The Changing Context of Transport Research

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Abstract This chapter gives the general context within which transport research takes place today and examines the increasing interest in international cooperation in tackling transport related problems and challenges. After referring briefly to the most important previous studies and reports on this subject, the chapter addresses the relevant key concepts and global challenges that seem to be the main forces driving transport research and transport research cooperation. One of the key issues examined, is the strong emphasis in all current transport research funding to satisfy short-term priorities related to increasing the industrial competitiveness of the respective country and serve as a means to expand technological influence and market-control. Researchers are normally asked to keep a mostly national focus, but whereas in the past that focus was dominated by tangible—though purely domestic—priorities, the new focus is on providing justification to claim the technological superiority of national industrial products at the global level. The chapter discusses the consequences of this approach and the merits of expanding cooperation at international level in order to reconstitute the traditional distinction between policy-oriented and industrial/technological research and the need to strengthen the contribution of social science disciplines, economics, and systems considerations. It further discusses the case of "legacy" versus "transformational" (transport) systems research and the top-down versus bottom-up approaches in triggering change in the transport sector. It argues that the current trends in forming transport research agendas are increasingly dominated by topics identified by the industry incumbents complemented by a bunch of policy topics intended to provide justification for a regulatory environment and political priorities that usually have a strong national focus. The chapter also discusses the general factors triggering international research cooperation in general and in transport in particular. It categorizes these factors in two main groups: Those related to policy makers or to government at large, and

All views expressed, are those of the author and do not reflect the views of the Organisation he is associated with.

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those related to researchers. The first results in a top-down process, in which government officials from different countries establish a collaborative framework, usually on the grounds of economic or diplomatic objectives, and offer it to researchers. The second results in a bottom-up process, in which personal networking is progressively institutionalized by research organizations, so that the research communities in the countries concerned lobby their respective government for support and resources. Finally, the chapter looks at ways in which the particular model of international cooperation in transport research can increase its disruptive innovative capacity and concludes that this can be done primarily through stronger leadership and involvement from governments and other multinational organizations as well as through a more collaborative approach and making researchers more influential in decision making.

Keywords Transport research · Transport research agendas · International cooperation · Disruptive innovation · Research governance · Transport cooperation

1 Background, Concepts and Definitions

In the last several years, the promotion of international cooperation in science, technology and innovation (ST&I) has received increased attention in research policy worldwide. The interest was particularly high in the areas of "frontier research", triggered by a need to put together material and human resources from a variety of sources and disciplines with a long-term perspective. Subsequently, it expanded to other sectors.

In the case of transport, international cooperation in ST&I and more particularly in performing research and creating innovation (RTD&I[1]) was fueled by the rapid expansion of mobility following globalization. The transport sector had a worthy historic tradition of international cooperation in the areas of infrastructure, vehicles, operations and legal instruments, which had resulted, after the Second World War, in formal contacts among governments (mainly through the UN's Economic Commissions for each region) which cooperated in bringing international uniformity and harmonization in issues such as road signs and signals, traffic regulation, freight vehicles and freight movement across countries. Consequently, transport research institutions across countries started cooperating (informally) and networking for the exchange of information and, in some cases, of researchers and practitioners. This cooperation was typically focusing on the search for practical solutions to concrete challenges as those emerged.

Building upon this tradition, transport stakeholders were generally keen to follow the path of frontier research and start exploring opportunities for better-structured, long-term cooperation at the international level. The European

[1]Research Technological Development and Innovation.

Union (EU) experience offered a good basis for such cooperation, as the EU research policy had considered transport as one of the research fields for funding within all of its so-called research *Framework Programmes (FP)*. Through these FPs and since the early 1990s, transport researchers and stakeholders in EU countries have been encouraged to undertake collaborative projects with increasing international participation, supported with generous European funding.

In parallel to the increased international cooperation that was initiated through EU funded research, several similar initiatives started in the US. The US Transportation Research Board (US/TRB) through its Executive Committee, which recently instituted an "*International Activities subcommittee*" but also through its standing *Committee on International Cooperation*, was actively and increasingly involved in promoting international cooperation in Transport research. An earlier initiative of the US/TRB in promoting international cooperation was to set up a working group under the TRB-ECTRI[2] Memorandum of Understanding for cooperation signed in 2006. That working group focused on, and finally issued, a report on "*European-United States Transport research collaboration*", in 2009 (ECTRI & TRB 2009).[3]

International cooperation in research, technological development and innovation (RTD&I) is a growing necessity worldwide. It aims at supporting and promoting such activities, in general and in the transport sector in particular, by the pooling of resources and other synergetic actions, and creating innovation.[4] It is an activity that encompasses a spectrum of cooperation actions as it is diagrammatically shown in Table 1. As shown in this Table, three different stages of cooperation can be distinguished:

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[2]European Conference of Transport Research Institutes.

[3]This ECTRI/TRB report was influential in strengthening cooperation between the EU and US. Since 2009, several initiatives promoting international cooperation in transport research were launched. They included:

1. Several EU-funded research projects focusing on promoting international cooperation on transport research have been launched, such as EUTRAIN and HERMES;
2. Four annual EU-US symposia, which were organized by the US/DoT in cooperation with the European Commission (EC/DG RTD) on the topics of logistics, research implementation, automated road transport, and climate, change adaptation; these symposia are to be continued.
3. The first Joint programming "INFRAVATION" initiative, with funding from the US/FHWA and FEHRL (The Federation of European Road Research Laboratories) and the European Commission;
4. Twinning actions between EU and US funded transport research projects in the area of road infrastructure.
5. The major European and US transport research data base portals have been unified since 2010. This resulted in the TRID data base which now collects information from the Transport research data base of the TRB (formerly TRIS) and the one of OECD (formerly ITRD); at the EU level, only, the Transport Research & Innovation Portal (TRIP) collects information on transport research from EU and national programs.

[4]"Innovation" refers to the market exploitation of Research results and creation of value through the production of marketable products.

Table 1 The international RTD&I cooperation continuum©*

Nascent stage cooperation			Emerging cooperation		Advanced cooperation	
Conference attendance; membership in key scientific or technology Associations; funding domestic researchers to obtain additional education abroad	One-way and two way scans and twinning projects	Cooperation Agreements enabling, the regular two-way exchanges of researchers and periodic technical exchange meetings	Establishment of research centers in one country by the private corporations of another in association with its Universities and research centers One-way influx of researchers or students from one country to another one	Issuance of research calls by one country (or group of countries—Union) that allows selective participation by research organizations in other countries Bilateral agreements on scientific and technology cooperation Issuance of coordinated research calls by two or more countries—or twinning of research projects already approved	Regular issuance of ST&I Calls for commonly funded Research and Technology Development jointly by government institutions in two or more countries Robust two-way exchange of ST&I students	Co-location of government and university researchers in research facilities commonly funded through the pooled funds of two or more countries

*By John F. Munro

(a) "***Nascent***", the stage in which there is no established rules or frameworks and cooperation is in its primary stages taking place on an ad hoc basis.
(b) "***Emerging***", in which there are specific structures in place for such cooperation and there are some legislative and statutory instruments on which it is based.
(c) Finally, the "***advanced***" cooperation stage where there are permanent and well established structures for such cooperation and all activities take place under well-established frameworks with known periodicity and security.

There are a number of activities that can take place in each category as shown in Table 1. The "**Nascent *stage***" contains collaborative actions as indicated in the three first columns of Table 1, and these take place between independent research administrations acting in cooperation. The other two stages of "***emerging***" and "***advanced***" cooperation entail more integrated forms of cooperation involving the commitment of specific research funding and common use of research facilities. Each column in Table 1 signifies a progressive developmental stage of cooperation moving from left to right.

International cooperation is thus viewed as a *continuum* with developmental stages of various collaborative initiatives which range from ad hoc international conferences to institutionalized cooperation between countries and the pooling of research funds for the issuance of joint research calls along with statutory frameworks covering the sharing of intellectual property and the delineation of the science or technology products as "exportable" products that create value.

The underlying factor of whether or not a country (or group of countries) moves from "***nascent***" cooperation to "***emerging***" and to "***advanced***" is whether enhanced cooperation is consistent with its core political and economic beliefs and especially its national and geopolitical interests. "Cooperation" is therefore—in essence—a rational decision that is (or should be) supported by the clear and sober recognition of specific national and international interests, realities and motivations. Conversely, cultural norms, socio-technical factors, and historical and institutional circumstances can slow down or even sidetrack such cooperation or, in the opposite case, be its proponents. In this chapter we will attempt to discuss and document the most important factors, trends, and events that affect international cooperation in the field of transport research and try to reveal the underlying *causal* or *systemic* factors[5] that are key to policy behavior concerning such cooperation.

[5]According to philosopher Karl Popper, "causal factors" refer to independent variables that are posited by scientists to cause a change in the dependent variable with falsifying the null hypotheses as the key philosophical objective of positivist science. *Systemic* factors are best viewed as political, cognitive, or institutional structures that constrain, delimit, or "tamp-down" policy behaviour.

2 Previous Relevant Work

2.1 The 2009 ECTRI/TRB Report

As mentioned already, the report "*EU/US Transportation Research Collaboration: Challenges and Opportunities*" (ECTRI & TRB 2009), was the result of a collaborative effort between United States (US) and European Union (EU) researchers in the framework of a Working Group set up under the Memorandum of Understanding signed between the *US/TRB* and the *European Conference of Transport Research Institutes* (ECTRI) in 2006. The report provides a thorough review of the background, practices and future prospects of research cooperation between the EU and the US, with emphasis in the following aspects:

- Description of the different paths that transport research has followed in Europe and the US, and similarities and differences among them. In the first case, with a focus on the role of the International Transport Forum (ITF) and the European Commission. In the second case, with a focus on TRB and US Federal programs.
- Discussion on the potential role of a market approach to research and technological development and innovation, and the actors involved. The report's narrative describes transport users as a weak demand side confronting a powerful coalition of governments, research organizations and industries on the supply side. The key role of governments was said to be justified by the characteristics of innovations as collective goods, with benefits reaped by free riders in the absence of adequate public intervention and regulation. The transition towards a knowledge economy was seen as to increase the relevance of the market in the research and innovation area, requiring new forms of cooperation between governments and markets. Furthermore, it was foreseen that the economic downturn would make the case for innovation more relevant, although it would also reduce the capacity of governments to act, due to austerity measures reducing public budgets. Some new cooperation schemes were also identified as being already in place, such as the roadmaps for transport research some governments negotiate with the industry, researchers and other stakeholders.
- Identification of globalization as the key driver for future cooperation, and revision of possible cooperation models based on continuation of the globalization trends. Seven models of international cooperation were explored, and the report made a call for a "unified environment for RTD involving many countries and research agencies".

ECTRI & TRB (2009) put forward a vision for future international collaboration that contains two main elements:

(A) The need for a new and enabling framework to which not only governments, but also private funding and market-approved processes would be necessary.

(B) Keeping as a long-term perspective, the creation of a "*Global Research and Innovation Area*" (inspired by the idea of the European Research Area, adapted to the global scale). This "area", would cover all research fields (not only transportation) and for this it would be necessary, among others to "benchmark the evolution of transport research in the different regions around the world", and to "create, develop, and enhance common research evaluation methods and criteria".

As regards transport research and innovation and the promotion of collaboration between the US and the EU the 2009 report made six recommendations which were the following:

(I) Mobilization of the human capital to initiate and promote participation in collaborative projects (with a focus on thematic issues of global concern). Relevant to this, the issue of researcher training with a stronger international perspective was touched.
(II) Build specific cooperation mechanisms and joint activities.
(III) Address the major barriers to cooperation which exist today.[6]

[6]The "barriers" identified in the ECTRI/TRB 2009 report were:

- *Limited interaction amongst transport researchers and limited dissemination of new research ideas and paradigms*; to this, we note that the exchange among researchers is expanding, at least in terms of attendance and presentations at international conferences. In addition, the number of indexed publications has grown and so has the number of co-authoring. Nevertheless, the exchange remains at the basic level of research projects and results and is far away from reaching a "strategically satisfactory" level yet.
- *Limited resources for shared research efforts at an international level*; it does not seem obvious to what extent the lack of such resources has played a significant role in promoting international cooperative efforts given the fact that the resources required in transport research are relatively modest, compared to other disciplines.
- *Lack of common policies for international research cooperation*; this can be seen as a pervasive barrier, as illustrated by the difficulties to push forward an ambitious emission-reduction roadmap at ICAO or IMO. In the last year, the international landscape has improved, as COP-21 and the UN 2015 Sustainable Development Summit have established a reasonable basis for a long-term vision, which the transport community could now translate into a more concrete global transport agenda. Furthermore, the priority areas for transport innovation in many countries around the world are covering similar topics, such as automation, electrification, or climate change adaptation and mitigation. An obvious asset of the transport sector is the wealth of international and multilateral agencies active in the field (IMO, ICAO, UNECE, ITF…) as well as a good number of international organizations like IRU, UIC, UITP, IATA, and others.
- *Lack of cooperation in setting the agendas* for transportation research addressing global problems (health, climate change, energy, travel behavior…); this barrier raises the additional question of the difficulties to define a global transport agenda as a standalone vision and the relatively lack of visibility of transport whenever global challenges are discussed.
- *Lack of global standardization and harmonization* of research knowledge including the sharing of available data. The most obvious obstacle here refers to the potential collision of interests among the industrial interests of countries under conditions of a global economic downturn.

(IV) Improvement of data management and data sharing capabilities.
(V) Facilitation of common education and training for research in the transport field.
(VI) Establish future joint programming and funding, with the long-term vision of creating *Transportation Joint Programming Initiatives (TJPI)* with common funding along the example of the European Joint Programming Initiatives (JPI).

The report encouraged giving priority to recommendations (II), (V) and (VI).

The ECTRI/TRB working group report of 2009 had a Euro/US-centric approach with scarce relevant reference to other regions, little or no discussion of transport research implementation issues, and more weight on "state funded research" with less visibility on the critical role of private sector research and public-private research interaction in promoting innovation. That report paid particular attention to governments' involvement, as transport has always been a highly regulated sector, with intense intergovernmental cooperation. Furthermore, the context in which the 2009 report was produced was that of rapid expansion of globalization, optimism about the future and what was at the time seen as a short-term economic downturn and the worries about the apparently slower path of transport research to cope with the opportunities provided by globalization.

2.2 The EU Funded Research Projects EUTRAIN and HERMES

EUTRAIN[7]—European Transport Research Area International Cooperation Activities—was a research project funded under the EU 7th Framework Programme for Research and Development (FP7) in the period 2011–2013. The work involved the review of the research capabilities, investment, future priorities and potential for cooperation with the EU, in several major countries and regions around the world. This served to further develop the recommendations of the TRB/ECTRI report and to widen them to cover new regions. EUTRAIN included active involvement of US transport officials and researchers. The project tried to reflect a bottom-up view on international cooperation in transport RTD&I, gathering the views of individual researchers and research organizations in many countries around the world including the US, Latin America, North Africa, Middle East, Russia and other CIS countries, as well as the Far-East (China, India, Japan). Information was collected through questionnaires, in-situ structured interviews and regional workshops.

It became clear, from these activities and subsequent analyses, that national transport priorities were the main drivers of transport research in most of these countries; international cooperation was perceived by researchers as a very

[7] http://www.eutrain-project.eu/.

attractive opportunity to expand their capacities, to reduce their dependence on limited national funding sources and to get involved in long-term, strategic and global challenges. However, it was not possible to define a precise road map to move in this direction; researchers' lobbying of their national governments was seen as the only practical way to move forward, as there were no global players identified to play a leading role.

The EUTRAIN project made a number of recommendations (EUTRAIN Consortium 2013), among which:

(a) Adopting new funding schemes such as joint programming, twinning of projects and creation of special funding entities.
(b) Benchmarking and harmonization of governance, programming and funding.
(c) Increasing global networking, including an international cooperation observatory, and a global network of "international cooperation champion" organizations in specific scientific fields of transport.

The EUTRAIN work did not pay much attention to the third player: the industry (or the users, to put it wider). Indeed, it considered the industry as a relevant player, but mostly from a funding perspective (private vs. public funding). The industry probably has an ambiguous role in the bilateral government-researchers relationship, as it has the capacity to play both roles: as direct or indirect funder (i.e. channeling towards researchers public funds received from governments, as it is the case in the modal partnerships promoted by the EU in the last decade), and as researcher (applying for public funding for their in-house research divisions, eventually teaming up with other researchers).

Another relevant project was **HERMES**[8] (*Establishing a CompreHEnsive transport Research information Management and Exchange System*) also funded under the EU's FP7 program between 2011 and 2014. It served to put in place an international transport database portal (http://intransport.eu/search/index.php) as a common entry point to information on transport research projects and their results and researchers active at the international level. This portal provides information on transport research, acting as an entry point to over 100 databases and websites and should provide in the future a database of researchers.

HERMES can be seen as a tool to facilitate international networking among researchers, and to strengthen the international transport research community. Furthermore, it could serve as a valuable tool for national research administrators and policy makers to get a broader picture of progress and challenges at the international level while developing their own national strategies. It was, therefore, basically aligned with the approach of EUTRAIN to strengthen the case for international cooperation, although with a dominant bottom-up approach.

[8] www.hermes-project.eu.

3 The Global Framework

3.1 Prospects for Global Growth and Economic Development

Figure 1 and Table 2, show the trends in GDP growth rates for the countries referred to in this book for the period 2009–2017. As shown in Table 2, the global GDP grew by almost 3.0% in 2016 and another 3.3% in 2017. The global economy continues to grow but rather at a slow pace.

The average GDP growth rates of OECD countries are slightly higher than the global ones. China shows considerably higher growth rates compared to the rest of the world, but its growth rate recently has been on the decline although still in the high percentage levels of 6 and 7% p.a.

Under such circumstances, the *World Economic Forum*[9] declared that the world ushers in the era of the "*fourth industrial revolution*", calling for the establishment of strategies for social development. It also pointed out that the ICT-based super-connected society and the fourth industrial revolution will accelerate convergence between industries, technologies and disciplines and groundbreaking innovation of science technology, further innovating and reorganizing the global industrial structure.

In particular, economically vulnerable classes, such as low-income families, elderly and disabled people, have become more marginalized due to rapid industrialization and economic polarization, and thus the role and importance of science and technology to address social issues has been highlighted more than ever. In addition, countries started to shift the focus of their national R&D projects from economic development to research and solution development that simultaneously seeks both economic development and improved quality of life.

Korea, China, and Japan as well as other countries in the Asia-Pacific region, have faced a fierce competition both within themselves and with other advanced countries such as the US and the EU.

Generally speaking, the world is going through a period of economic staginess where the global economic growth is positive but with rather modest values and countries that played the role of global powerhouses of growth and economic activity over the last decade, are likely to slow down their growth.

Surprisingly, this outlook is likely to create more incentives for international cooperation, as it was explained in the 1st chapter, because of the increased "insecurity" that is created by the low national economic output and the search for competitive advantages through the pooling of resources and getting in touch with more advanced systems of RTD&I production.

[9]In its annual meeting of 2016 in Davos-Klosters, Switzerland (https://www.weforum.org/events/world-economic-forum-annual-meeting-2016).

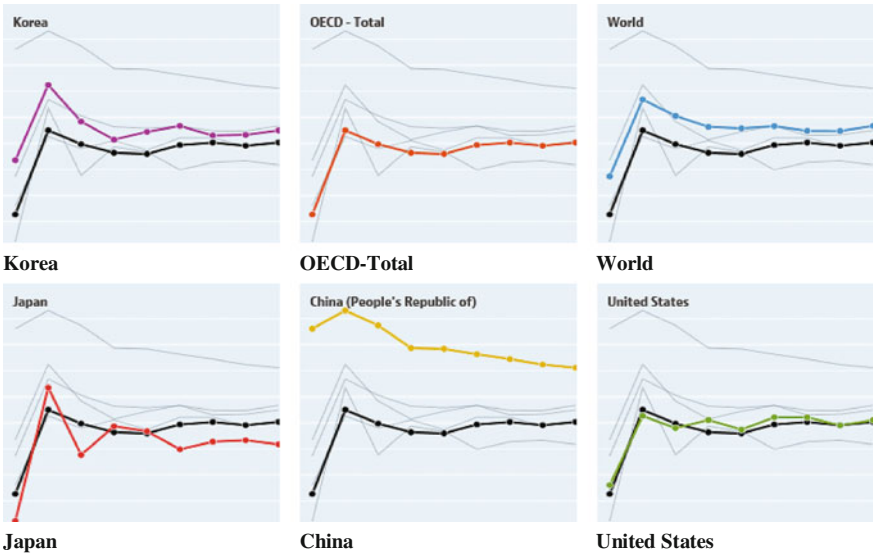

Fig. 1 Global GDP growth rates (2009–2017). *Source* OECD Data, July 22, (2016) collected and analyzed by KOTI (The Korean Transport Institute)

Table 2 Global GDP growth rates (2009–2017)

Country or region/Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
People's Republic of China	9.24	10.63	9.49	7.75	7.69	7.27	6.9	6.48	6.23
United States	−2.78	2.53	1.60	2.22	1.49	2.43	2.43	1.81	2.21
Japan	−5.53	4.71	−0.45	1.74	1.36	−0.03	0.55	0.67	0.36
Korea	0.71	6.50	3.68	2.29	2.90	3.34	2.61	2.66	3.00
Euro area (15 countries)	−4.47	2.02	1.62	−0.85	−0.28	0.99	1.57	1.63	1.74
OECD—Total	−3.45	3.00	1.95	1.28	1.19	1.88	2.07	1.83	2.07
World	−0.52	5.37	4.12	3.27	3.16	3.33	2.97	2.96	3.34

Source OECD Data, July 22, 2016

3.2 *Defining Global Challenges and Rules in the Transport Sector*

One of the key factors jeopardizing a "frontier" approach[10] in transport research is the lack of precise identification and agreement on the big global challenges that transport

[10]The "frontier approach" is a method with which economists have tried to use efficiency measurement techniques to measure the productive performance of a certain process or utility.

research should address. Embedded within many transport agents remains the perception that economic efficiency is the key challenge transport must address; a challenge many times oversimplified and addressed merely as fighting "congestion".

The term "global challenge" can be used in two different ways. In some cases, it seems to refer mainly to the economic challenges, which countries are facing due to the globalization process. In other cases, it refers to challenges that affect all countries and which cannot be solved without international cooperation. *It is in this second sense that "global challenges" can be seen as a justification for international cooperation in research.*[11]

As stated in the introduction of the "smart, green and integrated transport" section of the EU's current research framework, the H2020 program, the challenge is:

> *to boost the competitiveness of the European transport industries and achieve a European transport system that is resource-efficient, climate-and-environmentally-friendly, safe and seamless for the benefit of all citizens, the economy and society.*[12]

Attempts to identify big global challenges have been made at a number of global fora. Probably the better known ones, are the *Sustainable Development Goals (SDG)* that succeeded in September 2016 the "*Millennium Goals*" at the UN Sustainable Development Summit. Another suitable reference is the Millennium Project (millennium-project.org), launched in 1996 with the support of the UN and the Smithsonian Institute, among others. It identifies 15 global challenges, including (mentioning those closer to transport), sustainable development and climate change, global foresight and decision-making, rich-poor gap, and science and technology.

There is a general trend in research to move towards big international projects, multidisciplinar and including the social sciences, and to benefit from the

(Footnote 10 continued)

"Frontier" efficiency measurement techniques use a production possibility "frontier" to map a locus of potentially technically efficient output. To the extent that a process or utility fails to achieve an output combination on its production possibility frontier, and falls beneath this frontier, it can be said to be technically inefficient. As transport is not significantly involved in "frontier research", it has benefitted from the increasing focus for near-market applied research (Science Europe 2015). In the particular case of the EU, transport has benefited from its status as one of the "common European policies" to be funded within the successive European research programmes. Frontier research is mostly a bottom-up, long-term exercise. It goes beyond one discipline, and beyond current fundamental knowledge. It also requires particular funding rules and decision makers tolerant with uncertainty and even failure, as a high-risk effort. These conditions are mostly lacking in the transport sector. In spite of the long tradition of interaction between engineering and social sciences, which is also a remarkable asset for transport research, transport has not developed a "frontier" approach thus far (Science Europe 2015).

[11]Global challenges can be seen as associated to recent UN declarations, like the 2030 Agenda for Sustainable Development, approved in September 2015, and containing 17 sustainable development goals, including objectives such as industry innovation and infrastructure (#9); climate action (#13), which can be naturally associated to the need for research and innovation in the transport sector, etc.

[12](https://ec.europa.eu/programmes/horizon2020/en/h2020-section/smart-green-and-integrated-transport, accessed on 8 Sept. 2016).

opportunities of big data; this should be the way to address big challenges (Science Europe 2015). There is an obvious difficulty to translate any big challenges into a research agenda. With probably undue oversimplification, it could be suggested that these big challenges in the transport sector could result in a transition from the old economic paradigm of efficiency to the new integrated paradigm of low-carbon.[13] The increasing relevance of transport on GHG emissions has resulted in the low-carbon transport paradigm, which is also multidimensional, as it does not only refers to low-carbon emission technologies, but also to management and operations of the transport system reducing emissions, and to management of transport demand through better land use, location decisions, or substitution of mobility needs.

One of the most interesting dimensions of the old "efficiency" paradigm is its capacity to stimulate exponential demand growth. This has resulted in business models across most if not all service providers based on the assumption of ever growing demand that can be stimulated through low prices. The last two decades show that technological reductions in GHG emission reductions have been systematically outpaced by transport activity growth, thus requiring not only more decisive technological gains but a paradigm change.

A transition paradigm can be strongly facilitated by smooth provision of research results. Furthermore, it is dubious that this transition can be made based solely on incremental innovations. On the contrary, it seems that some degree of out-of-the-box thinking and disruptive innovation will be needed, and that a viable implementation path should be identified for disruptive innovation. This does not seem to be the general case in the transport system. On the contrary, there is evidence that the prevailing governance and institutional environment in the transport sector is strongly risk-adverse (Munro and Aparicio 2015); furthermore, the industrial and operational structure is dominated by incumbent agents with limited, at best, interest in quick implementation of disruptive changes that may compromise their dominant positions (Geels 2012).

The difficulties for disruptive innovation to be developed and implemented can be illustrated by the current situation in road transport. Disruptive proposals, such as electrification, automation or service sharing are experiencing an extremely slow and painful process towards their generalization. One reason for this is that, unlike other transport means, cars keep being, primarily, a personal consumption good. A change of paradigm radically reduces this dimension, putting at risk the position of too many incumbents and the profits and jobs associated to them.

Another key factor likely to affect international cooperation in transport RTD&I, is the definition and implementation of global rules and regulations concerning key areas of the global transport system. Such "rules and regulations" have for example been implemented in the case of the various environmental restrictions for climate

[13]It could probably better be framed as "sustainability" but this overused concept has lost precise significance. Low-carbon, on the contrary is clearly related to climate-change, which is probably the main challenge for the future of transport, and is consistent with the social, economic and environmental dimensions usually attached to "sustainable transport" before the latter lost a clear meaning and became a common place.

change mitigation and they have resulted in several key innovations for the reduction of pollutants from engines or the promotion of multimodality. This argument, is of course based on the correct meaning to the word "regulation" i.e. those universally agreed rules set to address key societal challenges. The other meaning of the word "regulation" i.e. the various administrative and legal requirements that are set by countries or groups of countries in order to serve specific "local" or "national" objectives, can be a disincentive or can jeopardize the creation of innovation, in the transport sector and in general. The absence or loosening of such "regulations" invariably weaken the dominant position of existing technologies and practices ("legacy" systems) and thus strengthen the transition to new and innovative solutions.

Regulations in the transport system have been decisive in the convergence of policies and technologies around the world. International agreements, standards and the influence of legislative solutions from one country into another have greatly facilitated emergence of an embryo of a global transport system. The transport sector has a long tradition of inter-governmental cooperation, supported by an effective networking of officials and professionals looking for practical solutions from colleagues and partners in other countries. This is not the case in many other sectors, and particularly in those which have received more attention in the last years for their innovation capacity, such as ITCs or biotechnology. On the one hand, these innovative sectors are not as constrained by their environmental impacts as transport is; on the other hand, these sectors do not require the same level of regulatory detail transport needs.

The strong physical dimension of transport activities, compared to other sectors, may explain the difficulties in translating the tradition of international cooperation in transport into actual innovation of a disruptive character. This suggests that transport needs to look for its particular model to increase its disruptive innovative capacity, presumably through stronger leadership and involvement from governments and multilateral organizations and a more collaborative approach, making researchers more influential in decision making.

4 The Nature and Changing Focus of International Collaborative Transport Research

4.1 The New Context of Transport Research

Rather than focusing on frontier topics, transport research has adopted an increasing interest for close-to-the-market applications, mainly aiming at supporting an industrial policy focused on competitiveness, particularly in Europe (Science Europe 2015). From this perspective, the profile of transport research has progressively moved away from the traits of frontier research sectors. Transport research seems to be dominated today by an incremental approach, a culture of

risk-avoidance and conservatism and a research agenda mostly controlled by the incumbent industry, with little interest in quick development and implementation of disruptive concepts (Munro and Aparicio 2015). Furthermore, the strong impact of the transport sector in many national economies, in terms of jobs—not to speak of indirect socio-economic and environmental effects—, would favor a cautious approach from policy makers, eager to avoid the incertitude associated to the quick deployment of alternative concepts and products in what is considered as a politically sensitive sector.

The current general context in transport research seems to be dominated by a short-term priority on industrial competitiveness in which research is expected to serve as a means to expand technological influence and market-control through the global acceptance of standards initially developed in one country or region. Researchers are normally asked to keep a mostly national focus, but whereas in the past, that focus was dominated by tangible—although purely domestic-transport-related priorities, the new focus is on providing justification to claim the technological superiority of national industrial products at the global level.

This approach has partially blurred the traditional distinction between policy-oriented and industrial/technological research. The former used to be associated to social science disciplines, and to a systems approach, and the latter to engineering, and a strong modal focus. Under the new emphasis on global competitiveness, policy research is increasingly asked to justify the advantage of particular technological concepts, and loses its long-term, strategic and disruptive ambitions to be partially subsumed within an industry-dominated narrative. This narrative is developed through a research agenda dominated by topics identified by the industry incumbents, and supported by a bunch of policy topics intended to provide justification for a regulatory environment and political priorities favoring the deployment of the technological concepts contained in the research agenda.

The differentiations between "frontier" and "industrial/technological" research are worth mentioning (see Fig. 2):

- *Bottom-up versus top-down*. The focus is moved here towards the agents who are setting the research agenda. Bottom-up research could potentially stimulate the generation of disruptive innovation and the expansion of the research frontier. Top-down research would rather focus on highly specific and well-delineated topics, as those typically established by the industry in their research agendas, and usually claims to be more efficient in delivering results to be actually implemented. The former promotes long-term, strategic research; the latter, short-term, incremental, close-to-market innovations. In practice, research policy seems to look for some sort of balance, and while privileging a top-down approach, is occasionally offering some channels for bottom-up research in many sectors, although rather exceptionally in the case of transport.
- *Modal versus transmodal research*. Partially linked to the policy/technological divide, as described above, although in the last decade the needs for technological developments to provide attractive multimodal services (freight logistics, integrated passenger services, and so on) seems to have made a part of the

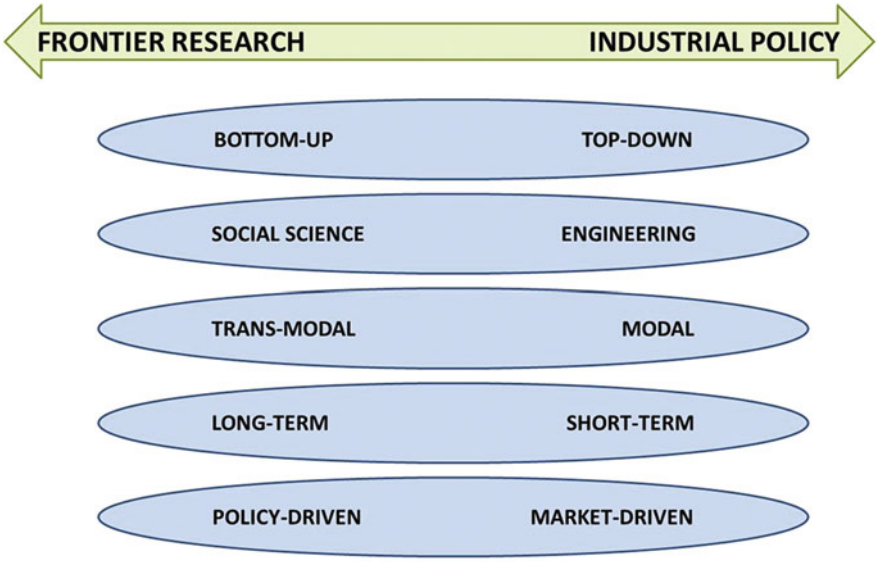

Fig. 2 The different characteristics between frontier research and "industrial" policymaking

industry more interested in the transmodal research gap. In spite of these developments, modal research largely dominates the scene, in terms of public (and private) funding, and remains seen by most decision makers as better suited for providing close-to-market solutions with gains in industrial competitiveness; therefore, transport research can be said to be led mostly by modal priorities and topics.

– *Long term versus short-term research*. Funders have become increasingly impatient towards long-term research (perceived as problem-creation, rather than problem-solving, challenging established agents' positions of comfort and requiring massive political effort for implementation). Short-term research is labelled as "problem-solving", ready-to-implementation and as industry-friendly. In terms of accountability, policy makers are increasingly concerned about providing impact metrics for the R&D budgets they administer, which also plays in favor of short-term research.

So, there is a fundamental divide, as also illustrated in Fig. 2, between "frontier" and "applied" industrial policy research. So far, international cooperation is growing mainly on an opportunistic basis, taking the most of particular hot topics, and of timely coincidence of research project objectives in different countries. Without big global challenges clearly identified and taken as a high priority by decision makers, the chances for frontier transport research to thrive remain limited.

A long term sustainable international transport research cooperation program should be based on a "menu" of long and short term research projects including research seeking incremental gains as well as research looking for breakthroughs. It should also include research support activities and a complete package of technology transfer and innovation producing activities i.e. fulfilling "industrial" policy making goals. The organizational scheme that works well for one menu item may not work well for others; so as a result, there may be diverse research program organizational schemes in each case which will have to be employed.

4.2 *The Case of "Legacy" Versus "Transformational" System Research*

With reference to the distinction between "legacy" and "transformational" systems that was discussed in the 1st Chap. "The Case for Transport Research Cooperation with China, Japan, Korea—Rationale for This Book and Summary of Its Findings", the transport research description made above would fit well with the characteristics of innovation in a "legacy sector", as also described by Bonvillian and Weiss (2015), i.e.: "innovation in transport would be dominated by a handful of well-established incumbents, focusing on those incremental changes that could accommodate users' and society's needs without compromising their position. In legacy systems, transformative, revolutionary changes are exceptions, made possible under unusual circumstances".

One interesting question is whether anything close to those "unusual circumstances" is likely to happen anytime soon, or has even been quietly evolving in the background. Progress in electric vehicles, ITCs and big-data management and analytics, new mobility concepts (vehicle sharing, multimodality) and new business models (the so-called collaborative economy) would be providing the necessary building stones for a radically new transport system, for the time being expanding only slowly in a few cities, but with huge potential to dominate urban mobility in the next decade (OECD/ITF 2015). The fusion of the autonomous vehicle technology with the electric vehicle concept, and the disruptive "mobility platform" it offers, would provide the moving force for the next transport paradigm (Canzler and Wittowsky 2016).

The availability of disruptive technologies is a necessary but not a sufficient condition for revolutions to occur: They need some triggering factors, and for a time it was considered that oil scarcity and climate change awareness could together get the transport sector away from its comfort-zone (Gilbert and Perl 2010). The experience, so far, is that these expectations have failed to materialize for the past two decades. Furthermore, an alternative transport paradigm would require deep changes in people's mobility behavior. Much has been told about new attitudes among urbanites and particularly among young adults making extensive use of their smartphones as a way to increase their social connectivity without needing to rely on a private car, which would no longer be the quintessential object of consumers'

desire; however, these trends at best co-exist with the evidence of consumers' preferences for SUVs and other *gas-guzzlers*, cooling down expectations about a quick generalization of alternative mobility concepts among our societies (Canzler and Wittowsky 2016).

Beyond the necessary emergency and growth of new mobility concepts, at least two conditions seem necessary for the transport revolution to occur: on the one hand, the expansion of low-mobility lifestyles beyond young urbanites; on the other hand, the phasing out of ICE vehicles, at least in their most outrageous *gas guzzling* versions. It seems that none of these conditions are likely to materialize anytime soon without more decisive action from governments.

4.3 Top-Down Versus Bottom-up Approaches in Triggering International RTD&I Cooperation

The factors triggering international research cooperation can be roughly categorized in two main groups: Those related to policy makers or to government at large, and those related to researchers. The first results in a top-down process, in which government officials from different countries establish a collaborative framework, usually on the grounds of economic or diplomatic objectives, and offer it to researchers. The second results in a bottom-up process, in which personal networking is progressively institutionalized by research organizations, so that the research communities in the countries concerned lobby their respective governments for support and resources.

The merits of a top-down approach to international cooperation in research are generally linked to two key objectives, the search of enhanced industrial competitiveness and the necessity to address emerging global challenges that seem intractable at the national level (Boekholt 2009). The compatibility between these objectives is far from obvious. In fact, it does not seem difficult to imagine situations in which the search of industrial competitiveness may result in making global challenges even more difficult to deal with. The fact is that there is not a precise definition of what the "global challenges" are. It is difficult, therefore, to reach agreement on the kind of industrial competitiveness that could be put at the service of a strategy facing those global challenges, and about the research agenda and efforts, which could provide the necessary support.

It is also difficult to establish how the objective of industrial competitiveness, which looks as intrinsically selfish and nation-focused, could be made compatible with a collaborative research effort with other governments. At the very least, it can be said that those countries with weaker industrial and research structures could be concerned about increasing their dependency if they engage in international cooperation, and receive any cooperation proposals suspiciously, at best.

Any type of international cooperation in research is likely to interact (and eventually interfere) with the development strategies and paths that the countries

have set for themselves; in fact, innovation is usually seen as a crucial component of such strategies for developed and emerging economies alike. In any domain—and transport is indeed a good illustration of this pattern—countries focus their research policies on the domestic market, taking into consideration the needs of research buyers (governments, industry…) and sellers (local universities, public institutions). Later on, they consider to move forward and enter the global arena, with a view to strengthening their still weak research tissues and to expand their lists of research priorities. Boekholt in (2009, p. 13) observes a similar pattern in the development of research sectors in Spain, China, and India, even if they developed at different times and rhythms. Indeed, some Asian countries, and particularly Korea and China do provide success stories about their innovation development capacity in certain sectors, including some transport areas.

The Asian experience shows the virtues of some kind of national protectionism at certain stages, coupled with cautious and increasing opening to international cooperation, as local research communities become strong enough to enter cooperation without being merely absorbed by stronger research institutions from the partnering countries. In this sense, the EU experience shows mixed results. On the one hand it is aimed at creating a single research area or market; on the other hand, innovation resources are increasingly concentrating in some countries with strong incumbent industries or research institutions, supported by a myriad of small research groups supporting them with little—if any—capacity to be influential in the policy making process.

From a bottom-up perspective, individual researchers and institutions are naturally interested in international networking as a way to expand their capacities and get feedback about them. However, their capacity of cooperation is limited if there are no appropriate mechanisms to support them. The mechanisms can be horizontal or designed for particular domains (Boekholt 2009, p. 27). Domain-based cooperation needs some kind of global champion or leader; this role can be played by international organizations (as it has been the case for the *International Energy Agency*, *IEA*), providing a consensual research agenda together with excellent knowledge of the general picture (*status quo*) in that particular domain and with proper identification of the opportunities ahead. As for horizontal cooperation, it results in increasingly similar structures and concepts applied to research policy around the world, independently of the research area.

In the case of transport research, it can be said that, although it has benefited from enhanced horizontal cooperation, it has largely lacked the kind of global leadership needed to successfully develop adequate structures for domain-based (i.e. transport-specific) international cooperation. No stakeholders, such as global industries or multilateral institutions have been interested or able to play such leadership role. The dichotomy between frontier and applied research could become less acute in the transport sector, as a consequence of the natural orientation of transport research towards real-life applications.

A number of remarks is worth making relative to the above:

- There is a distinct difference between researcher-driven and practitioner-driven bottom-up research programs. The former (like for example the U.S. National Science Foundation research) does take on longer-term, higher risk topics. The latter (like for example the US/NCHRP program) generally aims at incremental improvements and problem solving. In each case the money comes from the top, but the project proposals from the bottom.
- Top-down research can certainly be organized to address specifically longer-term, high risk, potentially high pay-off topics like for example the US/DOD's DARPA program.
- Although there is considerable common ground for international cooperation on issues related to the private sector and industry competitiveness, there is certainly a lot of common ground for international cooperation on topics related to publicly provided infrastructure, planning, and policy.
- It might be worth considering the impact (biases) of sponsoring research via transport operating agencies as opposed to centralized research/science government departments of ministries. One might argue that the former look for more immediate results but generally have technically well informed staff and understand the challenges of implementation. On the other hand, generalists who may tilt toward policy-related topics because they understand them better than topics that are more technical sometimes staff centralized agencies.

4.4 Important Distinctions and Maladjustments to Consider

Following Ulnicane (2015), cooperation can be defined mainly as "division of labor". This can also be applied to research projects or to research strategies and roadmaps. While collaborating, researchers are providing the results of intertwined tasks to a common objective while governments (or policy makers and other stakeholders from different countries) are jointly addressing the governing issues of an ambitious research agenda.

Transport can learn from other research areas where international cooperation has thrived in the last decades, with active support from governments like e.g. in medical research. For these areas, international cooperation has been articulated around multiannual road maps, as those agreed by the EU with countries such as South Korea, USA, China and Japan (The RS 2016). Interest in cooperation was fueled by attempts to reduce trade barriers, as globalization kept expanding.

Heinze and Kuhlman (2008) revised the changes in the institutional and organizational conditions under which scientific research has been made in the last 30 years, with a focus on frontier research. One of the most relevant changes have occurred in the profile and traits of research agents. Whereas in a handful of countries public research institutions continue to dominate the landscape, in others those institutions have vanished or at least greatly diminished their capacity. They seem to have been replaced by a myriad of small teams at universities, most of them struggling to get funding for projects and competing under "quasi-perfect" market conditions, with little if any bargaining capacity, and almost none political influence

in the research policy process. Some of these small players try to increase their influence by creating networks and clusters, eventually becoming virtual research centers. However, their political influence remains limited, compared to big institutes, and even more so at the international level: Big institutes have considerable core funding (and therefore, much higher capacity to face risks associated to innovation) and much more resource flexibility, provided they have lead capacity in research and they benefit from effective administration. Whereas big institutes are probably the ideal environment for researchers to get involved in international cooperation with a "disruptive" ambition, small research groups keep struggling with the effects of budget cuts and the limitations of their regulatory structures (e.g. the negative effects of self-control of academic and research careers).

Furthermore, there are a number of maladjustments in the research domain. The most obvious one may be the institutional mismatch between research "fields" and research "spaces". Research "fields" refers to the relatively independent sets of research topics receiving attention from the research community. Research "spaces" refers to the concrete institutions conducting or supporting research activities. Research fields are increasingly of a global nature, whereas research spaces remain mostly national and even local in many cases (Ulnicane 2015) and (Nedeva 2013). In the case of transport research, this mismatch sector can be particularly acute, as research fields were traditionally of a local scope, well-adjusted to a research space of a strong local character, whereas the transport research field became increasingly international only in the last couple of decades.

Other maladjustments refer to relationships among countries and among researchers:

- *Among countries*. International cooperation makes countries to face hard choices, particularly for those struggling to develop their research capacities. International cooperation is many times unbalanced, with one leading country reaping most of the benefits, and followers or associated countries merely providing support with low added value activities. Less advanced countries may have a difficult choice to make between two strategies: short-term "factor accumulation" (i.e., breeding the conditions to increase their research capacity) and long-term "knowledge creation" (Park et al. 2015). Under the first strategy, countries usually subordinate themselves to technology providers, which facilitates the achievement of short-term goals at the expense of giving in and forget about their long-term ambitions for research leadership. As the experience of China and Korea, illustrates, it seems possible nurturing own R&I entities, although this may be initially conflicting with international cooperation, understood in the usually broad, "open market" way. Indeed, the international cooperation experience within the EU, which is following that open, market-based approach, shows the risks of consolidating a hierarchical, center/periphery model dominated by a handful of major research institutions and incumbent industry in a few countries.
- *Among research agents*. There are many differences among the research activities and results that can be achieved by small university teams compared to big public research institutions (Heinze and Kuhlman 2008). Many technological fields in transport are difficult for universities to address, and seem better suited to bigger public research institutions (Park et al. 2015); these institutions are also

better suited than small teams to fill the gap between basic science (university) and technological development (industry). On the other hand, small teams are more flexible, and need much lower public support and funding. In the field of transport, governments have moved in different directions, with some countries privatizing or dismantling their public research institutions in the transport sector, others keeping those institutions while pushing them to get an increasing part of their funding from the market under competitive conditions. In just a few countries consolidating and reforming their public research institutions occurred in order to be able to play a bolder role at the global scale.

Maladjustments can also be found at the funding and resource-provision levels. Although there is a relationship between international cooperation and excellence, at least in terms of impact, and most researchers are very aware of the advantages of international activity for their careers, it is not easy for them to get the necessary resources. The convincing of decision-makers to provide those resources seems extremely difficult, if they manage to reach those decision makers at all (Jeong et al. 2014). Funding shortages are exacerbated by the trend to move from an institutional-based, fixed funding model to a project-based, flexible and variable model (Ulnicane 2015). Funding on a project-by-project basis inhibits flexibility, long-term thinking and risk-taking. There seems to be a need to move away from the current short-termism, fragmentation and project-focus in transport research.

Finally, international cooperation activities may unsettle the autonomy of the scientific field and change the power-sharing balance. International cooperation can therefore be seen as a threat by incumbent agents (industry, research organizations, even policy makers), poorly adjusted to accommodate to a rapid change transition towards new transport paradigms (Lebeau 2016).

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