found a lot of **general implications** of OS in the future:

- Open Science will have the possibility to create more **equality** due to 1) better access of research for more people/countries/institutions through open access publishing, 2) creating equal competition through new policies for data management 3) equal opportunities through free use of OSS.

- Open Science will increase **efficiency,** through 1) less time spent on data collection/duplicating work, 2) better efficiency for end-users due to reduction in operational cost, 3) solving complex problems faster due to access to more data.
- **Economic benefits** through 1) more efficient budgeting because of transparency 2) less time spent on duplication of work and collecting data 3) improved knowledge exchange 4) increased funding due to better marketing of research
- Open Science will lead to **innovation** and **new technology**. Economic savings will free a lot of resources that can be relocated to innovation activities. Also, the increased availability of data will lead to potentially faster innovation and also arising use of AI technology to handle the amounts of data.
- **Citizens participation** will bring citizens closer to policy making processes and hence raise the awareness in the general public, simplifying the process of implementing new policies.

However, the workshop groups also came up with some **transport specific** future implications of OS:

- **Lower emission** improving Quality of Life and air quality.
- **Faster travel time** increasing quality of life, saving costs and improving cities competitive advantage.
- **Improved traffic safety.**
- **Increased awareness** causing an increased acceptance of transport solutions/politics and faster changes in perceptions and behaviour i.e. important to change travel behaviour to reduce emission.
- **Artificial intelligence** causing better mobility services and faster commuting. However, AI systems also have unknown risks.

The competitive advantage of participating in Open Science can be seen both through better marketing of research, being able to relocate resources to other tasks and finding new white spots. It was mentioned that OS has the potential to attract more money into transport research, generate new projects and attract talented people to transport research.

Negative implications

Most former studies and the general attitudes towards Open Science are positive, and also in this study we found more positive impacts of Open Science than negative ones. However, we did establish some negative impacts that is important to have in mind in order for OS to become as sustainable as possible:

- **Job loss due** to 1) loss of competitive advantage and 2) increased use of artificial intelligence.
- **New types of risks** 1) hacking & malicious users creating software bugs 2) potential system failures (AI) with larger unknown consequences.
- **Increased cost** due to 1) infrastructure needs 2) malicious users creating software bugs 3) decision making based on 'wrong data' (lack of knowledge, low quality data, data bias).
- **Increased conflicts** due to more participants involved in research.

- **Time delays** due to more participants involved in research.
- **Increased energy consumption** due to new infrastructure needs.

In terms of job loss due to AIS, a possible positive impact is that people are retrained to improve their skills to manage/operate these new technologies[6].

5 Conclusions

Open Science will have impacts on both social, environmental and economic aspects of society – both positive and negative. Here is a short summary of the impacts in the four different areas of Open Science:

Open data

Most impacts seem to be positive:

- **economic** saving due to more efficient transport systems, more efficient research, more efficient legislation.
- improved **social impacts** due to safer transport systems, better air quality/environment, quicker travel, more jobs, improved quality of life.
- improved **environment** due to, for example, better legislation, and less emissions.

Even though some of the impacts might be negative:

- more **economic** and **environmental** impacts (energy consumption) due to increased need for infrastructure and data management.
- negative **social impacts** from loss of jobs due to loss of competitive advantages or artificial intelligence taking over some jobs.

Open Source Software

Potential positive impacts:

- **economic s**avings due to reduction of investment, operational, maintenance and upgrading costs which offers **economic** growth opportunities both for research community and industry.

[6] https://skillfulproject.eu/

- **multi-level positive** impacts surrounding the transport research outcomes focusing on the reproducibility, quality, efficiency and availability of OSS services that promote collaborative activities among research organizations and private companies.
- **Positive social** effects on the general public and end-users by offering equal opportunities to all involved parties independent from geographical and multi-dimensional **social** backgrounds.
- **Positive social and economic effects coming from** active public participation in transport research sector and promoting citizen science.

Potential negative Impacts:

- **negative economic** effects from insufficient marketing strategic plans of OSS initiatives dissemination plans (*due to "word to mouth" promotion approach*).
- **multi-level negative** impacts due to low number of patents on OSS products, which have insufficient security & GDPR standard protocols or outdated business models.

Open Access

Most important positive impacts:

- positive **economic impact** through cost saving due to faster access of publications.
- positive **social and economic** impact as a result of equal access to publications or higher visibility of the author, reducing economic difference and better job and funding opportunities.
- positive **multilevel impact** as linking global transport experts allows cross sectoral information exchange and enables solving transport issues.

Negative impacts:

- **negative social impact** due to increased cost of OA publications which creates gap in-between OA results and actual knowledge, small diversification of research topics in transport as well as unbalance in visibility for institutions and countries.
- **negative social and economic** impact due to reduced quality of publications limiting OS promotion and reducing funding for OA.
- **negative multilevel impact**, as a result of legal barriers while working with industry leading to closed access and lack of cultural change where the main concern is data protection.

Citizens science

Possible positive impacts:

- **Multilevel impact** as co-creation of knowledge in a bottom-up approach of science may increase the understanding and acceptance of scientific research and this may ease implementation of political measures in the transport area.
- **economic impact** due to revealing of gaps and white spots in transport research.
- **social impact** through stimulating citizens' contributions to make their own city or municipality more liveable, raising awareness and increasing transparency.
- improved **environmental impact** through faster acceptance of transport solutions/politics due to increased awareness and creation of liveable cities due to better applicability of results into real-life solutions (CS).

Possible negative impacts:

- **negative economic impact** because of increased involvements may slow down decision and planning processes and increase the cost of transport solutions.
- **negative social and economic impact** as it may increase the level of conflict related to transport research and solutions because of increased involvement of more people with different values.
- **negative social impact** by strengthen strong lobbying interests at the cost of citizens with less resources causing biased data.
- **negative, multilevel impact** due to security issues and due to increase of the amount of heterogeneous data which may be difficult to interpret and use (AI may partially resolve this problem).

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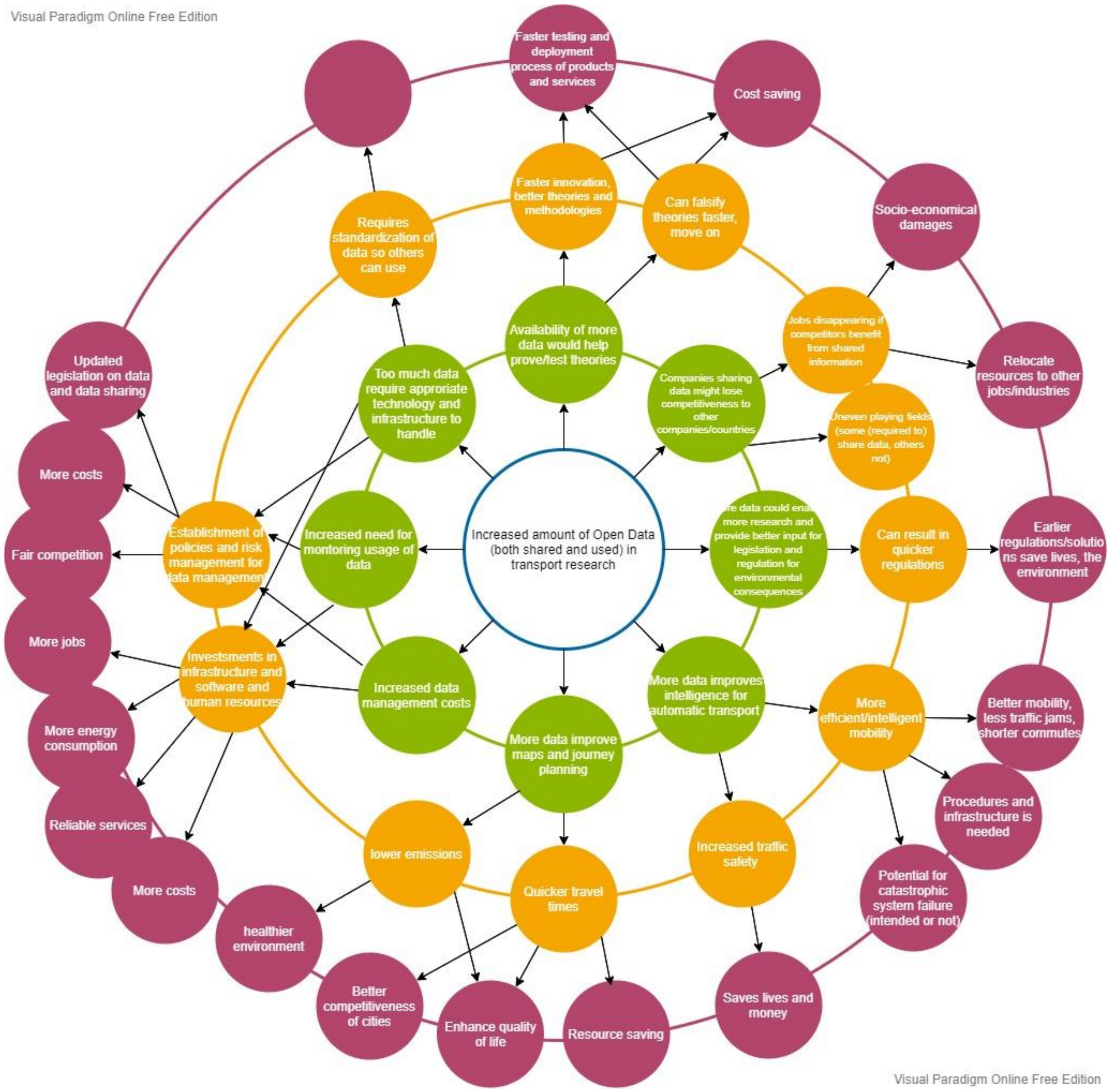
7 ANNEX – "Future Wheel" methodology diagrams assessed in D5.3 workshop


Visual Paradigm Online Free Edition
Increased use of Open Access
saving costs
faster solutions for complex problems
higher impacts (also on their own issues)
reduce duplication
reduce time for new innovation
Access to up-to-date research data
publishing of/ and access to research results for developing countries
reduced economic difference
enables global analysis as the state of the art
increases quality of research
higher quality (produce and use)
quick access to publications
equal access to publications
introduction of standardisation and methods
leads to better presentation of results
recognise peer-reviewed OA journals
DOAJ SEAL for Open Access publications
reduced quality of publications
increase of citations
better job opportunities, more funding
higher visibility of the author
limited OS promotion and reduced funding
lack of trust in OS
creating cross-sectoral communities
enhances (project) cooperation
linking global transport experts
higher cost for OA publications
solving transport issues
decreasing publishing activities with OA
better life, better cities
legal barriers when working with industry
gap between OA results and actual knowledge
cross-sectoral information exchange
descreasing number of small authoring entities
transferability of solutions
guidelines/ regulations for OA needed
risk of infringement due to copyrights, IPRs
removes barriers between transport modes
unbalance in visibility for institutions and countries
small diversification of research topics in transport
better use of economic ressources
economic risk leads to closed access
developing new/changed business models in transport area
no culture change - focus on data protection
Visual Paradigm Online Free Edition


Visual Paradigm Online Free Edition
Increased amount of Open Data (both shared and used) in transport research
Availability of more data would help prove/test theories
Companies sharing data might lose competitiveness to other companies/countries
More data could enable more research and provide better input for legislation and regulation for environmental consequences
More data improves intelligence for automatic transport
More data improve maps and journey planning
Increased data management costs
Increased need for montoring usage of data
Too much data require approriate technology and infrastructure to handle
Faster innovation, better theories and methodologies
Can falsify theories faster, move on
Jobs disappearing if competitors benefit from shared information
Uneven playing fields (some (required to) share data, others not)
Can result in quicker regulations
More efficient/intelligent mobility
Increased traffic safety
Quicker travel times
lower emissions
Investsments in infrastructure and software and human resources
Establishment of policies and risk management for data management
Requires standardization of data so others can use
Faster testing and deployment process of products and services
Cost saving
Socio-economical damages
Relocate resources to other jobs/industries
Earlier regulations/solutions save lives, the environment
Better mobility, less traffic jams, shorter commutes
Procedures and infrastructure is needed
Potential for catastrophic system failure (intended or not)
Saves lives and money
Resource saving
Enhance quality of life
Better competitiveness of cities
healthier environment
More costs
Reliable services
More energy consumption
More jobs
Fair competition
More costs
Updated legislation on data and data sharing
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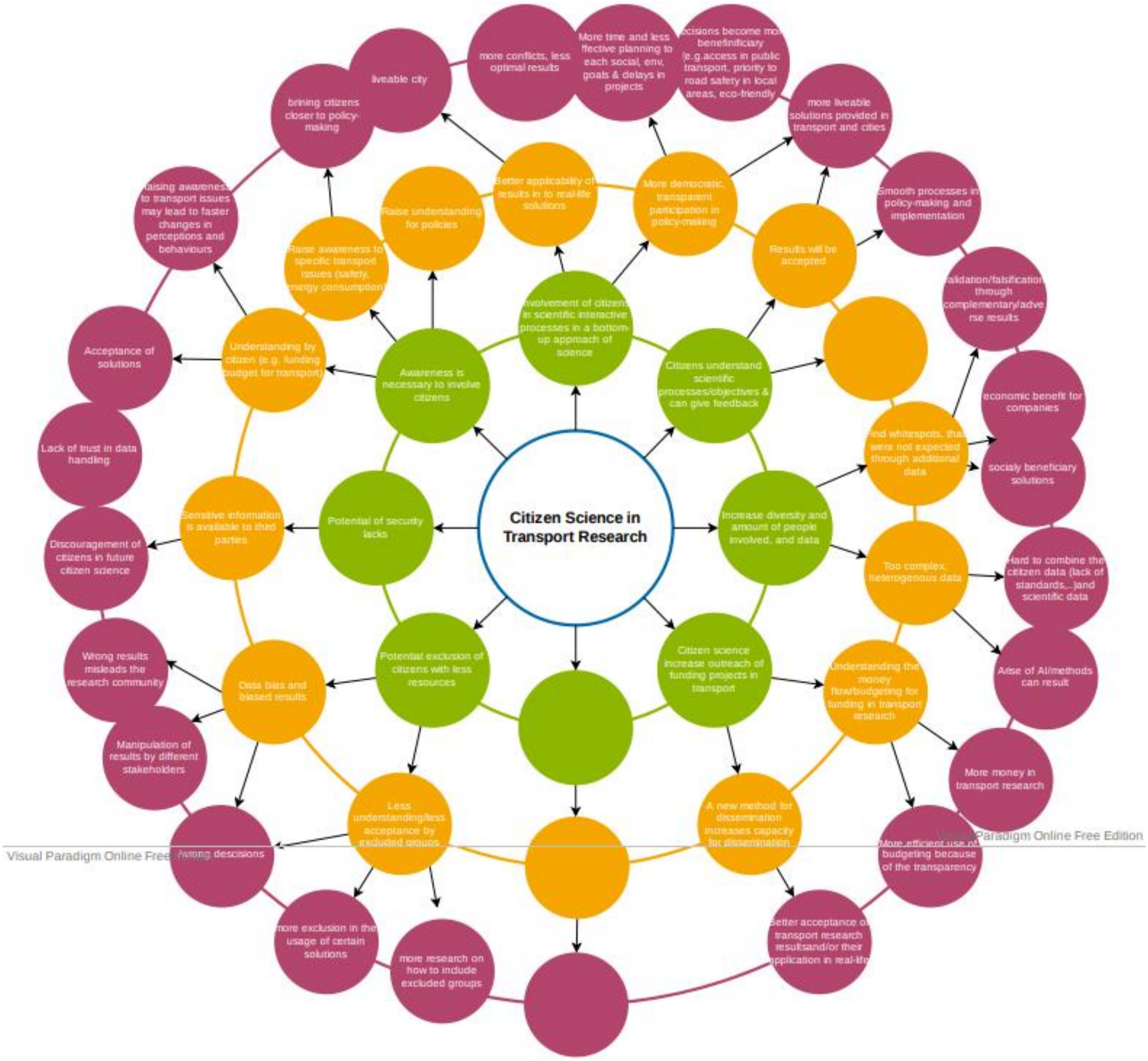
Citizen Science in Transport Research
Awareness is necessary to involve citizens
nvolvement of citizens in scientific interactive processes in a bottom-up approach of science
Citizens understand scientific processes/objectives & can give feedback
Potential of security lacks
Increase diversity and amount of people involved, and data
Potential exclusion of citizens with less resources
Citizen science increase outreach of funding projects in transport
Understanding by citizen (e.g. funding budget for transport)
Raise awareness to specific transport issues (safety, energy consumption)
Raise understanding for policies
Better applicability of results in to real-life solutions
More democratic, transparent participation in policy-making
Results will be accepted
nd whitespots, that were not expected through additional data
Too complex, heterogenous data
Understanding the money flow/budgeting for funding in transport research
A new method for dissemination increases capacity for dissemination
Less understanding/less acceptance by excluded groups
Data bias and biased results
Sensitive information is available to third parties
brining citizens closer to policy-making
liveable city
more conflicts, less optimal results
More time and less ffective planning to each social, env, goals & delays in projects
ecisions become more benefinificiary (e.g.access in public transport, priority to road safety in local areas, eco-friendly
more liveable solutions provided in transport and cities
Smooth processes in policy-making and implementation
alidation/falsification through complementary/adverse results
economic benefit for companies
socialy beneficiary solutions
Hard to combine the citizen data (lack of standards,...)and scientific data
Arise of AI/methods can result
More money in transport research
More efficient use of budgeting because of the transparency
Better acceptance of transport research resultsand/or their application in real-life
more research on how to include excluded groups
more exclusion in the usage of certain solutions
Wrong descisions
Manipulation of results by different stakeholders
Wrong results misleads the research community
Discouragement of citizens in future citizen science
Lack of trust in data handling
Acceptance of solutions
aising awareness to transport issues may lead to faster changes in perceptions and behaviours
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