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Review

# Women in Transport Research and Innovation: A European Perspective

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**Abstract:** Several gender differences exist in the transport sector. These include accessibility to transport modes, safety and security when travelling, and the participation of women in transport research and innovation (R&I). In order to achieve sustainable and inclusive transport, planners and policymakers should consider all impacts on gender equality. This paper sheds light on two main issues which interconnect through the decision-making process. The first relates to women's behaviour in the transport system (i.e., studies the gender mobility gap). The second concerns the role of women in transport R&I, particularly the topics covered by research projects and relevant descriptive statistics of their participation in the sector. Based on a literature review, this paper identifies critical issues in the European transport sector and key European Union policy initiatives and regulations that address gender equality and transport. The European Commission's Transport Research and Innovation Monitoring and Information System (TRIMIS) is used to summarise the status and evolution of European research in addressing women's issues in transport. It also analyses the participation of women in European transport research and innovation activities. The paper assesses progress to date and identifies challenges and opportunities for women, mobility, and transport. It concludes by providing policy recommendations to overcome the major barriers to gender equality in the European transport sector and to transport research and innovation.

**Keywords:** gender; equality; equity; European transport; research; employment



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## 1. Introduction

Gender equality in transport aims to reduce mobility inequalities between men and women. While several European policy areas have considered gender issues, little progress has been made in the transport sector [1,2], with increasing evidence to suggesting that transport is not gender neutral [3]. For example, only 22% of people employed in the European transport sector are women. This has implications for how transport systems are designed and operated to meet the travel needs of women [4].

Women have specific mobility characteristics regarding mode choice, time of travel, trip purpose, route, and travel distance [5–7]. The daily activities women undertake are more complex than those of men, women are often responsible for domestic chores, children, older relatives, and the sick [8]. Gender differences in travel patterns reflect the division of roles in the family and affect women's employment conditions, income levels, and mobility [1,9].

Understanding the factors that influence women's travel behaviour such as personal security and safety issues on public transport and attitudes to innovative transport technologies can contribute to the design and implementation of sustainable transport policies that improve gender equality in the European Union (EU) member states (MS) [10]. Although research on equality and women has been undertaken since the early 1980s, particularly in the UK and the US (e.g., [11]), women's issues in transport is a relatively new topic with

relevant European research funded projects starting less than 20 years ago. The extent to which European research addresses women's issues in transport and the participation of women in European transport research and innovation (R&I) activities is unclear, since we only found one publication on this topic [12]. Building on a previous study [12], this paper highlights the social and spatial dimensions of women's involvement in transport R&I and EU transport policy. This is important if we are to develop gender neutral transport in Europe that meets the mobility of everyone and considers also the impact of innovative mobility offers (e.g., shared mobility or autonomous vehicles) on all type of users. This paper sheds light on two main issues. The first relates to women's behaviour in the transport system (i.e., studies the gender mobility gap). The second concerns the role of women in transport R&I, particularly the topics covered by research projects and relevant descriptive statistics of their participation in the sector. These two main issues interconnect through the decision-making process; policymakers should be aware of the factors that influence women's travel behaviour and know the status of women's involvement in transport R&I. These two main topics feed each other and, only with the right information, planners will be able to propose gender-neutral policies. The research topics, therefore, represent the fifth goal of the United Nation's Agenda 2030: achieve gender equality and empower all women and girls.

This paper first reviews the most relevant literature and European initiatives related to women's mobility. Second, it examines the status and evolution of European research in tackling women's issues in transport by studying R&I dimensions such as EU research framework programmes, national funding, geographical and organisational distribution of funds, projects per MS, and mode of transport. To do this, we use the European Commission's (EC) Transport Research and Innovation Monitoring and Information System (TRIMIS) [13]. Third, we assess women's participation in transport R&I activities, including descriptive statistics, key features, and outline relevant capacities. We conclude by providing policy recommendations aimed at overcoming barriers to gender equality in transport.

## 2. Review of Research on Women in European Transport

### 2.1. Women's Mobility and Travel Behaviour

While MS national mobility surveys provide gender disaggregated data useful for gender and transport research, these data are not always comparable or standardised. Comparable data are available from EU harmonised time use surveys, but these provide only travel time and mode by gender and lack spatial information. The availability of national gender-disaggregated mobility data needs to be addressed to gain a greater understanding of gender and transport issues across the EU. Therefore, the literature review uses a search of ad hoc literature on the topic.

While there has been a change in the traditional gender roles and household tasks, women have more responsibility than men, undertaking unpaid care each week. This varies between 6 to 8 h in Nordic countries and can reach over 15 h in countries such as Italy, Croatia, Slovenia, Austria, Malta, Greece, and Cyprus. Part-time work remains the predominant way women engage in the labour market [14], which is confirmed for the case of Canada, where the largest gender income gap exists for married couples with children. However, this gap is reduced when hours spent on shopping and domestic tasks are considered [15]. These results suggest that women usually have a higher share of household responsibility than men do.

This imbalance of domestic tasks is a burden on women's time budget and can lead to higher levels of car use and daily trips over shorter distances compared to men. Women do more part-time work which limits employment opportunities and career development [16–18]. A 2019 travel survey found that women perform double the number of trips for domestic tasks, such as taking children to school, when compared to men [19]. Unfortunately, common specifications of transport models should be adjusted for specific cases [20], such as taking into account the patterns between residential households' location

and mobility choices [21]. In the context of gender equality, these specifications should clearly consider family dynamics.

Access to private transport is therefore a key factor in determining women's mobility and economic inclusion. Limited access to private transport can restrict women to a low-wage and low-skilled employment. The extent to which these processes affect women depends on geographic location, age, economic position, ethnic origin, and physical and intellectual abilities [22]. A recent study in Santiago de Chile [23] confirmed the gender mobility gap, with women visiting fewer unique locations than men and spending their time differently among such places. The authors linked this gap to lower income and lack of supply of public and private transport.

Women also have more non-work-related trips, travel off-peak hours, and use flexible transport modes than men [10,24]. As a result, car sharing, shared mobility, or mobility as a service (MaaS) could attract more female than male users when given better alternatives to private transport, offering greater utility and economic and environmental benefits [10,25].

Women's low rate of motorisation forces them to use public transport, walk, and cycle [1]. When compared to men, women tend to walk more for leisure and across all age groups [26]. Women therefore tend to be 'greener' not only because they have limited access to cars but also because they have different attitudes towards mobility (e.g., being more concerned about risk than men) [1,27–30].

However, women are unrepresented in commuter cycling, consequently missing the health benefits of active commuting over distances where walking is less practical. The gender gap in cycling is due to a differentiated response to the attractiveness of cycling, as women require a more conducive environment. This suggests a need to improve the cycling environment to attract more female cyclists [31] by including them in the design of cycling infrastructure [32]. In general, women undertake household tasks, carry more bags than men, and travel more often with children; therefore, their participation in the design of bicycles is important.

The future development of low emission mobility will need to recognise the complexity of mobility and the transport needs of women as they could have serious gender implications [22].

Younger women (aged under 30) are travelling further compared to younger men. Young men are less mobile as they approach early midlife, traditionally a life-course peak in travel mobility. Reasons for the greater mobility of young women than young men include lifestyle shifts and social changes. For example, young women are socially and economically independent, have accessed education and professional employment, and are therefore more equal to men [33].

Recent results suggest that safety, security, accessibility, and transport reliability are the main issues related to women's mobility [34]. Given these gender differences in transport, there is a need to focus on women's transport issues and undertake further research on the mobility needs of women to provide the evidence base for inclusive transport policies [35].

## 2.2. Women's Personal Security and Transport

Transport safety and security are key factors in women's mobility choices, especially regarding public transport use. Women use public transport more than men do and may feel exposed to physical aggression, sexual harassment, or other unwelcomed behaviour [36].

An international review revealed that emerging economies, where public space is regarded as a male domain, have higher rates of harassment and assault on public transport [37]. In France, the National Observatory of Crime and Criminal Justice (ONDRP) survey of sexual harassment on public transport found that 267,000 people—85% of whom were women—were sexually harassed on public transport between 2014 and 2015, including kissing, groping, flashing, and rape [38].

Concern about personal security has implications for several issues including the design of transport interchanges, waiting areas, and for staffing. With an increasing reduction in the physical presence of service staff, passengers may feel less secure as there

is no one there to assist, whatever the gender. Despite interventions such as lighting and security cameras, these have a limited impact on reducing women's fear, compared to formal surveillance by police or transport employees [39]. Indeed, results from a survey regarding medium-sized Italian railway stations [40] show that female users feel safer in the presence of other people and prefer intermodal exchanges close to the entrance as well as commercial activities inside the station.

### 2.3. Women and New Transport Technologies

The EC aims to ensure a smooth transition towards a mobility system which is safe, clean, connected, and automated. This requires reducing transport emissions by low-emission mobility by 2030 to at least 55% compared to 1990, including emissions and removals [41]. However, the decarbonisation of the transport sector and the introduction of innovative technologies are not necessarily gender neutral. It is therefore crucial that the specific needs of women are taken into account when developing new transport technologies and services [36].

Men tend to be early adopters of new vehicle technologies and are, for example, more likely to be interested in purchasing fully automated vehicles (AVs) than women [42].

In general, women tend to have a lower willingness to use AVs than men do, due to anxiety and fear of riding in an AV [43,44]. Women are inclined to be more hostile to AV technology such as driverless cars and trucks [45]. They are also less willing to pay for adding partial and full automation of their next vehicle [46].

One study [47] examined gender differences in early adopters of car sharing with and without electric vehicles (EVs). The results confirmed differences in income, employment status, and age, with women having a lower interest in technology and innovation than male users. Refs. [30,48] found that women have less driving experience of EVs and less interest in owning an EV compared to men. Women attached more importance to ease of use, safety, cost, and environmental impact and charging option than the range an EV can drive, which was important to men. In contrast, another study [49] suggests women tend to be more sceptical about the readiness and reliability of EV technology and infrastructure when compared to men.

Therefore, gender influences attitudes to the adoption of new vehicle technologies (e.g., vehicles with a higher degree of automation using artificial intelligence). Women tend to be more sceptical to emerging technologies and perceive higher risks from these technologies than men do. This lack of willingness for automation is not necessarily detrimental since it could mean that women are more risk-averse and use new technologies once these are operational and consolidated. This may be linked to the characteristics of new technologies and how they affect different individuals, but also to a more general concern about automation, which influences attitudes to new vehicle technologies.

### 2.4. Gender Equality and Transport in the EU

There are almost 40 European initiatives and regulations promoting gender equality [12]. These can be divided into three categories:

1. Gender mainstreaming initiatives introduced in the nineties aimed at incorporating equal opportunities into European policies and activities.
2. Gender equality initiatives and policies to promote the participation of women in European science and research.
3. Gender equality initiatives that promote the role of women in the transport sector, such as their participation in transport platforms and working groups (e.g., Women in Transport—EU Platform for change).

During the earlier years of the European Community, the concept of equal opportunities for men and women was limited to the principle of equal pay. However, equality of opportunity between men and women was later enshrined in the objectives of the Treaty of Amsterdam (1999) [50].



In 1996, the EC set out its strategic approach to mainstreaming equal opportunities between men and women, which incorporated equal opportunities into all European policies and activities [51] such as the 1998 new employment strategy [52]. Several policy initiatives related to gender equality, transport research, and innovation followed.

The EC Fifth Framework Programme for research and technological development (1998–2002) was the first time the EC emphasised the participation of women in European research [53]. In 2006, the European Institute for Gender Equality (EIGE) promoted gender equality, including gender mainstreaming in all EU policies and the resulting national policies. The EIGE online platform provides access to the Gender Equality Index and the Gender Statistics Database with the latter providing key performance indicators (KPIs) and insights on transport [54]. The EC has taken progressive action to mainstream gender issues into policy as part of its strategy to achieve greater gender equality. Mainstreaming has involved the integration of a gender perspective into the preparation, design, implementation, monitoring and evaluation of policies, regulatory measures, and spending programmes. This approach has assisted in promoting greater equality between women and men [55].

### 3. Evolution of Research Projects That Address Women and Transport Issues

TRIMIS is the EC analytical support tool for the establishment and implementation of the Strategic Transport Research and Innovation Agenda (STRIA), which outlines future transport R&I priorities to decarbonise the European transport sector outlined in seven roadmaps: cooperative, connected, and automated transport (CAT), transport electrification (EV), vehicle design and manufacturing (VDM), low emission alternative energy for transport (ALT), network and traffic management systems (NTM), smart mobility and services (SMO), and infrastructure (INF). TRIMIS contains an open-access, searchable database of projects and programmes of approximately 9000 projects grouped according to the seven roadmaps that have been financed by EU research Framework Programmes, EU MSs, and other countries. TRIMIS therefore maps and analyses technology trends and R&I capacities in the European transport sector. Appendix A shows the features and attributes of all projects in the TRIMIS database.

To select applicable projects relevant to women and transport a search was undertaken using five keywords based on the literature review (i.e., women, gender, equality, inequality, and equity). If a project contained the keyword in its description, it appeared in the search (i.e., a single keyword search). After carefully reading the description, method, and results of each project, the project was then included in the research or classified as non-applicable and discarded. Only relevant and strongly connected projects to the topic were included in the analysis. For example, a project that examined travel behaviour of women was strongly linked, whereas one addressing sustainable mobility was weakly connected since gender issues were not at the core of the research. Projects such as TINNGO (“Transport Innovation Gender Observatory”) and DIAMOND (“Revealing fair and actionable knowledge from data to support women’s inclusion in transport systems”) were strongly linked, while projects such as FLOW (“Furthering Less Congestion by creating Opportunities for more Walking and cycling”) and SUNRISE (“Sustainable Urban Neighbourhoods—Research and Implementation Support in Europe”) were weakly linked to this category and were therefore omitted from this analysis. Appendix B shows all the projects considered in the research.

In addition, a new feature that identifies whether the project addresses the following key topics was also included: safety and security, travel behaviour and travel patterns, socio-economic issues including job generation and job equality, and finally, other, which encompasses additional aspects (e.g., ergonomics). A project can address more than one STRIA roadmap, transport policy, or key topic. Since some projects fell under more than one category, the total number of tags was greater than the number of projects studied. In total, 60 projects were analysed using this approach.

A few projects within TRIMIS address women's issues in transport (less than 1% of the projects are strongly connected to the topic). Regarding the funding origin, the distribution was almost even, with 28 projects funded by EU MSs and 32 projects supported by European programmes such as Horizon 2020 (H2020) or the 7th Framework Programme (FP7), while there was no significant difference between MSs and the EU in the topics studied. Moreover, 63% of the research projects focused on passenger transport, 3% on freight transport, and the remaining 33% on both.

Road and multimodal transport covered 45% and 39%, respectively. Waterborne, rail, and air transport addressed 16% of the research projects. Regarding the geospatial scope of the projects, only 13% of the projects focused on the urban environment, whereas most strongly connected research projects (85%) had the category "other" as a location and just 2% of the research covered infrastructure nodes.

Classification according to the seven STRIA roadmaps shows that the projects had 69 tags. There was a higher proportion of projects tagged as "other" with 29 projects falling within that category. Twelve projects were linked to the STRIA roadmap SMO and eight projects were linked to VDM roadmap. The remaining roadmaps had fewer projects. It can be seen that only a small share of the projects was directly linked to a specific technology. CAT, ALT, ELT, and VDM roadmaps could usually be allocated to specific technologies and they only applied to approximately 20% of the projects.

Regarding the STRIA policy, the 60 projects had 104 tags. A total of 40 projects fell under societal/economic issues, 24 projects belonged to safety and security issues, and 19 analysed the decarbonisation of the transport sector. Figure 1a presents how the 104 tags were distributed across the different STRIA policies. A more in-depth analysis of the policies shows that 25 projects examined travel behaviour/travel patterns while 19 projects studied socio-economic issues, 18 projects safety and security issues, and only 11 projects belonged to the category "other". Figure 1b shows how the 73 tags were shared across the four transport issues.

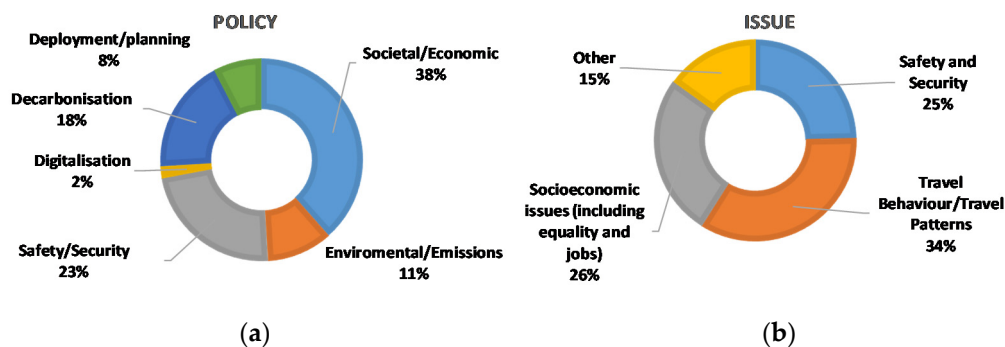
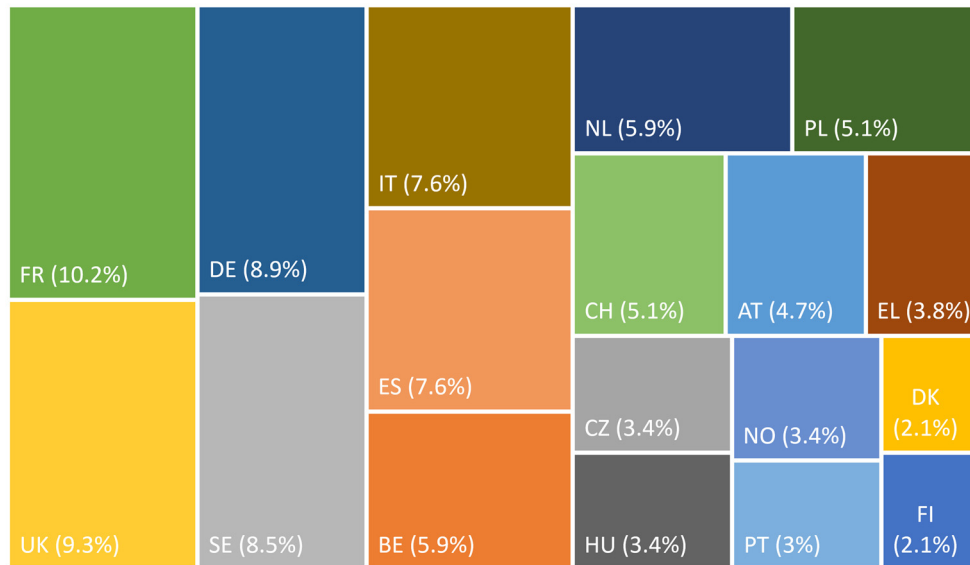


Figure 1. (a) (left) and (b) (right). Strongly connected projects divided by STRIA policy and transport issue.

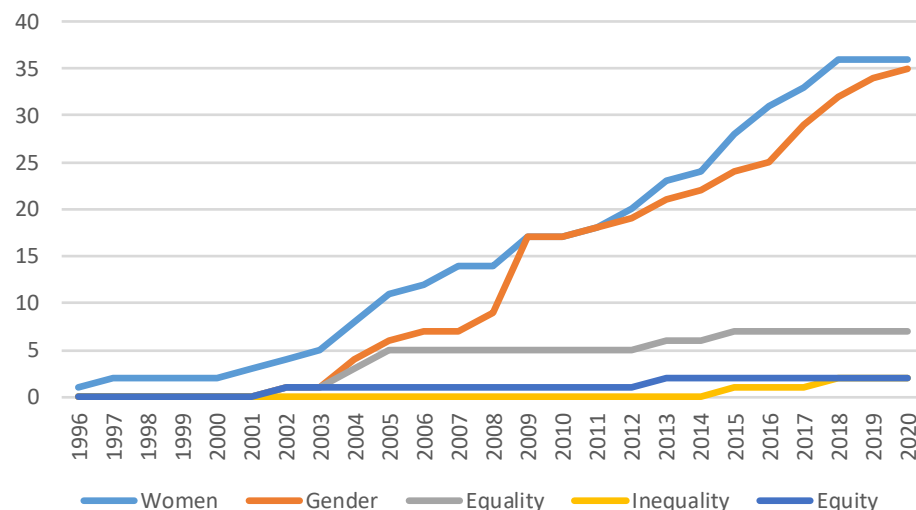
Figure 2 shows the participation of EU MSs, other European countries, and third countries in the 60 research projects analysed. For the sake of clarity, only countries with more than five projects are considered in the Figure. France, the United Kingdom (UK), and Germany had the highest number of research projects with 24, 22, and 21, respectively. There is a link between the size of the country, its economy, and the number of projects. However, other factors such as culture and women's role in society also appear to have an important influence on the research undertaken. Sweden (20 projects), the Netherlands (14 projects), and Switzerland (12 projects) are the best examples since the size of their economy does not justify their position. The population of Germany is around 82 million, the UK 66 million, Sweden is approximately 10 million, Switzerland is about 8 million, and of the Netherlands around 17 million. The ratio of projects per capita was at least three times higher in the latter group of countries when compared to Germany and the UK. These countries have similar characteristics: low unemployment, steady economic growth, and a high proportion of nationally funded projects. We could therefore conclude that

countries with healthy economies might be more aware of women's issues in transport, invest more at the national level because of socio-cultural factors, and be better prepared for European research programme calls. This higher awareness and these socio-cultural factors are well reflected in the Scandinavian countries since, for instance, they offer both partners the choice of equal parental leave and the position of women in the workforce is historically better than in other MSs [56].



**Figure 2.** Total projects divided by country participation.

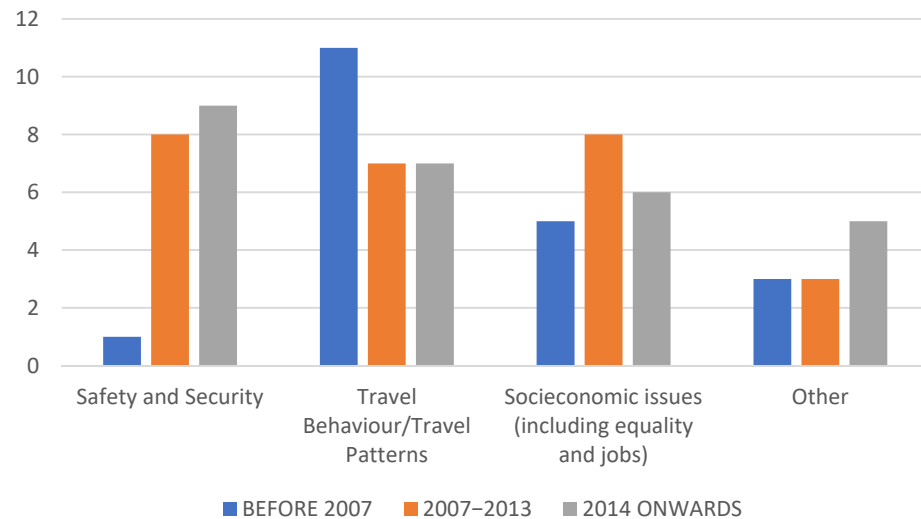
The keywords appeared 82 times in the description, method, or results of the 60 projects. Only seven projects included the keyword equality; instead, the keywords women (36 projects) and gender (35 projects) were widely used. The keyword gender has been used in the description of projects since 2004, while the use of the keyword women has grown steadily. Figure 3 shows how the use of women and gender keywords compared to other relevant ones has evolved.



**Figure 3.** Accumulated keywords appearances in projects per year.

Figure 4 shows the evolution of all projects (i.e., regardless of their funding origin) in three periods: before 2007, 2007–2013, which covers the period of FP7, and from 2014 onwards, which also overlaps the period of H2020.





**Figure 4.** Evolution of projects by transport issue.

Some conclusions arise from Figure 4. First, 16 projects were awarded before 2007, 22 projects in the period 2007–2013, and 22 projects from 2014 onwards. Second, safety and security issues were barely considered before 2007. Third, the higher number of projects in the category ‘other’ from 2014 is due to a higher level of multidisciplinary research. This higher level of multidisciplinary explains that the distribution among topics is more balanced than it used to be. In fact, EU-funded projects have a higher budget than before and more participants. This is particularly true in the projects awarded since 2018.

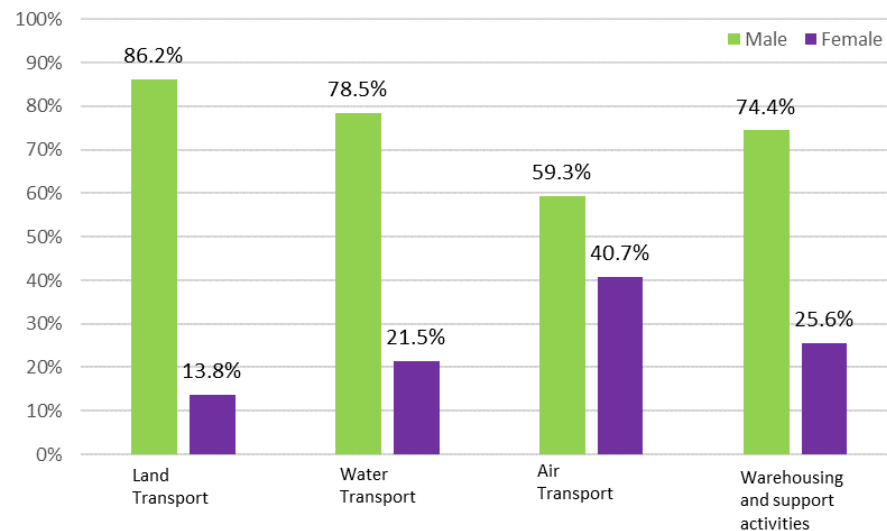
It should be noted that within the H2020 context, gender is a cross-cutting issue that promotes equality and integrates a gender dimension in R&I. A comparison of strongly connected projects of FP7 and H2020 showed an important increase in the budget of the projects from EUR 20.4 million to EUR 64 million. However, one project, INCIT-EV, which carried a large demonstration of user-centric urban and long-range charging solutions to boost an engaging deployment of electric vehicles in Europe, within H2020, had a budget of almost EUR 19 million and 33 participants, which distorts the overall picture. Therefore, although progress has been made, the gender dimension in R&I is not working or is not being fully followed in transport. Aside from increasing women in the research workforce, research consortia for the next European funding programme (Horizon Europe 2021–2027) should have a greater gender balance. In this way, R&I programmes will actively consider gender dimensions while supporting the research careers of women.

#### 4. Women’s Participation in European Transport R&I

##### 4.1. Women’s Participation in the Transport Sector

In the European transport sector, women are under-represented compared to their male colleagues [14]. This under-representation of women is due to several factors: difficulty finding a work–life balance; lack of appropriate working environment; lack of training and life-long learning opportunities or inadequate targeted recruitment [57]; persistence of stereotypes; harassment; and bullying [58]. Figure 5 shows the gender differentiation in each of the transport sub-sectors (land, water, air, warehousing, and supporting activities).

Women are significantly under-represented in the land transport sector, with 6.2 males for every female employee, while in the air transport sector women represent almost 44% of the employed people. However, some occupations are almost exclusively performed by men, for example, drivers of heavy trucks, buses, trams, cars, and taxis [59]. In addition to the statistics on the overall transport employment, the next sections provide a detailed analysis of the participation of women in transport research in Europe.



**Figure 5.** Gender differentiation in the European transport sector (%), 2018).

#### 4.2. Overview of Women's Participation in Research Activities

In 2015, most female researchers were employed in the higher education sector (HES) (62.5%) followed by the business enterprise sector (BES) (24.1%) and the government sector (GOV) (12.3%). In these sectors, female researchers are almost equally present compared to men in HES (42.1%) and GOV (42.5%), where female researchers are younger than their male counterparts, with most of them in the age groups under 35 and 35–44, while male researchers were mainly in the age groups 45–54 and over 55 [60]. This means that senior positions are predominately held by men and therefore research direction and leadership is male-dominated. This could be because of women having to balance household and career responsibilities and deal with workplace discrimination. Indeed, one study [61] found top-management commitment to be one of the key factors facilitating gender equality interventions in R&I.

#### 4.3. Overview of Women's Participation in Transport R&I

A detailed analysis of the presence of female researchers in transport R&I is challenging since data are not systematically collected and databases only partially cover this aspect, as transport research has traditionally covered mainly engineering aspects and only in recent years socio-economic, environmental, and geographical aspects have also become prevalent. The empirical approach used here required some assumptions to study women's participation in R&I, such as excluding female participation on published research papers or that transport-related researchers and research assistants are fairly contracted. The purpose of this subsection is therefore not to provide a full picture of transport R&I female participation, but rather to compare its evolution in the last years and study possible changes in the trends observed. Based on the information, an occupation analysis was developed to provide statistics on research-related occupations and gender differences in transport. The term "researcher" covers a broad range of activities linked to engineering, economics, and design fields in the transport sector and therefore needs an association to a specific occupation category according to the International Standard of Occupations Classification (ISCO-08). Within the ISCO-08 codes, the occupations that can be associated to transport research activities are Code 21—Science and engineering professionals and Code 31—Science and engineering associate professionals, which include, among others, engineers, architects, statisticians, physicists, statisticians, and associate professionals. To link research occupations with the transport sector (Code 21 and Code 31 of ISCO-08), the related economic activities associated to transport have been identified (see Table 1).

**Table 1.** Transport economic activities.

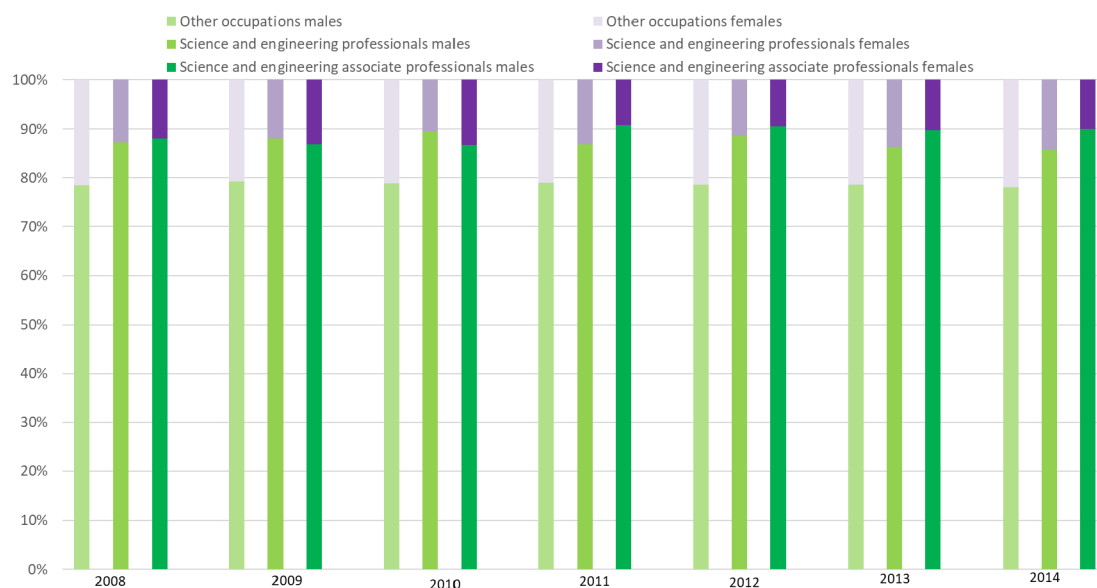
Transport Economic Activities	
C29	Manufacture of motor vehicles, trailers, and semi-trailers
C30	Manufacture of other transport equipment
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
H49	Land transport and transport via pipelines
H50	Water transport
H51	Air transport
H52	Warehousing and support activities for transportation
H53	Postal and courier activities <sup>1</sup>

<sup>1</sup> For the years prior to 2008, the NACE Rev. 1.1 and ISCO-88 apply and the corresponding codes were used. Source: ‘Nomenclature statistique des activités économiques dans la Communauté européenne (NACE Rev. 2) Classification’.

Based on the methodology presented in [62] and using the data from Eurofound’s European Jobs Monitor (1995–2014), a two-digit matrix combining Code 21 and Code 31 of ISCO-08 and NACE Rev.2 tables was created for each EU MS, summarising the occupation evolution in the transport sector with a focus on research-related occupations.

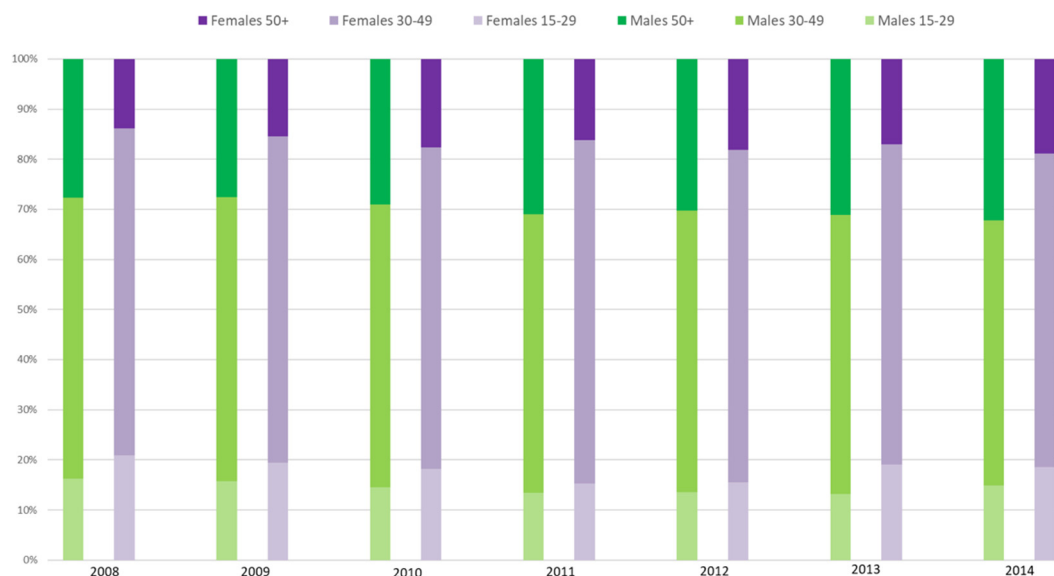
An analysis of transport research occupation trends over the period 2008–2014 showed that science and engineering and associate professionals represented 8% of the people employed in transport. Although the latest available data refers to 2014, this is not an issue to study trends. In fact, the former economic crisis, 2009–2010, is fully captured in the data, and we could not identify any major change. The transport sector has experienced no major occupational structure changes compared to other economic activities, as highlighted by [62].

The data show that women are under-represented in jobs linked to transport science and engineering. Figure 6 shows the gender difference for science and engineering professionals, science and engineering associate professionals, and for the remaining transport occupations. This illustrates that, while women are more represented in the remaining transport occupations (22% on average), the two research-associated occupations employ fewer women.



**Figure 6.** Gender differences in transport occupations with a focus on science and engineering professionals and associate ones (%), 2008–2014).

In the period 2008–2014, women in science and engineering professionals (ISCO-08, Code 21) represented approximately 12.5% of the total people employed. Women working as transport science and engineering associate professionals (ISCO-08, Code 31) were around 11%. The presence of women was higher in the age group 30–49 compared to men, and the opposite occurred for workers older than 50 years (see Figure 7). These results reflect the outcome of studies that examined gender differentiation in research [60], showing that in many European countries, most women researchers were in the under 35 and 35–44 age groups, while male colleagues were mainly present in the 45–54 and over 55 age groups.



**Figure 7.** Gender differences, according to age classes, in science and associate engineering professionals (Code 31-ISCO 08), (%), 2008–2014).

In 2014, there was a differentiation between women and men in terms of contractual agreements. When signing a permanent contract, as a scientist or engineer (ISCO-08, Code 21), almost 87% of the total were men with a full-time contract, while only 13% were female. With permanent part-time contracts, it was the opposite: almost 74% of female researchers compared to 26.5% of male researchers. Similar patterns existed in science and engineering associate professionals (Code 31-ISCO 08) with an even bigger share of male employees (91%) compared to women (9%), obtaining a permanent full-time contract. With permanent part-time agreements, 63% of the contracts were signed by men and 37% by women. The EIGE [63] shows that women are paid less than their male counterparts, because of lower level and lower paid jobs, more working hours, longer career breaks, and more frequent part-time work to reconcile work and care responsibilities.

An analysis of indicators related to occupation profiles, research activities, and profiles of researchers engaged in R&I transport projects under the H2020 Framework Programme was undertaken to gain a clearer understanding of the presence and characteristics of women researchers in transport. A case study was used here to examine gender representation in H2020-funded transport R&I projects, the typology of the job, and their educational qualifications.

Transport R&I projects were selected ensuring representation of the seven STRIA roadmaps, all transport modes, both the passenger and freight sector, and having a broad European geographical coverage. The seven STRIA roadmaps were represented by three projects for each roadmap, while transport modes refer to road, rail, waterborne, air, and multimodal transport. Each project involved organisations from several MSs ensuring a wide geographical coverage. The final sample of transport researchers comprised 769 persons, working for 223 organisations and participating in 21 European projects.

According to the sample, women were under-represented and accounted for 22% of 769 transport researchers. More than half of the researchers had an educational background in engineering (53%), of which only 19% was represented by women. For 17% of the sample, the educational background was not explicitly mentioned; economists represented 8% of the total number of researchers, of which 32% of transport economists were women. The remaining researchers belonged to other educational domains.

In order to gain a better understanding on the seniority of women in research teams, an additional analysis was undertaken, which examined the profiles of 116 (88 males and 28 females) transport researchers taking part in H2020 projects.

The focus was on two aspects: working experience in transport research and role as principal researcher, having managerial responsibilities in daily research activities. These two aspects give an idea of leadership roles among researchers between men and women. Among the researchers with over 10 years of experience, which were 74 in total, 81% were men and 19% were women. Concerning the experience in a managerial position in research activities, 50 people had such experience, 74% of these roles were held by man and 26% by female colleagues. The combination of these two variables, researcher with more than 10 years of experience and holding managerial responsibilities, identified people with high seniority in transport research. In total, 49 researchers were identified, 75.5% of them being male and 24.5% female. The gender gap is still present in senior positions in the transport research field. A recent study found that this gender gap exists in other sectors since only three developed countries worldwide have more than 40% of women in leadership roles in politics, media, or decision-making positions in private companies [64]. The data were collected from the profiles of H2020 participants in European transport projects. The information in the database varies depending on the company or project, sometimes leading to incomplete data, making the analysis quite challenging. Using standardised Curriculum Vitae forms to collect participants' information applying for EU funds would enable further analysis.

## 5. Discussion and Conclusions

This paper analyses gender differences in the transport sector across the EU, including the actual participation of women in European transport R&I activities and how European research addresses the gender gap. First, it provided a summary of key women and transport issues and described relevant EU policy initiatives and regulations regarding gender equality and transport. Second, it studied the status and evolution of European research in tackling women's issues in transport. Finally, it analysed women's participation in transport R&I activities, including descriptive statistics, key features, and relevant capacities.

Based on the literature review, a gender gap continues to exist in European transport and mobility. The reasons behind this gap also arise in other developed regions (e.g., imbalance of domestic tasks or a different perception of security), meaning that the lessons learned from this research can apply with minor modifications to other areas. In addition, the following conclusions and recommendations can be made based on this review:

- Transport safety and security are critical factors in women's mobility choices, and introducing innovative technologies and increased automation are not necessarily gender neutral, with women being less willing to use them. Further mainstreaming of gender into policy is therefore needed to close this gap. This requires developing a robust body of evidence, based on which planning policies that meet the travel and mobility needs of women. Transport technologies aimed at low emission mobility should also recognise women's transport needs. This is important given that women are more willing to use environmentally friendly transport modes.
- There is a need for more data on women-specific travel characteristics and their interest in the transport sector. Targeted R&I research should collect comparable data across the EU and internationally. For instance, more surveys analysing time spent in trips because of household tasks or a standardised description of research profiles within EU projects forms could facilitate a further analysis of gaps between men and women.

The latter could be fairly done by using a common framework for CVs in which years of experience and responsibilities taken should be at the core of it.

- Although research on equality and women has been undertaken, women's issues in transport is a relatively new topic. European regulations considered women and transport issues about 20 years ago while relevant European research funded projects started slightly later, around 15 years ago. Some financial progress has been made, particularly since 2018 when large projects have been awarded to consortia with several participants, but the gender dimension in R&I programmes is not sufficient or has not been fully considered. Therefore, further advances in addressing women's issues in transport research is needed. In other words, R&I projects should also study the impact of these new technologies on gender equality and, in particular, women's mobility needs. Projects with a cross-cutting working package studying the effect of disruptive technologies on social issues, specifically the gender mobility gap, might get a bonus in a system point-based scheme.
- Less than 1% of the projects within the TRIMIS database analyse women's issues in transport. No significant difference exists between MS-funded and EU-funded projects regarding the topics studied. Their main difference was found in the higher number of participants in EU-funded projects. However, the wealthier the country, the more social issues are taken into consideration. Countries with prosperous economies have a higher awareness of women's issues in transport, have higher levels of national investment, and seem to be better prepared for European research programme calls. The lessons and results deriving from the projects can apply to several fields; the evolution of the projects shows that safety and security issues were not always considered within European research; and in recent projects, there seems to be a higher level of multidisciplinary research.
- In the European transport sector, including transport research, women are under-represented compared to their male counterparts (22% of workers are female). The lower level of seniority of women compared to men could be a barrier for women to develop their transport research career. Household dynamics (e.g., childcare responsibilities) act as a barrier to career progression. This seniority gap also exists in other sectors in developed countries worldwide, suggesting that improving the gender gap in household chores might help. For instance, career breaks that are equally incentivised across parents might help close this gap.
- Only eight projects specifically addressed the problem of lack of qualified personnel and women, and all of these projects had been completed some time ago (six belong to the FP7 programme and two to H2020). MS funding did not seem to fund these types of projects. The share of women has not increased, even after the finalisation of projects addressing the lack of qualified personnel and women. Greater understanding of the reasons behind the lack of female transport researchers is needed to increase the share of women in transport. The involvement of a higher percentage of women in R&I will increase the awareness of the gender gap in mobility and facilitate a deeper study of its reasons and ways to address it.
- In order to analyse women's participation in R&I, two main assumptions were made. First, we excluded female participation on published research papers, which is at the core of scientific production. Second, we assumed that transport-related researchers and research assistants are fairly contracted. The purpose was, therefore, not to provide a full picture of transport R&I female participation, but rather to compare its evolution in the last years and study possible changes in the trends observed. Particularly interesting for future research lines would be to study female participation on published research papers, which remains unexplored.

In conclusion, large projects which analyse the impact of new and existing technologies and policies on women's mobility, including the use of gender-sensitive data and statistics, and gender-equitable research consortia should be encouraged in European transport research. In addition to increasing women in the research workforce, research consortia for



the next European funding programme (Horizon Europe 2021–2027) should have a greater gender balance. In this way, R&I programmes will actively consider gender dimensions in transport research and support the scientific careers of women, while providing the evidence base for planners and policy makers to achieve inclusive low emission mobility in the EU.

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## Appendix A

Features and attributes of all projects in the TRIMIS database:

- Title.
- Acronym.
- Start date and end date.
- Funding origin (e.g., European, EU MSs, international).
- Programmes linked to the project.
- Cost and EU contribution (feature only available for EU-funded projects).
- A description of the project which includes background and policy context, strategic objectives, methodology, and critical results.
- Organisations and partner organisations (feature only available for European funded projects).
- Technologies.
- Geospatial type (i.e., urban, infrastructure node or other location).
- Transport modes (i.e., road transport, rail transport, waterborne transport, aviation, multimodal).
- Transport policies (i.e., societal/economic issues, environmental/emission aspects, safety and security, digitalisation, deployment/planning/financing/market roll-out, other specified).
- Transport sectors (i.e., passenger, freight, both).
- STRIA Roadmaps (i.e., cooperative, connected and automated transport (CAT), transport electrification (ELT), vehicle design and manufacturing (VDM), low-emission alternative energy for transport (ALT), network and traffic management systems (NTM), smart mobility and services (SMO), infrastructure (INF), and other).
- Project status (i.e., completed or ongoing).

## Appendix B

Table A1. Projects considered for the research.

Acronym	Name	Start-End Year	Funded by
EUROPEAN FUNDED PROJECTS			
EXTRA 2	Euromethodologies for Travel Assessment	1996–1997	European (4th RTD Framework Programme)
SMILE LIFE	Sustainable Mobility Initiative for Local Environment	2001–2004	European (N/A)
EURNEX	European Rail Research Network of Excellence	2004–2007	European (6th RTD Framework Programme)
GMOSS	Global Monitoring for Security and Stability	2004–2008	European (6th RTD Framework Programme)
UNIACCESS	Design of Universal Accessibility Systems for Public Transport	2005–2006	European (6th RTD Framework Programme)
SEAT	Smart Technologies for stress free Air Travel	2006–2009	European (6th RTD Framework Programme)
PROMARC	Promoting Marine Research Careers	2008–2010	European (7th RTD Framework Programme)
SKILLRAIL	Training and Education for a more Competitive and Innovative Railway Sector	2009–2011	European (7th RTD Framework Programme)
FUTURAIL	Job Opportunities for the Railway Community of Tomorrow	2009–2010	European (7th RTD Framework Programme)
ITERATE	IT for Error Remediation and Trapping Emergencies	2009–2011	European (7th RTD Framework Programme)
RESTARTS	Raising European Student Awareness in Aeronautical Research through School-labs	2009–2012	European (7th RTD Framework Programme)
THOMO	Development of a finite element model of the human thorax and upper extremities	2009–2012	European (7th RTD Framework Programme)
COVER	Coordination of Vehicle and Road Safety Initiatives	2009–2013	European (7th RTD Framework Programme)
THORAX	Thoracic Injury Assessment for Improved Vehicle Safety	2009–2013	European (7th RTD Framework Programme)
ADSEAT	Adaptive seat to reduce neck injuries for female and male occupants	2009–2013	European (7th RTD Framework Programme)
KNOW-ME	The European Academic and Industry Network for Innovative Maritime Training, Education and R&D	2011–2014	European (7th RTD Framework Programme)
City-Hub	City-Hub	2012–2015	European (7th RTD Framework Programme)
PROMO-AIR	Promoting Aeronautics Innovation and Research	2013–2015	European (7th RTD Framework Programme)
TEA	Transport Equity Analysis: assessment and integration of equity criteria in transportation planning	2013–2017	European (N/A)
STRINGBIKE	Highly innovative push-pull handbike for boosting wheelchair mobility	2016–2017	European (Horizon 2020)
ENABLE.EU	Enabling the Energy Union through understanding the drivers of individual and collective energy choices in Europe	2016–2019	European (Horizon 2020)
TrustVehicle	Improved trustworthiness and weather-independence of conditional automated vehicles in mixed traffic scenarios	2017–2020	European (Horizon 2020)
QUIET	QUalifying and Implementing a user-centric designed and Efficient electric vehicle	2017–2020	European (Horizon 2020)
TranSim	The Next Generation Simulation-Based Training System for Optimal Transportation Systems	2017–2017	European (Horizon 2020)
WISE-ACT	Wider Impacts and Scenario Evaluation of Autonomous and Connected Transport	2017–2021	European (Horizon 2020)
DIAMOND	Revealing fair and actionable knowledge from data to support women's inclusion in transport systems	2018–2021	European (Horizon 2020)
TInnGO	Transport Innovation Gender Observatory	2018–2021	European (Horizon 2020)
OSCCAR	Future Occupant Safety for Crashes in Cars	2018–2021	European (Horizon 2020)
VIRTUAL	Open access virtual testing protocols for enhanced road users safety	2018–2022	European (Horizon 2020)
Trustonomy	Building Acceptance and Trust in Autonomous Mobility	2019–2022	European (Horizon 2020)
SPROUT	Sustainable Policy RespOnse to Urban mobility Transition	2019–2022	European (Horizon 2020)
INCIT-EV	Large demonstratiOn of user Centric urban and long-range charging solutions to boost an engaging deployment of Electric Vehicles in Europe	2020–2023	European (Horizon 2020)
MS FUNDED PROJECTS			
A9 (NRP 41)	Pedestrian and cycle traffic	1997–2001	National (Switzerland)
Targeted public transport	Targeted public transport	2002–2002	National (Norway)
SVI 2001/509	Sustainable development in the field of transport-Criteria and indicators for social aspects	2002–2005	National (Switzerland)
Air Travel& Venous Thromboembolism	Air Travel and Venous Thromboembolism	2003–2005	National (United Kingdom)
Household structure and car ownership	Household structure and car ownership	2004–2004	National (Norway)
CDV	Sustained Mobility—a chance for the future	2004–2010	National (Czech Republic)
Early assessment of trends in transportation planning and road construction (SVI 2000/378)	Early assessment of trends in transportation planning and road construction (SVI 2000/378)	2004–2006	National (Switzerland)
Gender and transport (SVI2004/013)	Gender and transport (SVI2004/013)	2005–2007	National (Switzerland)

Table 1. Cont.

Acronym	Name	Start–End Year	Funded by
Mobility patterns of retired people: a challenge for the transportation system 2030?	Mobility patterns of retired people: a challenge for the transportation system 2030?	2005–2006	National (Switzerland)
Leisure Traffic in Urban Areas (SVI 2004/074)	Leisure Traffic in Urban Areas (SVI 2004/074)	2006–2009	National (Switzerland)
Ways2go	Innovation and Technology for Evolving Mobility Needs	2007–2012	National (Austria)
Improving Passive Safety of Vehicles (MSM6840770043)	Improving Passive Safety of Vehicles (MSM6840770043)	2007–2013	National (Czech Republic)
'Driver Inattention and Distraction' as Cause of Accident: How Do Drivers Behave in Cars?	'Driver Inattention and Distraction' as Cause of Accident: How Do Drivers Behave in Cars? (SVI2007/007)	2008–2012	National (Switzerland)
Potential of car pooling (ASTRA2008/017)	Potential of car pooling (ASTRA2008/017)	2009–2012	National (Switzerland)
Differences in the effects of fuel price and income on private car use in Sweden 1999–2008	Differences in the effects of fuel price and income on private car use in Sweden 1999–2008	2011–2012	National (Sweden)
SoMoMUT	Soft Mode Modeling in Urban Trips	2012–2015	National (Portugal)
On the Move; Car, rail, and bus travel trends in Scotland	On the Move; Car, rail, and bus travel trends in Scotland	2012–2013	National (United Kingdom)
DEFAKTOS	New policies and procedures for the training of passenger control personnel	2013–2016	National (Germany)
Speeding	Speeding	2013–2013	National (Poland)
The survey of attitudes of Poles in relation to road safety	The survey of attitudes of Poles in relation to road safety	2014–2014	National (Poland)
Men's and women's chances to pass a driving test	Men's and women's chances to pass a driving test	2015–2015	National (Sweden)
The use of seat belts in Poland in 2015	The use of seat belts in Poland in 2015	2015–2015	National (Poland)
The use of helmets users of motorcycles, mopeds and bicycles in Poland in 2015	The use of helmets users of motorcycles, mopeds, and bicycles in Poland in 2015	2015–2015	National (Poland)
The use of seat belts in Sweden 2015	The use of seat belts in Sweden 2015	2015–2015	National (Sweden)
Forecasting intervals for the number of seriously injured in road traffic accidents	Forecasting intervals for the number of seriously injured in road traffic accidents	2015–2016	National (Sweden)
Evaluation of a Swedish alcohol interlock program for drink driving offenders	Evaluation of a Swedish alcohol interlock program for drink driving offenders	2016–2016	National (Sweden)
Innovation partnership programmes-mobilising new ways to meet societal challenges	Innovation partnership programmes—mobilising new ways to meet societal challenges	2016–2018	National (Sweden)
Exchanges	Goods, logistics, and the gender perspective	2017–2018	National (Austria)

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