REGION
The Journal of ERSA
Powered by WU

Volume 6, Number 3, 2019, D1–D21
DOI: 10.18335/region.v6i3.281

journal homepage: region.ersa.org

The future of European communication and transportation research: a research agenda*

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Received: 26 September 2019/Accepted: 13 November 2019

Abstract. Our mobility system is changing rapidly. We are at the crossroads of major changes in the way we travel and deliver goods. Research agendas are adapting to this changed environment with new challenges and opportunities. This paper presents a research agenda for the future of transportation research structured along eight cluster topics of the Network on European Communication and Transport Activities Research (NECTAR). The research agenda firstly highlights the growing complexity and need for multi- and interdisciplinary transportation research. Secondly, sustainability needs to be addressed in transportation research in its full meaning, including relationships between policy-making investigations and environmental and equity effects. Thirdly, Information and Communication Technologies (ICTs) and digitalisation, the development of autonomous vehicles, and shared mobility will have profound impacts on economies, spatial interactions all-around the world, and the availability of high resolution spatial and transportation data. Digitalisation generates many new research opportunities but also give rise to new concerns about privacy, safety, equity and public health.

1 Introduction

The field of transportation research has been growing in many different directions reflecting the wide variety of disciplinary orientations such as civil engineering, geography, urban and regional economics, mathematics, sociology, political science, psychology, computer science, health science, environmental science. This development is supported by a wide range of networks and conferences in different regions around the globe, which bring together transportation researchers. There are the well-known world conferences such as the World Conference on Transportation Research (WCTR) and the annual meetings of the Transportation Research Board (TRB) in Washington D.C., United States. Also, several disciplines have developed smaller specialized conferences, on specific sub-disciplines or specific modes. For example, rail transport, walking, cycling, or aviation.

In the late 1980s, transport problems were recognized as a European-wide phenomenon, with the growth in international trade, travel and telecommunications (Banister 1991).

*In collaboration with Moshe Givoni, Bart Jourquin, Robin Hickman, Andrew R. Goetz, Imre Keseru, Maria Attard, Edoardo Marcucci, Wafa Elias, Debbie Niemeier, Sandra Melo, Johan Woxenius, Anne Goodchild, Liv Osland, John Östh, Anette Haas, Olivier Bonin, Eric Vaz, Peter Nijkamp, Luca Zamparini, João Romão, Juan Carlos Martin, Aura Reggiani, Ahmed El-Geneidy, Benjamin Büttner, Pierre Zembri, Karen Lucas, Dick Ettema, Tanu Priya Uteng, Michael J. Widener, Luc Wismans, Emmanouil Tranos, Tuuli Toivonen and Elisabeth Mack.

Additionally, the breaking down of barriers within Europe made clear the need for a common transportation research agenda and a mechanism to include researchers from across Europe and from different disciplines. In 1992, the research network 'Network on European Communication and Transport Activities Research' (NECTAR) started as a non-profit and membership-based organization. NECTAR celebrated its 25th anniversary in 2017 in Madrid during its bi-annual conference (Geurs 2018). In the early days of NECTAR, research was significantly influenced by the process of European integration with the Maastricht Treaty in 1992, which also opened many new research questions regarding how the European Union (EU) will allow cross border transport and create new networks. This European perspective is quite clearly coming out of the initial clustering of themes, such as: 'Networks', 'Transport, Communications and Spatial Evolution in Europe', 'Transport, Spatial Opportunities and Borders' and 'Economic Analysis and Transport Policy Processes in Europe'.

The 25th NECTAR anniversary was a good moment to reflect on what changed and what should be the research priorities for the next 25 years. Also, a discussion on a transportation research agenda seems opportune and necessary given current contemporary societal problems such as global warming and rapid technological developments in the transportation field. In the 25 years after the birth of NECTAR, the transport landscape has changed dramatically. Digitalisation and new technologies are changing our travel behaviour and logistics activities.

In this discussion paper, we reflect on what the research agenda for the coming 25 years should be. Over 60 NECTAR members from a variety of disciplines have contributed to this paper. Firstly, we received inputs from 26 NECTAR members who participated in a small survey (distributed to over 200 NECTAR members) in which we asked them to identify research directions likely to emerge in the next 25 years. Secondly, the coordinators of the clusters (four co-chairs per cluster), have discussed future research directions using the survey results as inputs for their discussion. This resulted in a research agenda for the next 25 years. In the remainder of the paper we firstly describe the scope of NECTAR, followed by the history and research agenda of each of the eight clusters, and lastly provide a synthesis and conclusion.

2 The scope of NECTAR

The aim of NECTAR was (and still is) to foster research collaboration and exchange of information in the fields of transport, communication and mobility among European scholars from different disciplines and countries, with particular emphasis on a social science orientation. NECTAR members study the behaviour of individuals, groups and governments within a spatial framework. The NECTAR research community utilizes a wide variety of perspectives to analyse the challenges facing transport and communication, and the impact these challenges have on society at all levels of spatial aggregation.

So far, NECTAR has hosted 15 international conferences and organized over 100 workshops and special sessions around the world. Also, many joint cluster events have been organized on cross-cutting research areas. The clusters have collaborated in hundreds of publications. Over 30 books and special issues in international journals have been published since 1992. In the NECTAR book series, published by Edward Elgar, eight books have been published since 2011 on topics such as 'Transportation and economic development', 'Accessibility, Equity and Efficiency', 'ICT for Transport', 'Smart Transport Networks, 'City Distribution and Urban Freight Transport', and 'Transport, Space and Equity' .

The core of NECTAR consists of thematic and multidisciplinary clusters. The clusters come together frequently in between the larger bi-annual NECTAR conferences and organize workshops and special sessions on specific research themes. The clusters are dynamic in nature, and pursue new emerging research themes. In the NECTAR history, clusters have stopped (only one of the five original clusters is still active), new clusters have been formed and some clusters have shifted their focus.

Currently, NECTAR comprises of 8 clusters: 'Transport Infrastructure Impacts and Evaluation' (Cluster 1), 'Policy and Environment' (Cluster 2), 'Logistics and Freight'

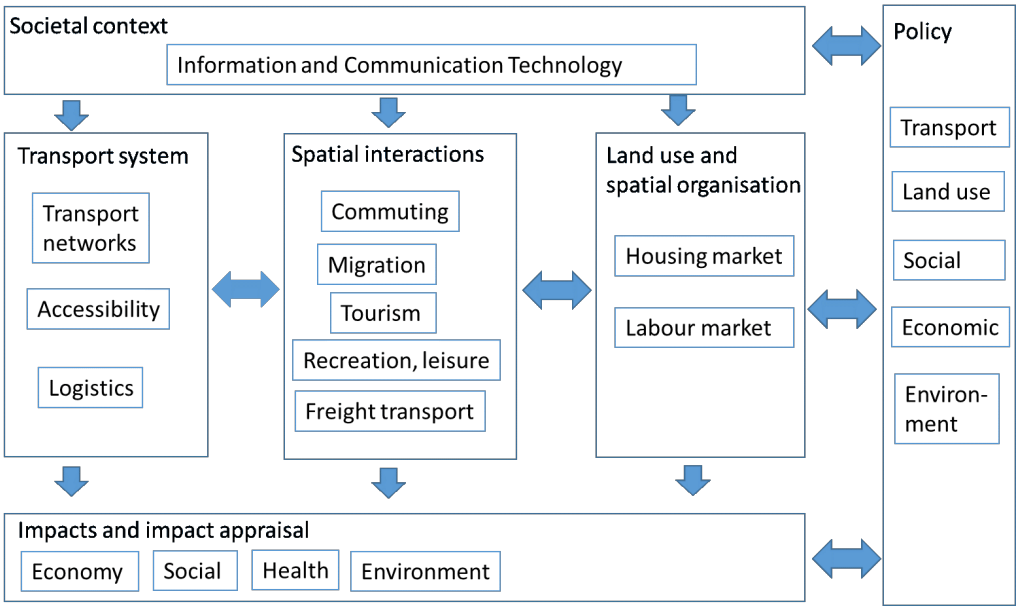

Figure 1: The scope of the NECTAR

(Cluster 3), 'Commuting, Migration, Housing and Labour Markets' (Cluster 4), 'Leisure, Recreation and Tourism' (Cluster 5), 'Accessibility' (Cluster 6), 'Social issues and Health' (Cluster 7) and 'ICT' (Cluster 8). The scope and relationships of the clusters are visualized in Figure 1. The clusters cover the reciprocal relationships between transportation (transport networks, transport and mobility providers, accessibility, logistic operators), spatial interactions (commuting, migration, tourism, freight transport) and land use (housing and labour markets). Moreover, several NECTAR clusters address governance issues and examine the impacts of transportation policies and relevant land-use, social, economic and social policies that influence the transport system, spatial interactions and land use, and their impacts on society (economy, social, health, environment).

3 Transport networks, impacts and evaluation

3.1 History and background of the cluster

The 'Networks' cluster has been active since the start of NECTAR in 1992. As noted in the introduction, research in NECTAR in the early days was very much inspired by the process of European integration allowing cross border transport and creating new networks. Throughout its history, the Networks cluster has organised over 30 workshops and special sessions. The cluster focused on the analysis and evaluation of complex transport networks, including air transport. In more recent years, emphasis is put on the social impacts of infrastructure and methodologies to assess it. In 2017, the title of the cluster changed to 'Transport Infrastructure Impacts and Evaluation'. The new title better suits the scope of research issues discussed in recent meetings and publications, such as macro level impacts such as the wider economic impacts of transport networks (Bråthen, Givoni 2017) and micro level impacts such as social inequity. Recent years saw research activities dedicated to more specific issues like: 'Exploring equity issues of ICTs for transport networks' (Thomopoulos et al. 2015); 'A future for Walking and Cycling networks'; 'Efficient European multimodal networks'; 'Smart transport network investments and smart outcomes?', and 'Enhancing network efficiency: air transport and sustainability' (Miyoshi et al. 2018). Moreover, the wide range of spatial and social equity impacts of transport systems has been explored by the cluster (Hickman et al. 2019).

3.2 A research agenda

A broader evaluation approach

Future research is needed to widen the scope of current transport policy development and project appraisal approaches. Travel time is central to our understanding of transport, and to analysis and decision making in the transport sector. Currently, transport planning is based on the rationale that all travel is 'wasteful' and travel time ought to be minimised. This is complemented by the argument that greater choice between activities at alternative destination options is beneficial. Hence, a better transport system is one that provides a wider range of destinations that can be reached in the time available to any individual. The inevitable consequence of this thinking is to promote speed as the primary objective of transport systems with a view to 'saving time' (Banister 2011). This leads to longer travel distances, has distributional outcomes (greater inequality), and results in greater use of resources, as higher speed increases energy consumption and carbon emissions. Banister et al. (2019) introduce the concept of reasonable travel time defined as the door-to-door journey time that is acceptable to the individual traveller for reaching a particular destination, and its associated activities, given the conditions provided to turn 'lost time' into 'useful time' while travelling. This means prioritising more than just travel time and speed. It can be argued that as a general rule, improving the journey experience would be an easier and cheaper means to achieve this, as compared with reducing the door-to-door travel time. Turning into the assessment of impacts, clearly this must move beyond the focus on travel time savings, to consider other various social, environmental and economic impacts and importantly the spatial impacts of (investment in) transport infrastructure, development impacts in particular, and at all spatial levels.

In this regard, the Capability Approach (Beyazit 2011) offers a new type of 'impacts' that transport infrastructure contribute to and related impacts on Mobility and Mobility Capital (Shliselberg, Givoni 2018). A different set of impacts, some of which are new, requires the development of different, new or modified, evaluation tools. The main questions here will be if measurement is possible and if so, then how to measure, and can (should) the impact be quantified and/or 'monetized'? The shifting focus in urban transport planning to walking and cycling infrastructure, which are considered 'small' compared to motorized transport infrastructure likewise require a new evaluation approach, that of so-called 'small' projects.

Digitalisation, technology and mobility services

The complexity of multimodal transport network analysis is growing as the landscape of European urban transport networks is becoming increasingly varied with the emergence of shared mobility services such as bike sharing, car sharing and ride sharing. While technology that enable automated vehicles will be transformative, it is undeniable as well that the shift from transportation systems to both Mobility as a Service (MaaS) and the sharing economy are equally transformative. Such shifts may well have deeper impacts on accessibility. The traditional dichotomy between private transportation (automobile in particular), and public transportation is quickly becoming irrelevant. Ride hailing services (UBER, LYFT, Bla-Bla-Car, etc.) as well as dockless (e-)bikes and personal light electric vehicles (PLEV), such as e-scooters, are creating a new geography that is less impeded by fixities. Research is needed to analyse and quantify the network implications and the societal impacts of these new transport modes, in particular for equity, social inclusion, and traffic safety.

Uncertainty in transport planning and network design

In a number of spheres of policy, it appears uncertainty has intensified in the face of globalisation, economic instability, climate change, technological innovation and changing consumer preferences (Lyons, Davidson 2016). There is growing interest in, and use of, techniques that can help decision making processes where deep uncertainty is involved. The 'deep uncertainty' that exist with respect to future mobility practices (see for example Givoni, Perl 2017) means also that such infrastructure must be 'flexible' to

become 'adaptive' (Haasnoot et al. 2013). Lyons, Davidson (2016) advocate a stronger orientation towards regime-testing. Through regime-testing, our understanding of the nature of the world is challenged and uncertainty is treated as an opportunity to shape the future.

4 Commuting, migration, housing and labour markets

4.1 History and background of the cluster

An important focus throughout the history of NECTAR is related to transport and spatial interactions. The NECTAR cluster 'Commuting, Migration, Housing and Labour Markets' has, since its inception, focused on topics related to commuting, migration, housing and labour markets. These topics are fundamental for the functioning of the economy and for the everyday life of many people. Haas, Osland (2014) summarise the complex relationships between commuting, migration and the housing and labour markets in an editorial of a special issue with NECTAR workshop papers in the journal of Urban Studies. In order to obtain an efficient labour market, workers should locate and relocate to where the relevant jobs are to be found. From an economic point of view, commuting and migration are essential elements for obtaining a well-functioning labour market. Finally, housing is a basic good and for many people rents or loan repayments make up a relatively large proportion of their overall budget. Due to its central role during the financial and economic crisis starting in 2007-2008, it has become clear that housing prices are important for the development of the overall economy in many countries (e.g. see Zabel 2012). Moreover, across the globe and especially in Europe, migration flows challenge regional labour and housing markets. The cluster encompasses theoretical and empirical research that focuses on analyses that increase the understanding of these linked topics, methodologically as well as for policy implications.

4.2 A research agenda

The past activities of the cluster 'Commuting, Migration, Housing and Labour Markets' has mainly focused on the complex interactions between housing and labour markets, and on patterns of migration and commuting. We believe this will also be an important research focus in the future. This focus is also echoed by the responses of the survey among NECTAR members. The overall umbrella of the research of this cluster will be the links between the various spatial interactions and different facets of sustainability, including environment, affordability, integration, participation, efficiency and fairness. Some new research directions will be pursued given a range of structural and demographic changes in the economy, while maintaining the continuum of previous research directions. These new research direction are described below.

Inequalities in the labour and housing markets

The issue of inequality has been studied for many years but regional issues of inequality will be a major topic in the future. There are growing spatial disparities in housing and labour markets in centrally versus less centrally located areas. Also, a relevant research topic is inequality in accessibility to jobs for various groups of people living in different types of regions, in particular for migrants. Research should consider differences in gender, age, socioeconomic status, culture, education and their associated occupational challenges and developments. Research questions include how specific groups can manage to change their unemployment status and what is the best way (route) out of unemployment for the various groups? Also, links between accessibility, technological advances, (affordable) housing, density, and the overall environment in urban areas need to be addressed.

Advanced spatial interaction and matching analysis

Research on commuting and migration in relation to labour and housing markets will also in the next decades need to be spatially oriented, because economic and social development happens most of all as a function of proximity. Research will need to remain

focused on spatial interactions, spatial linkages, distances, and spatial matching – both with regards to housing and labour markets. In future research, a place-based life-cycle perspective will be relevant and the focus will increasingly be on various age groups. Focus will especially be placed on the older generations, given the demographic development in many European countries. The advances in geo-computation and growing availability of high resolution spatial data (big data, and combinations of spatial approaches over time) will provide new research opportunities. Big data, machine learning algorithms and geo-referenced databases will likely become more important to study commuting, migration, labour and housing markets.

Digitalisation, commuting and labour market

Studying commuting is increasing in importance in the digital age, in particular the effects of digitalisation on firms, employees and their mobility patterns. Milakis et al. (2017, 2018) state that automated vehicles could have significant implications for cities and transport systems ranging from first order (e.g., traffic, commuting, travel demand), second-order (e.g. vehicle ownership and sharing, location choices and land use, labour and housing markets) to third-order (energy consumption, air pollution, safety, social equity, economy and public health) effects. All of these implications are highly uncertain and are important research topics. Furthermore, the shift from transportation systems to both MaaS and the sharing economy, will also impact vehicle ownership, parking demand, and the need for parking supply in cities. Furthermore, in many developed countries digitalisation has changed the labour market. The Netherlands, for example, have seen a very rapid increase in the number of solo self-employed (solopreneurs) over the last decades which has led to an increase in the demand for flexible work spaces and reduces inner-city car traffic, as most Dutch solopreneurs travel to work by bike or public transport. Self-employed workers are likely to have distinctive travel behaviour because, compared to employees, they have greater autonomy over work scheduling and are less affected by imperfect information about the labour market (Shin 2019). Studies in the United States suggest that self-employed commuters have a shorter commuting distance and time than their 'traditional' employee counterparts. However, this seems to be offset by increased travel distance and time for other work-related and non-work purposes (Shin 2019).

5 Transport, leisure, recreation and tourism

5.1 History and background of the cluster

An emerging research theme which was recently recognized within NECTAR was transportation, communication and mobility in relation to leisure, tourism and recreation. The cluster on 'Leisure, recreation and tourism' started in 2016. The research theme of this cluster is truly multi- and interdisciplinary. Research on leisure, tourism and recreation is booming in many disciplines: economics, sociology, psychology, management sciences, and environmental sciences among others. Transport constitutes a crucial yet understudied element in tourism, since it connects tourists from their origin to their destination, it creates the conditions for mobility within destinations, or to travel to secondary destinations. Moreover, in some cases, transport can be seen as a core component of the tourism experience in itself (e.g. scenic railways and buses). The interactions between transport, leisure, recreation and tourism are growing in importance as also tourism is one of the fastest growing economic sectors. Jointly, travel and tourism currently account for almost 10% of world GDP, when direct, indirect and induced effects are considered (WTTC 2014). Moreover, the increase in leisure time in many countries has constituted one of the most remarkable trends in the last decades matched by a decrease in working hours (OECD 2009). Consequently, a large amount of the travel behavior and demand is increasingly determined by ecological, social and entertainment motives (discretionary time consumption).

5.2 A research agenda

Research in this field should focus on sustainable tourism development and management, taking into consideration contemporary societal problems, such as climate change and the limits of non-renewable sources of energy. Several core and interrelated problems require research along different lines.

Sustainable tourism development

Attention to the impact of tourism on the environment, and climate change in particular, is growing since the 2000s. Research interest on climate change and tourism has increased from, on average, only 0.9% of all publications in the tourism domain in the 1990s to 2.6% in the 2000s and up to 3.4% in the 2010-2016 period (Peeters 2017). Given the current growth in tourism and the absence of interventions to reduce its climate impact, the tourism sector is likely to render the Paris (2015) climate targets unachievable. The tourism sector has pledged to reduce its greenhouse-gas (GHG) emissions, specifically 70% by 2050. However, current emission trends in the tourism sector will result in a tripling in the same timeframe (Gössling, Scott 2018). The reduction of GHGs from aviation are a crucial element to develop a credible mitigation strategy. Analysis of the environmental pressure of day-visitors and tourists to Amsterdam for example showed that long-haul tourists accounted for less than 25% of tourism revenues but were responsible for 70% of the environmental footprint of inbound tourism to Amsterdam (Peeters, Schouten 2006). For the next decades, analysis of economic efficiency (the cost competitiveness of a destination and ensuring access to a destination) and sustainable tourism development (environmental and landscape impacts) will be an important research field.

Advanced multi-scale governance analysis

Sustainable tourism development is complex as it requires institutional coordination across different territorial scales. There is a complementarity of scales between international (for mobility between origin and destination), national (for mobility between origin and destination or between the primary and secondary destinations), regional (for mobility between the primary and secondary destinations) and local (for mobility within the destination) transport services and networks. Moreover, there are many different stakeholders in different sectors (transport service providers and regulators, tourism service providers, regulators and management organizations). Romão et al. (2018) note that coordination between tourism transport services within the local territorial scale of the destination can already be problematic regarding issues such as pricing, route planning or possible conflicts between the demand of tourists for transport services to specific locations within the cities and the daily needs of the resident population. Contemporary developments in transport infrastructures (mostly in less developed countries) in the context of strong tourism development (in particular in urban areas) justify increasing efforts in research and planning.

Digitalisation and Information, Communication and Telecommunications (ICTs)

ICTs are increasingly important in order to match supply and demand of tourism services, in both space and time (e.g. Romão et al. 2015). On the other hand, increasing mediatisation and interactivity related to the development of social networks reinforce the importance of tourists as co-creators of destination images. As sustainability is a key issue for the creation of the image of contemporary tourism destinations, sustainable transport services and networks are crucially important for ecological protection and economic efficiency, but also for the image and differentiation of each destination. Moreover, ICT and digitalization also exert a deep impact on the renovation of ticketing services for transport, increasing flexibility and supporting the complementarity between different types of transports in a context of inter-modality. Thus, the deep impacts of ICT and digitalization on the provision and utilization of both tourism and transport services will offer a wide field of research opportunities in the future.

Advanced tourism data metrics and analysis

The present advances in geo-computation and spatial analysis further enhance the potential of understanding socio-economic dynamics at regional level, given the existence of large digital data sets (GPS, mobile applications, social media). In regards to these data sets, complex system analysis brings together a unique opportunity for enabling an adaptive spatial vision for tourism, leisure and recreation, as exemplified by Raun et al. (2016). Quantitative and qualitative methods may be used and intertwined with Geographic Information Systems and Science. In particular, for enhancing the understanding of the limits of carrying capacity as well as the vulnerability of fragile regions of the future. Advanced tourism data metrics and analysis become a key part of modern tourism and recreation research. Furthermore, from a statistical and modelling perspective, we observe an increasing use of (physical and virtual) network analysis, spatial autocorrelation models, econometric models, agent-based models, structural equations models, and multicriteria and benchmark studies. The increasing availability of adequate datasets as well as the development of more sophisticated user-friendly computation methods and tools will ensure that research in this broad field will tend to be even more important in the future.

6 Logistics and freight transport

6.1 History and background of the cluster

The demand for freight transport is still increasing with a fast pace. The underlying trends for this are that on the one hand of the supply chain is globalization and on the other hand there is a fragmentation of flows due to e-commerce, nanostores and just-in-time deliveries. This increase in freight transport demand poses serious questions in terms of sustainability. How can we get towards a sustainable and zero-emission deliveries of goods? In 2001, the cluster 'Logistics and Freight' started. In the early years of the cluster's research, intermodal transport was its focus (Macharis, Marcucci 2004, Caris et al. 2013). The cluster further evolved along the line of the supply chain, and in recent years focused attention on 'the last mile' and city logistics. The cluster's activities were the last ten years dedicated to more specific themes like sustainable logistics (Macharis et al. 2014), multi-perspective analysis on city distribution and urban freight transport (Macharis, Melo 2011), and the role of planning towards sustainable urban mobility (Brůhová Foltýnová et al. 2018).

6.2 A research agenda

Looking forward, two main topics are clear from the survey responses: the pressure from online shopping and the integration between freight and passenger transport. Both topics are explained below.

Digitalisation and supply chains

Digitalisation has drastically changed the traditional supply chains. The role of retailers becomes unclear and the pressure to allow for online sales options is enormous but often not implementable in a profitable way due to the increased logistics costs. For all actors it is important to implement more sustainable solutions. According to the respondents of the survey, several innovative solutions to consider are smart city logistics, drones, and autonomous vehicles. This change in supply chain characteristics will also have an impact on the location patterns of commercial establishments which needs to be researched more closely.

Integration of freight and passenger transport

Some respondents pointed to the possibilities of integrating passenger and freight transport (Arvidsson et al. 2016). This can be done in several ways. First, it can mean that facilities for passenger transport could also be used for goods: night use of parking for last mile deliveries, transport interchanges, etc. Parking and relationships between urban freight

and land use patterns should be analysed more closely. Next, it can also mean that the crowd, people like you and I will be used for crowd logistics and shipping. Recent research showed that crowd logistics is not sustainable if it is done by private cars (Buldeo Rai et al. 2017). Instead, public transport-based crowdshipping, in which only public transport or walking is allowed to bring the parcels to the end destination, represents an environmentally friendly and acceptable solution (Gatta et al. 2019, Serafini et al. 2018). Possibilities to bundle and use public transport, bike or walk should be incorporated in the concept but new types of employment raise social issues (Dablanc et al. 2017). Thirdly, it was pointed out that this integration between passenger and freight transport should be done as well at the governance level, as often freight and passenger transport is treated by different departments. Recent research showed that collaborative governance models, based on a proactive and effective stakeholders' cooperation, produce positive effects on both the environmental and service performance (Macharis et al. 2019, Marcucci et al. 2017a). Of course, attention should still be put on green logistics and more efficient freight transport. For the maritime transport, the last mile, and everything in between – it is important to have better monitoring tools of emissions and external costs. Possibilities for more sustainable solutions should be researched. The definition, implementation and up-take of effective solutions is not an easy task and there is a need for specific assessment methods.

Diffused and standardised logistic protocols

If the future of freight transport is heading towards sharing and collaboration, or even the physical internet in which information on the resources from the logistics sector would be shared in order to use the available capacity fully, protocols should be standardised. Still a lot of discussion and more fact-based evidence has to be collected for advancing knowledge on the gains and gain sharing of collective systems. Next to (ICT) technology, we will need more research on the behavioural aspect of all actors in the logistic chain, including the consumer. How is behaviour changed and what is driving this behaviour? Moreover, it is important to predict future behaviour (Marcucci, Gatta 2016) and how to stimulate behaviour change (e.g. gamification, Marcucci et al. 2018).

7 Accessibility

7.1 History and background of the cluster

It is well known that the definition of accessibility originates from Hansen (1959) as 'the potential of opportunities for interaction'. Geurs, van Wee (2004) extend this definition contending that the accessibility analysis should be based on four main components: (1) land-use; (2) the transportation system; (3) the temporal or time dimension; and (4) the individual or segmentation analysis. Geurs and van Wee extend the what (opportunities) and the how (interaction) with the when (time) and the who. There are many different approaches to measuring accessibility. The measures and methods are categorized by Martín, Reggiani (2007) into six different categories: (1) potential of opportunities; (2) physical measures; (3) expected utility; (4) inverse function of competition; (5) joint accessibility; and (6) dynamic accessibility.

The cluster 'Accessibility' started in 2008 and has become a leading group of accessibility researchers. Since the seminal workshop, 19 cluster events have been organized, and special issues and books have been organized on accessibility modelling (Martín, van Wee 2011, Reggiani, Martín 2011, Geurs et al. 2015), accessibility and planning of urban settlements (De Montis, Reggiani 2013), the impact of accessibility on social and economic activities (De Montis, Reggiani 2012), accessibility and spatial interactions (Condeço-Melhorado et al. 2015), the measurement of transport impedances in accessibility analysis (Geurs, Östh 2016), accessibility, transport planning and policy making (Geurs et al. 2012, Condeço-Melhorado, Geurs 2017) and linkages between accessibility, equity and efficiency (Geurs et al. 2016).

7.2 A research agenda

Use of big data for accessibility analysis

From the survey responses and recent cluster meetings it is clear that the trend that has been unfolding for the last three years on the use of big data for accessibility analysis is amplifying and quickly becoming part of the standard approaches for accessibility analysis and practice. ICT technologies, in the form of GPS, smartphones, credit cards, transport smart cards, social media posts, and new mobility service providers, generate a large amount of geo-located data as a valuable input for accessibility analysis. Nevertheless, Condeço-Melhorado et al. (2018) contend that despite big data already being available, its use in accessibility analysis is still in its infancy. In addition, they argue that theory on accessibility might be revisited in the light of the fast dynamics of big data and related micro-behavioural patterns.

New methodological approaches for accessibility measurement

Other type of responses focus more on new methodological approaches that extend the applicability of accessibility analysis to other fields. Of particular interest are the differences observed for some territories of the decay friction parameter (Östh et al. 2014). In this respect, the debate is still open regarding whether these differences are more based on the preferences of the citizens or on the constraints of the transport system and land use. Another interesting extension is that of the measurement of spatial spillovers (Gutiérrez et al. 2010). It is well known that transport investments affect not only the life of the residents and tax-payers but also tourists and other economic stakeholders. Therefore, it is important to take into account that transport investment can be suboptimal if these externalities are not considered in a cost-benefit analysis.

Accessibility, resilience, vulnerability and social capital

Other interesting extensions are related to the analysis of resilience, vulnerability and even social capital (García-Palomares et al. 2018, Östh et al. 2018a,b, Taylor 2017). These extensions deal with the spatial distribution of some components of accessibility measures and the relationship with the pivotal issues raised by the new fields included in the extensions. According to Caschili et al. (2015), the concepts of resilience, vulnerability, criticality and connectivity are all intertwined. Östh et al. (2018a) use other concepts to explain how spatial systems exhibit complex patterns of socio-economic development, such as (un)employment, income, mobility, ethnic composition, and urbanisation rates. They show that the resilience of spatial systems is co-determined by factors such as market proximity, land use, transport systems and socio-economic population composition.

Digitalisation, technology and mobility services

Technological developments towards autonomous vehicles and of the sharing economy/mobility as a service (MaaS) can have profound impacts on accessibility. Milakis et al. (2018) find three viewpoints in a group of accessibility experts analysing the impacts of autonomous vehicles in the four accessibility components. Viewpoint A expects that accessibility benefits stemming from autonomous vehicles will be highly uncertain, mainly because of induced travel demand that will likely cancel out travel time and cost savings in the long term. Viewpoint B anticipates that accessibility changes because of autonomous vehicles will have two opposing implications for urban form: densification of city centre and further urban sprawl. Finally, viewpoint C expects that those who can afford an autonomous vehicle will mainly enjoy its benefits, thus autonomous vehicles will have more negative than positive implications for social equity. Urban spaces may potentially become more frictionless and less centered on transportation nodes and links. In the decades to come, digitalisation and technological developments towards autonomous and shared mobility is expected to be an important research topic to study, notably quantifying accessibility and societal implications. As noted in Section 4.2, these technological

developments could have significant first, second and third order impacts on cities and transport systems and thus accessibility.

Affordability and equity issues that affect the normative pillar of the accessibility analysis

The normative pillar of the accessibility analysis regarding considerations of equity, social inclusion, inclusive urban development and transport mode preferences should leave their ideological trenches. More studies are needed to better understand the policy implications of transportation programs on specific groups, such as seniors or the unemployed. In this strand of literature, Guzman, Oviedo (2018) contend that it is necessary to use metrics that can reflect the moral dimension of inequality to assess redistributive policies that can alleviate the needs of some specific and targeted social groups which are currently worse-off.

8 Transport and ICT

8.1 8.1 History and background of the cluster

The technological changes related to ICTs have created new challenges for transportation research, the nature of which requires cross-disciplinary approaches. The NECTAR cluster 'ICT', which started in 2014, addresses these multifaceted impacts of ICT. The cluster addresses these challenges by bringing together researchers with an interest in the implications of ICT on urban and transport networks as well as in the use of big data sources for urban and transport analysis and modelling. The cluster has so far organised 4 workshops and special sessions, a common denominator was incorporating new sources of big data and using dedicated ICT applications for transport analysis (Wismans et al. 2018, Tranos, Mack 2018). The focus on this area reflected the urge of researchers to take advantage of the new opportunities that the recent abundance of data has created to better understand transportation.

8.2 A research agenda

ICTs have had and still have a transformative impact on transport systems, mobility and spatial-economic developments. ICTs directly affect space, the economy and travel behaviour by dramatically changing transaction and transportation costs. ICT developments drive the development of the emerging mobility services such as bike sharing, ride sharing, technological developments towards connected and autonomous vehicles.

Big data and transportation research

At the same time, ICTs are changing transportation research. The digital revolution has generated an abundance of digitally collected bottom-up data, the utilization of which in spatial and transport analysis has just begun. The breadth of such sources, which include anything from online social networks to passive and active crowd sourcing data, has the potential to assist researchers in better understanding spatial phenomena: from commuting to car speed analysis. More and more transport researchers are utilising such data sources, which are becoming part of the mainstream toolkit for transport analysis. A common trend is visible, demonstrating that even if traditional data is better and more reliable for the end-user, an increasing number of end-users require non-traditional data (from lower quality data sources) due to cost efficiency and data collection speed. This has resulted in the rapid development of methods and tools for transport analysis in two major streams. The first uses high level data to gain a better understanding of (aggregated) mobility patterns (e.g. using mobile phone data). The second stream makes use of dedicated applications for individual travel patterns (e.g. smart phone applications) (Wismans et al. 2018). Digital technologies are here to stay and the challenges they impose will not vanish. Thus, research will be needed to further combine and integrate data sources to allow for consistent travel behaviour knowledge on individuals as well as at aggregated levels.

Technological innovations and privacy, safety, equity and public health

The survey and cluster meetings indicate a need for research on autonomous vehicles, ethics, privacy issues, and public health. The changes that are about to take place in the transportation sector and the current innovations, including big data analytics and driverless vehicles, create new opportunities for discovering the balance between ethics/responsibility and costs/benefits. For example, current innovations can be used to help determine liability in accidents, streamline insurance pricing, motivate better driving practices, and improve safety. Yet, current innovations also give rise to new concerns about privacy, safety, equity and public health. Autonomous vehicles have implications for many public health issues beyond their potential to improve safety. These range from concerns about increasing automobile use and reduced use of healthier alternatives (e.g. biking, walking) to concerns that over-emphasizing autonomous vehicles may reduce public transport usages and divert funding from efforts to improve public transport (Schroll 2015, Milakis et al. 2017, Milakis 2019).

As noted in Section 4.2, technological developments have the capacity to directly affect transportation systems and there are possible second and third order effects on land use and spatial development, public health, etc. This increases the need for cross-disciplinary approaches, which can help tackle both the conceptual and methodological complexities. This is essential in order for the next 25 years of transport research to be even more informative than the previous 25.

9 Policy and the environment

9.1 History and background of the cluster

The cluster 'Policy and Environment' has been created in 2006 and focuses on analyzing, forecasting, measuring and discussing transport policy and its direct and indirect impacts on the environment. The cluster has organized 8 workshops on a variety of topics, including transport pricing, regulating of transport infrastructures and services, transitions towards sustainable mobility, modelling of the adoption of electric vehicles and inequalities in environmental quality. In recent years, the work of the cluster has focused on the role of instruments, individuals and institutions in the transition towards sustainable mobility (Geerlings et al. 2012) and the role of planning towards sustainable urban mobility (Brůhová Foltýnová et al. 2018).

9.2 A research agenda

Issues raised in the survey among NECTAR members and in discussions with the 'Policy and Environment' cluster were the following: firstly, the strong links between transport policy, the environment, equity and climate change; secondly, the role of stakeholder engagement in policy making; and thirdly the governance implications of technological development such as autonomous vehicles.

Transport policy, equity and climate change

The link between transport policy and environmental impact can be operationalized by correlating it directly to climate change. The inter-relationships between transport, the environment, and equity also signal the importance of understanding and improving governance. Advancing our understanding of the relationships between policymaking and environmental issues will be important to develop innovative methods and models capable of tackling the complexity of freight and passenger transport planning. Technology will play an important role in further progress toward meeting climate change goals and supporting policy. However, when it comes to transport, there has been much debate but little real action over issues of climate change, and the contribution of the transport sector to climate change is likely to increase both in relative and absolute terms. Without policy or regulation changes, transport emissions are forecasted to double over the next 30 years (IEA/OECD 2009). In addition to technological developments, there is a need to reduce levels of mobility, at least in the richer countries, and in particular air travel.

This requires new levels of coordination between all agencies and strong citizen support (Banister 2018). In addition to climate mitigation, governments and industries also need to invest in climate adaptation measures and policies to improve the resilience of transport systems.

Technology in general and digitalisation in particular have had a profound impact on economies all-around the world and this will change how people interact with one another, how they work, how they travel, and how they shop. At the same time, there is a need to reduce GHG emissions and regional/local growth in motorized transport. Concentrating on digitalized services connected to groceries is relevant and important. Research shows that online grocery stores can reduce up to 50% of their GHG emissions if service quality, monetary and environmental costs are included in vehicle routing decisions (Wygonik, Goodchild 2011). The success or failure of climate policies will depend on local government's approach to transport and land use. The examples of e-groceries and autonomous vehicles are illustrative of the complexity embedded in the social phenomena linked to, and influenced by, transport related choices and policies. This field of investigation calls for a research effort based on multi- and interdisciplinary approach focusing on the following main pillars: (1) decision-making process, (2) stakeholder engagement, (3) socio-technical analysis, (4) socio-behavioral analysis, (5) governance, (6) equity, and (7) safety.

Digitalisation, technological development and policy making

Technological innovations will have a strong effect on how vehicles are operated, owned or rented, and consequently on the environment. However, as noted in Section 3.2 there is huge uncertainty in the impacts of these innovations and there is need for tools and techniques that can help decision making processes where deep uncertainty is involved. Understanding the relationship between policy-making investigations, environmental consequences, and equity effects will be crucial. Furthermore, the role of government is changing with the digitalisation of society.

The emergence of shared mobility operators might be disruptive to public transport services that are heavily regulated by governments and transport authorities. In the past years, authorities have reacted in very different ways to Uber's tenacious and highly competitive approach to building (and destroying) markets. Cohen (2018) concludes that authorities need to form a clear understanding of the possible impacts of new mobility operators on the communities they serve. What makes Uber significant for transport authorities is that it is an aggressive competitor which, through its massive private-equity backing and business model of operating at a financial loss, it is able to undercut the conventional private-hire/taxi market in numerous locations causing Uber's rapid expansion (Cohen 2018).

Political acceptability is integral when considering the feasibility of implementing transport policies and their related issues as described above. This implies not only ensuring that the policies implemented produce net benefits to society, but also duly considering distributional effects that, among other issues, depend on the innovative and inclusive policymaking protocols developed. This complex and articulated process should rest on a deep and theoretically sound reflection. This process requires considering market structure, regulation, use of supporting/deterring policies (e.g. environmental taxes, tolls and subsidies), and complemented by new and innovative measures (e.g. cash-out policies, Evangelinos et al. 2018; off-hour deliveries, Marcucci, Gatta 2017; crowdshipping, Marcucci et al. 2017b).

Stakeholder engagement, transport modelling and decision making

Methodologically, recent trends testify to the usefulness of integrating discrete choice models and agent-based models. Such integration overcomes their respective limits and provides a thorough socio-behavioral analysis, accounting for stakeholder preferences and their interaction with respect to innovative policies (Marcucci et al. 2017c). We believe that stakeholders' acceptance of innovative transport policies will be crucial, since they are those who bear the consequences of the decisions made (Gatta, Marcucci 2014).

Even if public participation is considered important for the success of a decision-making process, in general it is not well-structured and there is a lack of methods to support group decision-making that can guide stakeholders' involvement towards thoroughly considered decisions (Le Pira et al. 2017). The gap of knowledge between methods used for technical/economic evaluation and those exploited to support stakeholder engagement is significant. Future research should deal with innovative methods and procedures that can be used for participatory decision-support systems and stakeholder analysis, both in passenger and freight transport planning. Stakeholders' reception, based on robust methods, such as stated preference analyses, represent an important building block for providing decision-makers with useful tools (Gatta, Marcucci 2016, Gatta et al. 2017, Valeri et al. 2016).

10 Social and health issues in transport

10.1 History and background of the cluster

The cluster 'Social and Health Issues' was established in Madrid, at the 2017 NECTAR conference with the remit to recognize the increasing importance of social and health inequalities arising from the transportation domain. The focus of the cluster is on emerging social research and health methodologies. The aim is to consider both the Global North and Global South as well as their inter-connections. Many disciplines engage in this broad topic area, bringing with them their own concepts, theories, methodologies and policy concerns. The aim is to draw together these disparate discourses to create opportunities for discussion, knowledge exchange, and co-production of new research in this area.

The research interests of the cluster can be categorized into three broad themes.

1. The impacts of transport systems and policies on social and health inequalities.
2. Inequalities in transport and health for socially vulnerable groups including, but not limited to, older adults, younger people, low-income population, and refugees.
3. Inequalities in access to services and activity centres as it relates to well-being and quality of life.

The cluster also aims to collaborate in the promotion of new and hybrid methodologies to identify and evaluate these broad issues and their interrelatedness.

10.2 A research agenda

The impacts of transport systems and policies on social and health inequalities

Strong links exist between social disadvantage, transport poverty, and health inequities, but these interconnections remain understudied, hidden and unacknowledged (Widener, Hatzopoulou 2016). In the same spirit, both the design and implementation of transport projects have largely been treated as isolated projects in the technical/technocratic domains. These systems have had huge social and health impacts, which are poorly understood and most often completely ignored in urban-transport planning exercises. For example, questions pertaining to exposure to air pollutants – when do they matter, which kinds are important for whom, and how does transport moderate their impacts? – need further investigation.

Inequalities in transport and health for socially vulnerable groups

For transport researchers and policy makers engaged in establishing agendas for sustainable transport planning, the 'social' dimensions of transport systems are much less well understood and articulated than economic and environmental factors. To a certain extent, the social and well-being dimension is being discussed in the Global North (Ettema et al. 2010), but this discussion is either completely absent or in its nascent stages in the Global South (see Priya Uteng, Lucas 2017). This gap is exemplified by various international development agencies that have insisted on including social impact assessments but often

fall short of providing coherent assessments. Thus, distributional impacts end up as checklist items in the toolkits approach. Though Vanclay (2002) highlighted this issue in 2002, still social appraisals are tick-box, standalone exercises conducted after the standard economic cost benefit analysis (CBA) has been completed.

Inequalities in access to services and activity centres as it relates to well-being and quality of life

While there is some overlap with the cluster on Accessibility, studies documenting access and accessibility to places and activities that promote quality of life and health are a key component to understanding the links between transportation and social and health inequalities. The core issue is that spatial systems interact with the accessibility afforded to them to create complex patterns of socioeconomic development, thereby either exacerbating or ameliorating access to opportunities (Farber et al. 2018, Östh et al. 2018a). These deviations often get expressed in terms of access to livelihood, health, education, and other opportunities that directly impact quality of life, well-being, and health. Inequalities in access should be studied for different demographic groups – young, elderly, children, women, disabled, as well as their interplay. Additionally, researchers should examine the ways different development sectors (health, education, employment, welfare, etc.) are accessed individually, and in concert with each other.

Promotion of new and hybrid methodologies

The transportation sector is at a pivotal junction in terms of both availability of 'new' kinds of data, and detailing these datasets in terms of their granularity and precision. This junction offers a chance to rectify the mistakes of focussing on aggregated results alone, at the cost of neglecting differences among demographic and social groups. There is a strong need for a robust approach to fuse disaggregated data collection and analyses based on social and health outcomes in the standard models like land use transport interaction models (LUTI), standard transport models, environmental impact assessments, etc. Further, the upcoming methods for designing integrated multimodal transport solutions have been found to be non-inclusive. New and hybrid methodologies to assess the 'inclusivity' of these solutions needs to be promoted.

11 Conclusions and synthesis

Our mobility system is changing rapidly. We are at the crossroad of major changes in the way we travel and deliver goods. Research agendas are adapting to this changed environment with new challenges and opportunities. In this paper we brought these research agendas together structured along the clusters of the NECTAR network. This resulted in bringing together the knowledge of many experts from Europe and beyond.

Many of the research topics described by the clusters are also linked to research topics which are related to other NECTAR clusters, which highlights growing complexity and growing need for multi- and interdisciplinary transportation research. In summary, there are three topics that will influence research in most of the clusters in the decades to come.

Firstly, sustainability needs to be addressed in its full meaning, including relationships between policy-making, environmental impacts, and equity effects. In particular, when it comes to transport, there has been much debate but little real action over issues of climate change, and the contribution of the transport sector to climate change is forecasted to increase both in relative and absolute terms.

Secondly, ICTs and digitalisation, the development of (shared) autonomous vehicles and shared mobility are topics that will be addressed by most of the clusters as they have a profound impact on global economies. These developments will change how people interact with one another, how they work, how they travel, and how they shop. It will also have a strong impact on how vehicles are operated, owned/rented, and consequently on the environment. Also, policy-making is about to undergo a paradigm shift linked to the driverless and shared mobility revolution. This raises major research issues related to the

governance of technological innovations as well as stakeholder and end-user involvements to achieve inclusive and equitable transport systems.

Thirdly, the advances in geo-computation and growing availability of high resolution spatial and transportation data generates many new research opportunities for theoretical, methodological and applied research. Specifically, research areas include the reciprocal relationships between transport systems, spatial interactions (including commuting, migration, tourism and freight transport) and land use as well as its impacts on society. However, at the same time there are challenges related to privacy as well as practicing open and reproducible research and development. Traditional and newly developing travel models will need be scrutinized for how they can ethically and responsibly harness the increasingly available big data sources.

Will these research lines be followed for the next 25 years? Probably not. We are only seeing some of the changes that are occurring. As researchers we will have to be open and keep track of further changes. Over the past 25 years NECTAR has been an active and productive network and will continue, in the decades to come, discussing these new research opportunities in an interdisciplinary and focused way. We warmly invite everyone to reflect and comment on this research agenda and join the discussions on the future of transportation research. Feel welcome to join any of the upcoming NECTAR events!

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