Customer-centered knowledge management: challenges and implications for knowledge-based innovation in the public transport sector

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Abstract

Purpose – *This study aims to explore the role of knowledge management practices in supporting current and emerging passengers' and customer needs, aiming to create value. Specifically, the research examines the importance of customer-centred knowledge management in the delivery of innovative services and practices in the public transport sector, promoting the role of interactions between mobility stakeholders and travellers.*

Design/methodology/approach – *A theoretical framework is developed and supported by the background literature on customer-centric knowledge management approaches, business model innovation, as well as on inter-organisational and network co-operations.*

Findings – *Results show that the development of sustainable innovation and technologies in the transport sector requires knowledge management practices, which enable the access to knowledge about users' needs, the mapping and evaluation of innovative knowledge, the promotion of knowledge-based innovation through collective approaches, as well as the acquisition and integration of new knowledge.*

Research limitations/implications – *The conceptual framework developed in the paper remains limited to a theoretical understanding. Further research should empirically examine knowledge issues related to the intangible character and intellectual capital intensiveness of innovation in the transport sector.*

Practical implications – *Researchers, public transport companies and public transport authorities are expected to benefit from this research, by developing mechanisms for customer-centred knowledge management, which is found to lead to innovative services and practices in the public transport sector. Another practical implication regards the adoption of knowledge management practices, leading to technological innovations in public transport, and advancing the level of sustainability in transport systems.*

Originality/value – *The originality of this study lies in the development of a customer-focussed knowledge management framework, which provides a novel perspective of value creation in an attempt to engage researchers and practitioners from the transport industry in the conceptualisation and development of innovative solutions.*

Keywords *Customer-driven innovation, Knowledge dissemination, Knowledge integration, Knowledge-based innovation, Public transport*

Paper type *Research paper*

1. Introduction

The public transport sector represents a significant industry and market in the developed world. However, it is a relatively underexplored field, with few studies demonstrating the role of knowledge management in society's efforts to promote innovation in the transport sector, contributing to the expansion of the knowledge economy. This paper sheds light to

"The need for novel methods of transportation emerges due to the numerous challenges arising from the limited ability of public transportation solutions to provide smooth mobility."

the uncharted areas of the existing transport literature, by examining the importance of customer-centred knowledge management, and investigating the role of interactions between mobility stakeholders and travellers in developing innovative services and practices in the public transport sector.

The first part of this paper explores the current transportation market trends within the European context. Following the findings of previous studies – which provide valuable information on market segmentation strategies and identify customers' needs in public transport – we attempt to expand existing knowledge on innovative concepts and services in a vital industry, which consists of a keystone of sustainable development (Hickman, 2014; Howarth and Ryley, 2012). The role of knowledge-based innovation and, more specifically, the influence of groups' and crowd's collective innovation and ideas generating methods, is investigated with regards to the development and promotion of innovation in the public transport sector. This is particularly critical in today's challenging environment, in which knowledge is created, transferred and absorbed by individuals, organisations and the civil society. The dynamics within and the impact of knowledge economy's framework on regional innovation development and problem-solving initiatives lead to additional consideration regarding the conditions and criteria by which organisations create, seek and combine knowledge to develop and support innovation systems that take multi-modal knowledge into account within the triple bottom line sustainability framework (Cooke, 2001; Johannessen and Olsen, 2010). The second part of this paper investigates the role of customer-centred knowledge management in the development of innovative transport strategies and technologies. In this context, we examine the role of users' acceptance as well as delve into the incentives of transport operators and consider the exploitation methods employed to access customer knowledge in an attempt to discover emerging innovative concepts. The final part of this paper covers knowledge management principles and practices, which support innovation in the transport sector, such as bottom-up approaches. In particular, we describe ways and means by which knowledge management practices contribute to and encourage an active involvement of users, inspiring business sectors to introduce innovative options.

Overall, this study explores the importance of knowledge management practices in supporting present and emerging passengers' and potential customers' needs, as well as examines the level of the provided public transport services (supply) for value creation (i.e. limiting costs and generating new revenues). It aims to address this special issue's question, "*How knowledge management supports the processes of developing sustainable, integrated transport strategies and technologies*", focussing on the topic, "*Knowledge Management as a tool to facilitate dialogue with the public sector and with other disciplines and industries*".

2. Evolutions of the public transport sector in Europe: the potentials of knowledge-based innovation

According to the European Commission's White Paper (2011), new innovative mobility patterns must be fostered. The need for novel methods of transportation emerges because of the numerous challenges arising from the limited ability of public transportation solutions to provide smooth mobility – deriving from the inadequate understanding of demand and supply factors. Travellers' demands are drastically changing, while a clear

customer-centric focus is quasi-absent. In particular, the public transportation supply fails to keep up with users' needs, as these are expressed through demands, whereas these needs significantly adapt to today's changing and demanding lifestyle, demonstrating a poor marketing and customer focus from the side of the transport operators. Nevertheless, this challenge constitutes only a part of the industry's deficiencies. In addition, efficiency problems – and related unknown needs – arise in the public transport sector. Such issues occur partly because of the inability of the transport supply stakeholders to communicate or share their knowledge efficiently (i.e. communication between public transportation authorities, operators, local regulators, policymakers, even transport researchers). Furthermore, the sector may be penalised by the fact that new technologies and research outcomes are not adequately utilised. Finally, costs are increasing, whereas budgets shrink, making it difficult for the operators to maintain service quality, as more users experiment with alternative methods of transportation.

An important part of the public transport sector change is, therefore, foreseen in the adoption of efficient customer-centred public transportation, aiming to facilitate seamless and integrated travels. Looking at the importance of sustainable growth, as this is emphasised in knowledge economies (Melnikas, 2010), we argue that knowledge-based innovation constitutes a relevant lever that stimulates, drives and introduces sustainable developments in the public transport sector. The corresponding coordination and problem-solving mechanisms that develop between government institutions and public transport organisations is being impacted by the three traditional forms of organisation: hierarchy/authority, market/price and community/trust. Adler (2001, p. 215) argued, "as knowledge becomes increasingly important in our economy, we should expect high-trust institutional forms to proliferate", underlining the importance of reflective trust within stakeholders' relationships, as a factor that influences the behaviour and participation of social actors (i.e. public communities, customers, etc.) in knowledge-based innovation initiatives. This view is consistent with research findings underlining the value of knowledge and knowledge management strategies in leveraging innovation capabilities, effectiveness, efficiency and financial results (López-Nicolás and Meroño-Cerdán, 2011). Quintane *et al.* (2011, p. 946) defined innovation as "*duplicable knowledge considered new in the context it is introduced to, and demonstrated useful in practice*". Drawing on these findings, examples of knowledge-based innovation include service provision (based on customer knowledge), business models (based on competitors' knowledge), infrastructures (based on value creation mechanisms), knowledge engineering (based on technical knowledge) and networks' operations and maintenance (based on the expertise of transport professionals). Following the previous argument, knowledge-based innovation supports processes related to the development of sustainable technologies, addressing the fundamental needs of the sector. Recent studies indicate the importance and impact of external knowledge, networking and stakeholders' relationships on technological innovation, as key drivers of customer orientation, value creation and growth (Laursen *et al.*, 2012; De Castro *et al.*, 2011; Belussi and Pilotti, 2011). In this perspective, it comes forward that the deployment, integration and utilisation of knowledge resources intercede between intra-organisational intangible assets and outputs of growth and innovation performance (Maurer *et al.*, 2011).

"Applications of knowledge-based innovation solutions include the development of collective expertise and knowledge partnerships, supporting the European Public Transport industry towards excellence and global competitiveness."

> **"The explosion in the knowledge on transport systems is set to deliver a continuous stream of new applications."**

Public transport organisations are particularly challenged to investigate such outputs, as there exists an array of urging societal demands, including the reduction of traffic congestion in Europe, which consists one of the continent's greatest challenges, in terms of time, cost and environmental transport impacts (air pollution, green house gas emissions, etc.). Best practices that could improve the quality of life at cities and the city attractiveness to residents and to new entrepreneurial initiatives should be developed and disseminated in a strategic attempt to make cities competitive. The adoption of such approaches for the creation of a sustainable and inclusive future emerged by facilitating the mobility of all and the access to markets and services, creating economic opportunities and reducing social exclusion. An example of such "knowledge cities" is detailed in Dvir and Pasher (2004), demonstrating the role of knowledge cities and city hubs (which are characterised by the fact that intensive knowledge flows take place between stakeholders) in knowledge development, dissemination, capitalisation and, finally, catalysation for innovation (Metaxiotis and Ergazakis, 2008). Finally, applications of knowledge-based innovation solutions include the development of collective expertise and knowledge partnerships, supporting the European Public Transport industry towards excellence and global competitiveness. This is particularly relevant in a business context where the supply of goods and services for public transportation signifies a dynamic market, with transport supply players represented in various European countries.

In line with the above-mentioned views, we claim that the need for innovation in public transport sector shall be addressed through knowledge management practices supporting a modal share increase of public transportation. This point can only be realised by taking into account certain knowledge management mechanisms, which have received little and limited attention in existing literature. These specific mechanisms – developed according to the point of view of transport policymakers – characterise the public transport sector, while the lack thereof relates to significant limitations and barriers for improvement of the industry as a whole. Applications of such mechanisms are detailed in the following subsections.

2.1 Co-modal knowledge solutions in support of sustainable mobility strategies

Transport is a complex system that depends on multiple knowledge assets, including knowledge covering, geographic distribution of residential populations, location of employment and other activities (i.e. urban form, patterns of consumption, etc.), organisation of production and availability and quality of different types of infrastructure. Owing to the complexity and amount of knowledge solicited by operations of the transport system, and its interactions with various stakeholders, any intervention in the transport sector must be based on a long-term knowledge management vision to instantiate a safer, efficient and sustainable travel of people (mainly because the transport policy dialogue takes a significant amount of time to be implemented), and therefore, the necessary new knowledge integration stages must be planned well in advance. The research findings of An *et al.* (2014) highlight that a system's effectiveness and sustainability are enhanced through a multi-layer integration of knowledge management activities (i.e. connectivity), the remediation of knowledge activities as well as reformation of knowledge management to achieve convergence in established collaborations. Based on this framework, we herewith suggest that these three dimensions (multi-layer integration, multi-directional remediation and multi-dimensional reformation) concur to build an effective policy dialogue and, therefore, entrust stakeholders to best use the limited resources they have available to enhance the competitiveness and sustainability of the public transport sector. Likewise,

Mohamed *et al.* (2009) have empirically demonstrated the critical role of knowledge management in the efficient use of resources and sustainable development across time and geographies. We consider the development and evolution of the knowledge economies as a critical growth framework that enables global restructuring based on the principles of the three pillars of sustainability. Reflecting on the importance of intellectual capital and knowledge production in knowledge-based economies, we argue that a metamorphosis – that has come through the transformation of industry-government-society dynamics – is required with regards to the way companies create value, innovate and grow. Therefore, policymaking and management thinking should re-examine their approaches on policy and business development, incorporating insights from a knowledge society that requires attention as to the economic, social and environmental aspects of adopted problem-solving techniques and product development processes.

Taking these new dynamics into consideration, the European Union sets goals to establish a transport system that meets society's economic, social and environmental needs and is conducive to an inclusive society and a fully integrated and competitive Europe; we argue that it is of imperative importance to develop knowledge management practices that support multi-modal solutions. The four knowledge modes that emerge from the interactions and dynamics between tacit and explicit knowledge, as these are described and modelled by Nonaka *et al.* (2000), provide a clear picture of knowledge sharing and conversion, underlining the value of SECI (i.e. socialisation, externalisation, combination and internalisation) in blending insights and data from different types of stakeholders and creating knowledge, leading to the development of innovative solutions that meet current needs. Specifically, Jones (2013) has advocated for the use of a practice-centred and outcome-oriented approach as successfully contributing to transport management practices. Following this argument, a number of key knowledge evolution perspectives should be taken into consideration when designing a sustainable public transport system. For instance, a systematic knowledge gathering from policymakers may indicate regional disparities, whereas demographic phenomena, such as job specialisation or regional differentiated growth of employment, influence mobility demand due to the spatial dispersion of functions (Rosenbloom, 2005). Another illustration of application perspectives of knowledge management is the demographic ageing, which appears as a challenge for societies as well as for the mobility and the transportation system itself; decreasing individual mobility of elderly and increasing needs of safety cause a shift from active mobility of mid-agers to passive mobility of the elderly. Consequently, mobility supply not only has to react on these changes but also needs to adopt a proactive approach to benefit from the latest scientific and knowledge development created in the sector. Increasing disparities of income, energy and mobility prices need to be considered in systems, aiming to disseminate such information to transport researchers and policymakers, both at the national and international level. Therefore, a robust knowledge system aiming to identify, collected and disseminate the needs of specific customers will contribute to better address the demand of specific features for dedicated categories of passengers.

On the subject of the use of knowledge by transport network users, passengers' choices are expected to take place concerning changes to the relation of public transport with its business partners. Paradoxically, improving public transport components may not create similar pattern of impact on modal shift. This is why co-modality has been put relatively recently at the cornerstone of transport policy: the optimised usage of different transport modes in combination for the provision of door-to-door sustainable solutions is, at the same time, an objective and a tool for managing knowledge. A key enabler of co-modality and of the knowledge and information transfer from passengers to operators and vice versa is the usage of information and communication services (ICT), in particular travel information services. Usually such technologies are identified as intelligent transport systems (ITS). In fact, a number of research projects on ITS have focussed on the dissemination of knowledge to reducing congestion and increasing safety. Similarly, environmental benefits

are often assessed through the analysis of customer knowledge, such as the reduction of total trip length and duration.

2.2 The limited financial resources of public and private sector to support expertise and knowledge

According to the OECD (2012), world's gross domestic product (GDP) is expected to possibly double over the period to 2030. To meet this increasing demand, governments face the challenge of maintaining good transport infrastructure networks and adding new capacity in key strategic areas. This requires important financial investments and consideration as to the quality of the transport system as a key determinant of performance in the transport sector (OECD, 2013). The completion of the trans-European multi-modal transport network requires about €550 billion until 2020, from which €215 billion can be referred to the removal of the main bottlenecks. From a knowledge economy perspective, this imposes three main challenges to researchers and policymakers. The first relates to the development of innovative knowledge. In particular, where will new sources of skills, capabilities and finances required to improve the qualifications of the workforce come from? And, what is the role of the private sector? The second challenge relates to adaptation mechanisms. In other words, will the financial, organisational, institutional and regulatory arrangements currently in place have sufficient expertise knowledge available to be able to respond adequately to the complex challenges they face? And, are these knowledge resources sustainable over the longer term? Greater emphasis shall, therefore, be placed on the development of cost-effective avenues to knowledge and expertise (Riege and Lindsay, 2006) to facilitate the development of public policies. This dimension of expertise knowledge is raised by Du Plessis (2007), who argues that innovation becomes extremely dependent upon knowledge availability. Finally, the last challenge concerns knowledge optimisation mechanisms. This aspect refers to the appropriate form of financing for knowledge (the amount and type of knowledge) required to adequately support transport infrastructure projects, in which complexity is heightened by the high rate of new services development as well as a tremendous amount of knowledge available (Du Plessis, 2007).

Transport financing is not only complex in their planning, design and delivery, as such projects require long-term development and maintenance costs, and it is difficult to strike a balance between the public and private interests for efficient knowledge acquisition and application mechanisms. Governments often seek for alternatives to reduce fiscal costs of the transport sector. Public investment has been on a falling trend in Europe since the 1970s from about 5 to 2.5 per cent of GDP in the 2000s (Välilä *et al.*, 2005). The search for alternative knowledge exploitation models is often justified and based on a belief that current financing systems are insufficient to meet and support existing and upcoming development and maintenance needs. Many governments have pursued the use of various "innovative" alternative models, sometimes as part of a concerted policy focussing on infrastructure in general or given modes in particular, and often on a piecemeal basis. However, the lack of knowledge of customers still impedes the identification and diffusion of best practices in the domain.

2.3 The lack of knowledge of non-customers and high diversity of business models and operators

Public transport sector should adopt a knowledge management perspective with the aim of facilitating knowledge flows between actors and, therefore, increasing significantly its modal share at limited extra cost. However, limited relevant initiatives have been introduced in the knowledge management literature. At best, transport planners' and experts' initiatives were traditionally based on the knowledge of stated preference of passenger needs. This approach, which indicates some lacks in concrete knowledge collection methods, is not sufficient to generate the needed innovation for the public transport sector, in particular the reuse and creation of knowledge to induce radical innovation, which could provoke the

desired significant modal shift. Current passengers have limited knowledge (if not at all) and, therefore, very few alternatives for serving their mobility needs, and thus, they are considered to be captive in public transportation solutions and loyal. The non-users, on the other hand, should be targeted not by using economic incentives without any effectiveness, but mainly by introducing new innovative concepts and personalised services, related to the public transportation industry and providing other than economic incentives that could change their travel behaviour.

2.4 The dependence of public transportation services from knowledge used in the public sector

Although a wide array of technologies and infrastructures has become available to the public transport sector, the fact that it was not driven for many decades by the market forces has been an impediment to develop a customer- and user-oriented strategy, and pertaining knowledge-oriented services. Although extensive knowledge has been collected on some population groups, such as elderly, disabled and other people with reduced mobility, with the aim of identifying their mobility needs, there appears to be a tremendous lack of knowledge both with respect to a special focus on the public transport sector and also the coverage of the needs of other population groups. Particularly, current non-customers of public transport tend to be overlooked. Moreover, the fact that the world is changing rapidly and new forms of societal organisation and technologies are emerging influences and re-defines the needs and requirements of knowledge services focussing on the captive and potential customers of the public transport sector. What will be the future needs of public transport users taking into account the current trends? Despite the gaps in market analysis and segmentation and the investigation of the needs of several population groups, public transport sector lacks a strong "business culture" that could enable it either to transfer and quickly adopt good practices, applied in other cases, or even promote innovation, by introducing totally new services to meet customers' requirements. In contrast to the public transport sector, which mainly regards buses- and track-based transport modes, aviation has a long experience of market competition that has facilitated the creation of new knowledge and, thus, led to the improvement of the level of services provided as well as to the creation of new ones. In this view, public transport could become the backbone of new integrated knowledge services that are provided on a co-operative basis and framework.

This section contributed to recognise the significance of the innovation factor and knowledge-based innovation, towards the fulfilment of the Commission's underlying aim – which increases the public transport share with limited investments in resources. In this perspective, the creation and introduction of innovative knowledge related to the public transport industry (knowledge services, knowledge creation incentives, novel knowledge use business approaches, etc.) are required. Public transport sector must become attractive, especially for the non-users, to provoke a modal shift in favour of it. It also needs knowledge integration measures of policies that will ensure interoperability of the different urban transport modes and, subsequently, smooth movements for the passengers and dialogue between the different policymakers. Similarly, knowledge integration initiatives encompass societal issues of sustainability as well as efficiency challenges (Ducruet and Van der Host, 2009). The newly created knowledge and knowledge-based solutions developed for public transport should fit to the users' and non-users' requirements and needs in the view of a customer-centred knowledge management approach. Moreover, the investigation of such requirements in terms of knowledge management principles, focussing not only on the knowledge resources but also mainly on knowledge creation behavioural incentives that could support stakeholders (public transport operators/ authorities) in dispelling radical behaviour change lock-ups, and exploring the effect of innovative interventions on transport mode selection, is needed. This argument is supported by the body of literature pointing to the interactive nature of innovation, in relation

to the multiplicity and strength of interdependencies between these actors (De Martino *et al.*, 2013). This aspect is further investigated in the next section.

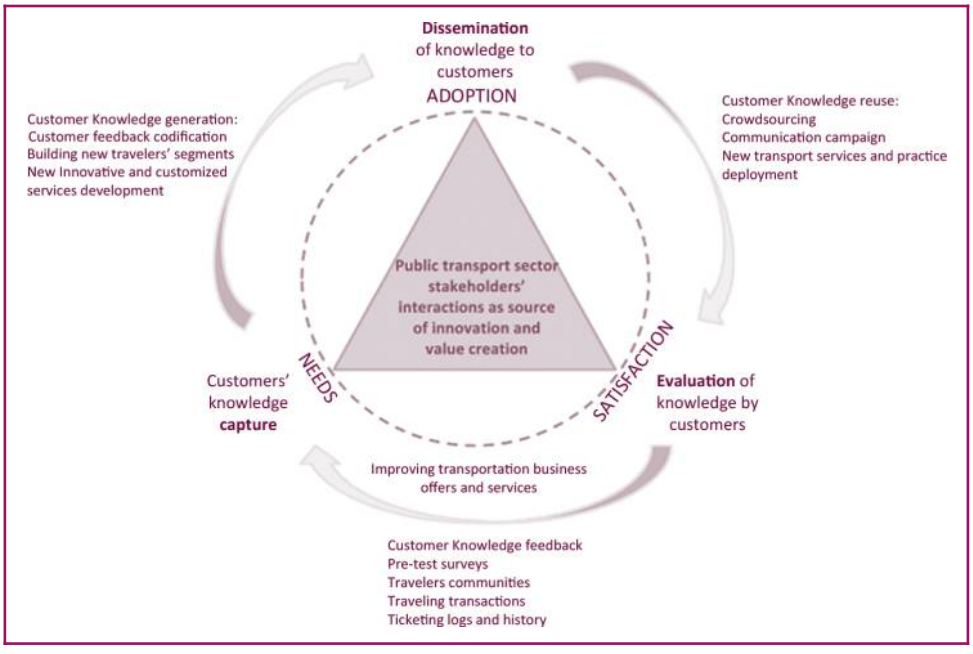
3. Developing new transport strategies and technologies in transport: the role of customer-centred knowledge management

The recent economic downturn has forced the public to looking for different, more rewarding ways of performing commercial activities. Surprisingly, users typically fail to engage in the overall issue of congestion and public transport usage because of the lack of knowledge access (i.e. end-users seem unaware of the importance of congestion issues and how these affect their own lives). Alternatively, specific user groups such as elder people may not have integrated the necessary knowledge in relation to an underlying resistance to new technology and change. In this perspective, addressing the issue of non-users and the possible ways to engage them becomes an important point. However, a business style approach focussed on marketing and advertising principles cannot sustainably convince these non-users to adopt a different travel behaviour. Behavioural research illustrates clearly that behaviour change (even non-sustainable) is much more elusive – people do not always behave as they intend or in their best interest – so engaging and convincing them is not an easy task – proven motivational "weapons" are needed and, most importantly, the availability and accessibility to appropriate knowledge for policymakers to use.

In this context, public transport has been widely recognised as having the necessary potential to enable congestion reduction, guaranteeing quality of life, sustainable mobility and development for travellers. To succeed a significant increase of the public transport shares, this must be integrated into the lifestyle and the needs of citizens and, therefore, sufficient knowledge disseminated to the targeted users. This means that public transport services should focus their knowledge management approaches, methodologies and tools on the knowledge needs of their customers and prospect users. This is consistent with the research findings of Carbonell *et al.* (2012), highlighting the role of customer involvement in successful new service development and new service advantages as ensuring superior market performance. Two of the key dimensions highlighted in this study are the relational closeness and lead-user characteristics. Other researchers have added the role of supplier integration (Lin *et al.*, 2010). Thus, prerequisites for the success of this customer-centred knowledge focus are the identification and review of the current and future needs of captive and potential transport customers (services demand aspect), as well as the needs of public transportation operators and authorities (services supply aspect), which are based on societal and market trends. Second, the adoption of satisfactory knowledge services that enable the measurement of customer satisfaction and the nature and weight played by the demand management. Finally, the exploitation of customer knowledge to introduce new innovative customised services significantly contributes to add value to the transport service supply, meeting customers' needs. Such a customer-centred knowledge management approach reflects great societal and market challenges (car-independent lifestyles, energy efficiency, environmental concerns, digital society needs, more efficient mobility, customised and personalised care and services, sustainability aim, etc.), which are increasingly changing the research paradigm. This shift in the academic representation of knowledge mechanisms is illustrated in the framework below (Figure 1).

Research in knowledge management for transport is, therefore, shifting from a product- or service-oriented research to a customer-oriented, collaborative and heuristic knowledge management approach, which requires the co-operation of all stakeholders and mobility actors. Besides, lifestyles are being individualised, affecting life choices on the place of residence and the travel behaviour and diffusing the travel patterns, while people, especially the young ones, are becoming more environmentally concerned, changing the global value. In this context, we claim that introducing innovation in public transport has to be the result of a "push-pull" knowledge mechanisms between supply industry strategies

Figure 1 Conceptual framework for customer-centred knowledge management for innovation in the public transport sector



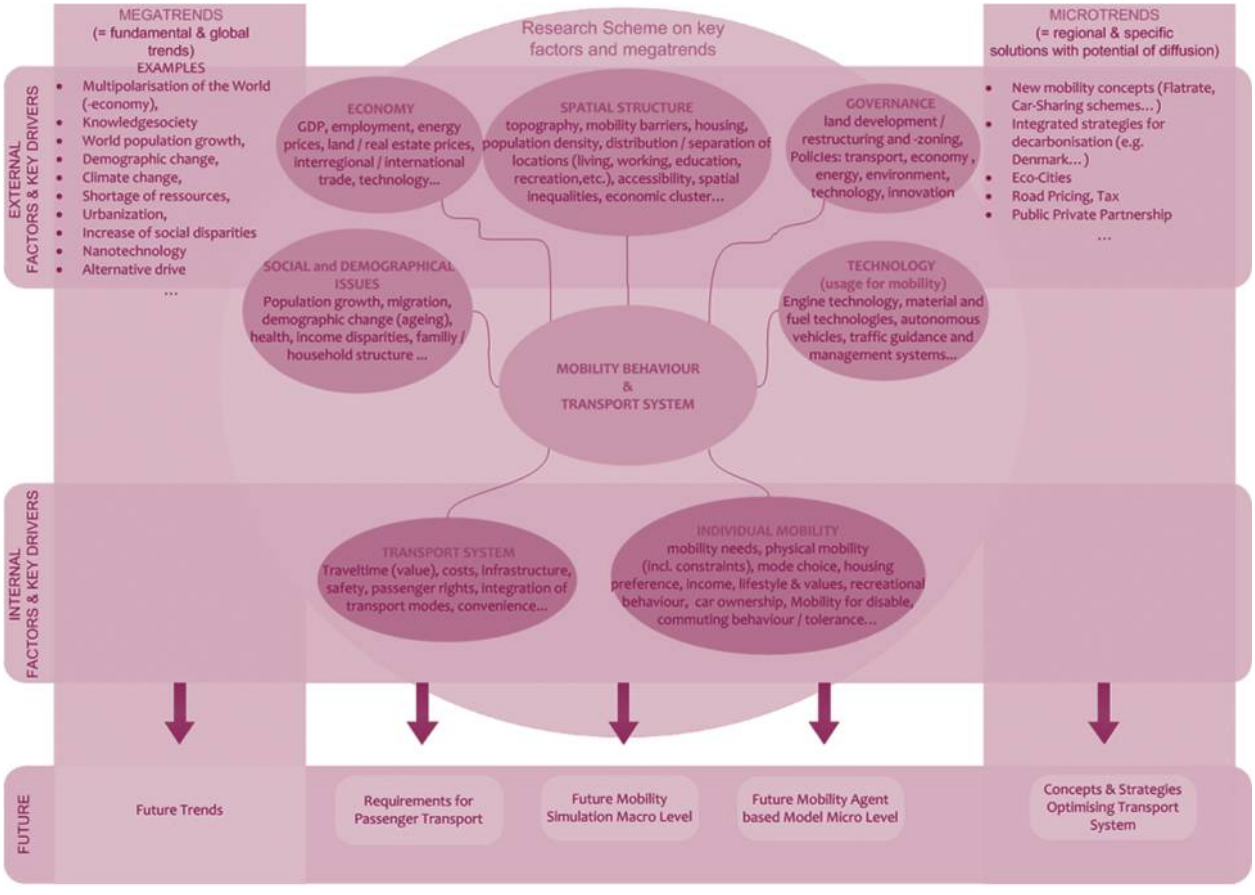
and end-users' needs, including those by public transport authorities and operators. In line with such push-pull knowledge mechanisms, researchers have shown the importance of selective knowledge revealing as a means to shape the collaborative behaviour of actors in the context of an organisation's ecosystem (Alexy *et al.*, 2013). Taking the transport sector as ecosystem reference, there is a need to rethink knowledge management applications beyond conventional transport models, promoting and improving the existing multi-modal transport systems and adopting a new understanding and appreciation of public transport solutions.

Characteristics of user-oriented knowledge activities oriented towards innovative services include, for instance, two-way information; knowledge diffusion strategies that contribute to create a greater sense of community between travellers and public transport agencies (because selective knowledge revealing strategies have notably stronger impact when there exist high coordination needs between current and potentially unwilling actors [Alexy *et al.*, 2013]); a knowledge network between agencies that enable them to become strongly adaptive and networked; predictive consumer knowledge that provides supply transport actors with significant agility in provision of services; and continuous creation of new knowledge with users, provided that resources required to such knowledge management approaches are committed. Additionally, the formalisation of experience feedback on services also enables the effective exploitation of knowledge to achieve continuous improvement in projects (Jabrouni *et al.*, 2011).

4. Empirical evidence of customer-centred knowledge management in public transport: the case of OPTIMISM project

An illustration of such customer-centred knowledge management principles is the OPTIMISM project (2013) (Figure 2), which derived a number of suggestions for future transport measures and strategies to support modal shift and co-modal transport based on public transport. OPTIMISM based its research methodology on building a framework of key drivers, relevant aspects and trends influencing mobility patterns and transportation.

Figure 2 OPTIMISM's research framework



Source: OPTIMISM project (2011)

The research scheme provided an understanding of the complex system and served as a guideline for interpreting research results according to their relevance inside the transportation system.

Eleven megatrends were identified based on a literature analysis covering all dimensions of sustainability: economic, social and environmental. The megatrends were classified as "recent" if being already observable for the past years or decades and as "prospective" if they are likely, although characterised by some uncertainty. They also included issues related to technology, cohesion and mobility. The megatrends were discussed, assessed and ranked by experts with regard to their potential impact on the future transportation system. As a result, a recent megatrend "urbanisation" and a prospective megatrend "shortage of resources" were estimated to have the highest impact. Table I summarises the impact of the megatrends, showing their value in time.

The identified megatrends were integrated in a Delphi survey aiming at the definition of scenarios to be modelled. The modelling had the goal to assess the impacts of co-modality ICT-based strategies for the optimisation of future passenger transport systems. The OPTIMISM Delphi survey proved to be useful for finalising the OPTIMISM scenario-building process and led to the identification of the two most relevant key factors in terms of their uncertainty and impacts on future passenger transport systems: energy (oil) prices and support of sustainable mobility policies. Based on the two-scenario variables, energy price

Table I List of megatrends

Impact	*Megatrend*	*Time horizon*
High	Urbanisation	Recent
	Shortage of resources	Prospective
	Globalisation 2.0	Recent
	Climate change and environmental ethics	Recent
	Technology change	Prospective
Medium	Mobility crisis and European policy reaction	Prospective
	World population growth	Recent
	Demographic and social change Europe	Recent
	European market deregulation	Recent
	Increase of inter-/intra-national social disparities	Recent
Low	Knowledge society and economy Europe	Recent

and policy measures, four OPTIMISM scenarios were identified, along with the reference scenario, which was based on the European Commission studies:

- SC0 – reference scenario;
- SC1 – baseline trend for oil price/"do-as-today" for co-modality;
- SC2 – "global action" trend for oil price/"do-as-today" for co-modality;
- SC3 – baseline trend for oil price/"do-maximum" for co-modality; and
- SC4 – "global action" trend for oil price/"do-maximum" for co-modality.

Based on the results of scenario simulations, the following conclusions should be underlined. As of 2010, the share of private cars in passenger transport is 74 per cent, and it is expected to reduce to 70 per cent by 2030. It is also expected that the modal shares of rail transport will increase from 7.7 to 9.3 per cent and aviation from 8.2 to 11.3 per cent by 2030. The results of the simulations show that the OPTIMISM policy measures may have significant impacts on existing mobility patterns through a substantial modal shift from private car to public transport, which may still result in positive environmental impacts. Combination of OPTIMISM co-modality and internalisation measures may reduce the carbon dioxide, nitrogen oxides and particulate matter transport emissions in 2030 by 1.3, 0.1 and 0.4 per cent, respectively. These positive impacts of knowledge management practices are more noticeable, particularly in higher fuel prices environment and with internalisation of external costs of road transport. The OPTIMISM strategies mainly comprise ICT-based policy measures and only include passenger transport excluding freight; hence, their impact on transport emissions is rather small. The relatively low impact of OPTIMISM strategies can be explained by the insufficiency in the amount of customer-knowledge available to stakeholders, in comparison with technological knowledge. As a conclusion, OPTIMISM strategies/policy measures supporting co-modality and integration of knowledge have positive mobility and environmental impacts. This is supported by Etzkowitz (2011), who analysed the organisational dynamics within and between society, industry and government, creating an innovation ecosystem, based on science, technology and a culture of entrepreneurial initiative.

This section has addressed the challenges of the ways and means by which the facilitation of knowledge sharing and reuse efficiently connects public transport industry with other business sectors, including those other than public transportation to stimulate the effects of knowledge spillovers. The above-mentioned illustration sets the ground for the development and application of appropriate knowledge management tools and methods to trigger collective and collaborative knowledge creation in public transport sector and other public and private organisations, by encouraging professionals, experts and customers to engage in sharing their respective competencies and skills. This view is supported by a recent research conducted by An *et al.* (2014), demonstrating the role of knowledge management in supporting collaborative innovation at a trans-disciplinary level. In line with

these findings, we suggest that specific knowledge sharing and creation initiatives (crowdsourcing and co-creation) are organised, targeting both the other transport modes (i.e. aviation sector, taxis, etc.) as well as the other sectors of economy (i.e. real estate, advertising, digital marketing, health services, etc.). This view can lead to the identification and emergence of integrated knowledge services, including diffusion of information regarding the tariffs, fare products, comfort, security, etc. Therefore, special emphasis will be placed on the knowledge initiative focussing on promoting knowledge diffusion and accessibility such "open data", crowdsourcing, social media, etc., as potential fields for the development of new knowledge services and applications that are incorporated to the public transport or are related with it. The scope and the content of creating knowledge ties, thus, aim to facilitate dialogue among sectors as well as developing potential synergies, strategic partnerships and alliances among public transport bodies and those coming from the mobility sector (taxis, car-sharing enterprises, parking facilities owners, etc.), or other business fields (information providers, major mobility generators, etc.).

5. Knowledge management in theory and practice: bridging the gap between researchers and policymakers for sustainable value creation

The limitations of current evolutions in the public transport sector has been discussed. A user-centred knowledge management approach should be applied for a sustainable evolution of the industry suppliers towards the target of public transport's share increase and congestion reduction. Even though the role of user-centred knowledge management approaches is not negligible, this approach cannot stand alone with great success serving only theoretically mentioned aim. It comprises mostly a necessary condition, but not a sufficient one, as practices enabling to bridge the gap between researchers and policymakers are expected to demonstrate superior effectiveness.

Besides, research has provided insufficient credible evidence on which novel approaches (motives, infrastructures, technologies, regulatory frameworks, etc.) directly affect the adoption of public transport, and which of those are more cost-effective. Efficient knowledge evaluation and decision-making aids are needed to assess the value created by innovative tools that exist and, more importantly, the ones that could be proposed. Likewise, researchers and policymakers could take the initiative to employ technology, current resources and research insights and use these as a way to inspire people and make them engage in the uptake of public transport and innovations that will improve their lives. Facilitating dialogue between the different stakeholders of the transport industry does not only concern traditional actors (i.e. industry, transport operators or non-governmental organisations), as these are not always well-equipped with the necessary knowledge to do so). Alternative methodologies – such as social innovation and entrepreneurship and establishment of partnerships with the traditional transport actors – require only limited cost while creating significant value and at the same time solving important challenges such as congestions issues in a sustainable and efficient way. Focussing on such approaches does not exclude the traditional business actors, but it seems to be required and a good approach to try to apply such principles to the public transport to develop its innovation capabilities.

5.1 Improving the innovation capacity through collective knowledge mechanisms

Undoubtedly, innovation is the major driver in new models of growth, aiming to increase productivity and raise standards of living. Perhaps a major challenge for the European public transport sector is to adopt a strategic approach to innovation. An approach whereby innovation is the overarching policy objective, where we take a medium- to longer-term perspective, where all policy instruments, measures and funding are designed to contribute to innovation, where European Union and national/regional policies are closely aligned and mutually reinforcing, and last but not least, where the highest political level sets a strategic agenda, regularly monitors progress and tackles delays (European Commission, 2010).

Growth is increasingly related to the capacity of regional economies to change and innovate. Regions and cities have become the primary spatial units where knowledge is transferred, innovation systems are built and competition to attract investments and talents takes place (European Commission, 2009). Strategic choices for regions depend on national development patterns and policies as well as the specific regional situation: frontier regions that are already capitalising on strong knowledge-based assets, regions that need to find a new development path because of exhaustion of past development models or regions in a more difficult catching up situation. To implement strategies responding to these diverse conditions, a smart mix of policy instruments has to be developed. This mix should strike the right balance between the goals of knowledge creation, diffusion and absorption as appropriate for the regional context. The mix should also ensure synergies across individual instruments in view of their overall effectiveness (OECD, 2011). Structuring the appropriate policies and roadmaps based on the region's strengths while suggesting solutions to overcome the weaknesses requires a thorough study taking into consideration the innovation actors, the schemes, key innovation activities and the interaction amongst the important stakeholders.

In this perspective, networked communities of stakeholders with actually different origins, background and economic constellations contribute to create a critical mass in sustainability transport, boosting competitiveness and effective usage of research resources in the transport industry. Following this approach, the market could exploit the full potential of available funds in national and international level, returning the public funds invested to society. Moreover, bringing together research networks for conducting research in transport issues has a direct future economic impact, as research is considered a competitive tool for sustainable development. Networked scientists and companies could be supported in the creation of breakthrough knowledge and excellence. Specifically, both ICT tools and human networks can be exploited to stimulate research and innovation so as to cater the society needs and ethics. The exchange of scientific knowledge and the support of collaborative efforts stimulate the potential of accelerating the scientific excellence of research teams.

Based on this argument, knowledge and technology transfer mechanisms could potentially support the innovation chain. The creation of official or unofficial networks of stakeholders could help accelerate the innovation process, possibly under the form of clusters. In particular, cluster literature suggests that clusters provide: a common pool of resources (Krugman, 1991; Porter, 1990), opportunities for informal interactions and knowledge flow (Maskell, 2001; Tallman *et al.*, 2004) and stimulus for innovation via competition in the cluster (Porter, 1998). In other words, members of a cluster benefit from the concentration of knowledge on customers and their relationships, co-operation of firms in related industries, the concentration of specialised information-generating entities and customer sophistication. Cluster members can often discern buyer trends faster than isolated competitors. Silicon Valley and Texas-based computer companies, for instance, plug into customer needs and trends quickly and effectively (Porter, 2000). Therefore, clusters have an important role in innovation and productivity growth. Their primary role lies in increasing a cluster member's awareness of technological developments and motivation to engage in innovation, and in reducing uncertainty in innovation. This is particularly relevant for the public transport sector transformation, as clusters engaged in new services development may adopt a temporary project network structure (Iacono *et al.*, 2012). Further, the concept of cluster vitality (the extent to which a cluster is imbued with new knowledge resources over time) becomes critical for sustained flow of cluster benefits (Gnyawali and Srivastava, 2013). A number of sectoral and cross-modal transport clusters have been created within the past years in Europe. Leading examples of cluster creation are in Germany and Spain. Despite the fact that clusters that support transport innovation are, in most cases, not autonomous, they evolve in response to the structures and purposes of societal milieu in member states, associated states and their regions in which the transport system operates.

5.2 Mechanisms of new knowledge integration as seedbed for innovation

Apart from the development of existing innovative services and practices, knowledge management approaches contribute to new knowledge integration and, therefore, the public transport industry's innovation capacity by engaging people (travellers or non-travellers) as well as attempting to bring together representatives of various business sectors and creating knowledge exchange systems with the aim of co-operating and generating possible synergies. An example of these synergies is collective knowledge management approaches, which enable stakeholders themselves to be part of the design and creative process for public transport. Modern knowledge creation and dissemination methodologies can be utilised for this purpose, for example, crowdsourcing of ideas, communities' engagement, co-creation solutions and cross-discipline workshops.

According to the impact assessment of the White Paper on Transport (2011):

> EU research policies have not been able to address the full cycle of research, innovation and deployment in an integrated way through focusing on the most promising technologies and bringing together all actors involved. As a result the potential of research and innovation in contributing to EU transport policy objectives has not been exploited to its full extent.

Based on this view, we argue that the integration of knowledge management approaches combining different views and perspectives contributes to the sector's innovation capacity. This view is illustrated in Table II.

Through integrating knowledge dimensions, the innovation capacity of the public transport sector will be sustainably improved and new knowledge will be integrated, strengthening the competitiveness and growth of companies. This view further calls for the study of potential barriers and unfavourable conditions, for instance, cases where many players seem to interact inefficiently. In this context, policymakers and researchers need to instantiate cross-sector knowledge exchange to blending basic and applied research through cross-discipline collaboration instances, developing practical concepts with innovation potential and, finally, openly collaborating with industry stakeholders and transport industry researchers, while attempting to reach a critical number of stakeholders.

To tackle these aforementioned issues, the development of sustainable innovation and technologies requires knowledge management practices, enabling the access to knowledge of user needs, the mapping and evaluation of existing innovative knowledge, the promotion of knowledge-based innovation in public transport sector through collective approaches (crowdsourcing and co-creation approaches), providing access to advanced

Table II Integrating a tri-dimensional view of multi-modal customer knowledge integration to foster innovation and new service development capabilities

Variables/values	*Knowledge practices* *Knowledge "about" public transportation travellers (existing or potential)*	*Knowledge "for" public transportation travellers (existing or potential)*	*Knowledge "from" public transportation travellers (existing or potential)*
Customer knowledge object	Public transportation travellers needs (expressed or tacit)	Public transportation services and associated benefits	Public transportation sector satisfaction
Knowledge capture focus	Collecting data from travellers through surveys or interviews	Collecting data on existing transportation services and practices (benchmarking)	Collecting data on new services and practices deployment
Knowledge dissemination focus	Communication and messages segmented according to customer profiles	Communication and messages focussed on features of new products and services	Communication messages focusses on differentiation between different product and services
Knowledge evaluation focus	Direct customer feedback on **needs** prior and at the launch of new services or practices	Level of **adoption** of communication campaigns around product and services	Assessment of the use rate and **satisfaction** of new products and services

knowledge about consumers to decision-makers, supporting the acquisition and integration of new knowledge aiming to conceptualise new services and improve customers' satisfaction and, last but not least, developing a knowledge management roadmap serving public transport operators and authorities, covering knowledge management requirements (user perspective), solutions (operational perspective) and prioritisation of the deployment of selected knowledge management activities (Liang *et al.*, 2012) in a continuous innovation process (Xu *et al.*, 2010).

6. Discussion and conclusion

Transport systems exist to provide social and economic connections, and people quickly take up the opportunities offered by increased mobility. However, because of its potentially detrimental impact on the environment and public health, the transport sector also poses one of the greatest policy challenges for sustainable development within the European Union. To tackle these challenges, innovation and related support mechanisms are essential in the transport sector. This is increasingly important as political and technological changes, open access to the global knowledge economy – producing both new markets and increased competition. Therefore, the diffusion of innovation is not only a scientific obligation but also a societal need, as it affects the economy and, subsequently, the work and well-being of millions of European citizens. Based on scientific breakthroughs in recent years, the explosion in the knowledge on transport systems is set to deliver a continuous stream of new applications. Three main horizontal axes can be affected by knowledge management in sustainable transport.

6.1 Society: better life

Defining social impacts delivered through knowledge management in transport is not an easy task. One of the difficulties of assessing social impacts, especially in transport policy, is that often, no clear distinction can be made between social, economic and environmental impacts. For instance, a policy that reduces air pollution induced by transport activities affects primarily the natural environment, but also human health, thanks to improved air quality. It has, therefore, both social and environmental impacts. Despite this difficulty, several indicators highlight the link between transport knowledge management and society and the positive impact. For example, a well-performing transport system features prominently among the characteristics of cities that are ranked high in the surveys on quality of life. Overall, collaborative research has extensive societal impacts contributing to faster advancement of science and existing problems solving. In this perspective, new knowledge management initiatives are the cornerstone of development stronger relationships among different countries, providing the proper ground for joint fore-thinking activities.

6.2 Economy: competitive industry

The European automotive industry is a world leader in research and development with a significant impact on economy and employment. Knowledge management systems can further strengthen the competitiveness of the industry and open up the path for major breakthrough innovations not only from large industrial co-operates but also for small and medium-sized enterprises too. Two key elements to a successful economy and creation of competitive industry are as follows:

1. understanding of the status quo in the subject matter; and
2. successful exploitation and deployment of products and services.

6.3 Research: excellence science

The European Union is committed to support excellent research ideas and encourages multi-national collaborative work. In general, collaborative research has extensive societal impacts contributing to faster advancement of science and existing problem-solving. The

research common initiatives are the cornerstone of developing stronger relationships among different countries. The exchange of scientific knowledge and the support of collaborative efforts stimulate the potential of accelerating the scientific excellence of research teams.

In line with these three application examples, this study, therefore, contributes to promoting the use of knowledge management methods and tools aiming to facilitate and encourage the development of dialogues among public transport sectors as well as with other business sectors. The arguments developed earlier in the paper highlight the importance of developing and implementing new knowledge services that meet users' demands and contribute to increasing the provided level of service, subsequently leading to increased sustainability. Researchers, public transport companies and public transport authorities are expected to benefit from this research, by developing mechanisms for customer-centred knowledge management, which is found to lead to innovative services and practices in the public transport sector. Another practical implication regards the adoption of knowledge management practices, leading to technological innovations in public transport and advancing the level of sustainability in transport systems. Finally, approaches and techniques that favour inclusive information and multi-modal knowledge-sharing lead to identification of challenges and to innovative solutions.

Specifically, innovative public transport concepts, namely, knowledge services, knowledge creation incentives, knowledge management practices and knowledge products, such as travellers applications, are needed to generate sustainable evolution within the public transport sector, minimising significant structural investments. To do so, a strategy option is to increase the attractiveness of public transport. Thus, the goal of supporting research was to identify knowledge solutions, which contribute to make public transport more attractive and understandable for customers. In this context, the present paper findings indicate that the public transport stakeholders have to initiate a shift towards not only a more user-centred and marketing approach, but to go even further beyond the current "traditional marketing approach for transport suppliers" (which is considered to be rather dated to the "leaders" of marketing, both individuals and firms). Policymakers and public institutions should develop knowledge management approaches towards an integrated knowledge system approach, which covers customer knowledge (customer orientation, marketing research, e.g. conjoint analysis), collaborative knowledge creation (crowdsourcing, collective intelligence, e.g. co-creation and co-design), knowledge evaluation (implementing available methodologies for socio-economic assessment) as well as business modelling within a wide knowledge sharing platform, aiming to address the challenges that appear as barriers for public transport environment.

6.4 Limitations and perspective for further research

According to JRC's "Mapping innovation in the European transport sector" (2011), two main drivers are stimulating innovation in transport:

1. First, the ambition to increase the range and improve the quality of transportation equipment and services – and with this to ultimately increase market shares and enter into new markets – and to simultaneously add flexibility and reduce costs in the production processes.
2. Second, regulatory and fiscal policies steer innovation efforts by stimulating the rapid adoption of innovative technologies (knowledge integration) and significant market transformations.

Further research should, however, specifically seek to consider knowledge issues related to the intangible character and high intellectual capital intensiveness of innovation, reinforced by problems in hiring qualified workforce.

A second perspective of research covers the knowledge flows underlying the structure of market demand and supply and how effective knowledge management can contribute to

reduce the mismatches between consumer demand and innovation supply, as well as lack of information and confidence in innovative solutions from consumers. In this context, knowledge spillovers become increasingly important because of growing global competition, in an attempt to overcome the lack of qualified personnel available. Such research perspectives could also seek to differentiate the role of knowledge management practices in radical or systemic innovations strategies for transport. This is because incremental innovations that remain within the boundaries of the existing market and technologies/processes of an organisation are built on existing knowledge bases, whereas radical innovations imply the creation of or new ways of utilising knowledge. In particular, future research may seek to examine whether radical and systemic innovations are hampered by lock-in phenomena (with regards to knowledge flows, technology, infrastructure and markets).

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