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Exploitation of IT research results and the creation of innovation in the context of collaborative Transport R&D projects

A Thesis submitted for the Degree of Doctor of Philosophy

by

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Abstract

When looking at European research Programmes over the last 20 years or so, one realizes that the conditions and mechanisms that will induce the research performing Organizations to initiate or facilitate the implementation of their research results are largely not understood and certainly not in place. As it is documented in the literature review, currently there is relatively little progress or attention being paid to the necessary steps for the exploitation of research results. Therefore, building the environment that will facilitate the exploitation of such results within a research producing entity and knowledge of the factors that will affect it, becomes an important condition for the ultimate production of innovation. This realization and the author's own experience with involvement in R&D projects that created results of a technological nature with innovation producing potential but which were largely left unexploited (five such projects are summarily described in the Thesis with emphasis on their "innovation potential"), was the initial motivation for this research.

By investigating the current state-of-the-art and current experience, it was also evident that we should concentrate on publicly funded research as this type of research funding is primarily in need to "induce" research implementation. It is also more interested in the non-tangible results of research activities that relate to the social values and the well-being of society, i.e., issues that do not provide the necessary economic justification for research results implementation that is the key motivation of privately funded research. Furthermore, publicly funded research deals with large collaborative research projects whose many partners often do not agree or do not have the same motives concerning implementation and the mechanisms concerning their decisions are not well understood. The specific field of Transportation was chosen as the field for our analysis for several reasons: First, it is currently one of the most innovative sectors worldwide. Secondly, it is one of the largest economic sectors in Europe accounting for almost 5% of its Gross Domestic Product (GDP). Thirdly, it is an area where governments are particularly committed. Fourthly, Transport innovation still remains hampered by legacy systems and outdated practices which create a specifically difficult environment for the implementation of research results and finally, the research results that come to the fore in the field of Transportation have the real possibility of bringing changes on a scale and importance that fully justifies the need to understand and support the mechanisms that will induce innovation. Most of the above arguments are particularly valid for the fields of

Transportation in which *Information Technology* (IT) is a fundamental enabler, and these are the so-called *Intelligent Transportation Systems* (ITS).

Thus, the main objective of this PhD Thesis is *to investigate the factors and conditions that influence the exploitation of IT research results and the consequent creation of innovation* (i.e. market induced implementation of research products) *in the context of publicly-funded collaborative research project in the Transport sector, focusing on ITS* (Intelligent Transport Systems).

Our chosen methodological approach aimed at addressing three research questions that closely relate to the main objective of the Thesis. The first research question focuses on the *inherent characteristics of the Organisation* as factors that can influence its ability to exploit IT research results and induce innovations successfully. The second research question focuses on the *aspects of the research project* as determinants of an Organisation's exploitation and innovation potential. The third research question focuses on the characteristics of the "subject" of the research, i.e., the *attributes of the research-context* and examines the potential effects on the Organisation's ability to commercially exploit the research results of the project.

The methodology chosen to address the research questions consisted of two phases. The first phase of the methodology was exploratory in nature and primarily employed qualitative research methods. This phase focused on reviewing the academic literature to identify key factors that significantly hinder or enable the ability of the Organisation to transform research results into marketable innovations successfully. Based on the literature review, a preliminary conceptual model was created, to act as the guide for our analysis. Following the literature review, five real-life examples of Transport research projects or implemented products that resulted from such projects were analyzed, to conduct a preliminary research on the subject. These were drawn from the previous work experience of the author and their analysis aimed at further examining and identifying further issues involved with the implementation and exploitation of research results.

Additionally, eight semi-structured in-depth interviews were conducted with experts from the Transport sector in this phase. The framework of themes explored during the interviews was relevant to the variables identified from the literature review (preliminary conceptual model) and the preliminary research. The purpose of the interviews was to utilize the knowledge and experience of the experts, to "validate" our preliminary conceptual model and identify additional contextual factors that potentially alter our conceptual model.

The second phase of the methodology was explanatory and built on the results of the literature review, the preliminary research and the first round of in-depth interviews with experts from the Transport sector. This phase consisted of a mix of qualitative and quantitative methods that were employed to provide confirmatory evidence, regarding the magnitude of the effects that identified factors have on the innovation potential of Organisations conducting or exploiting research. The primary tool employed during this phase was a large-scale web-based questionnaire survey, aimed at gathering data and information regarding the whole range of factors identified as determinants of successful exploitation of IT research results in collaborative publicly funded Transport R&D projects. The final part of the explanatory phase came after a preliminary quantitative analysis of the results of the questionnaire survey. It involved a second round of semi-structured in-depth interviews with a subset of the experts from the Transport sector that were interviewed during the first phase. This part allowed us to validate and interpret our results in the context of the operational and business environment of the Transport sector and in the light of the experts' experience.

As mentioned above, the focus of our research was to identify the determinants of the implementation potential and the subsequent creation of innovation for Organisations participating in publicly-funded collaborative Transport R&D projects. To do so, we examined three categories of factors that were derived from the exploratory phase of our methodology. The first category relates to the characteristics of the Organisation conducting the original research or undertaking its exploitation. These factors characterize the internal environment of the Organisation that is likely to motivate and induce innovation through the exploitation of the research results. This level focused on examining the Organisation's *absorptive capacity*, *previous innovation record*, *experience with R&D projects*, *previous collaborations/familiarity* with projects partners as well as its *size* and *age*. The second factor category related to the inherent characteristics of the research project that can influence the Organisation in its exploitation effort. In this level, we examined factors such as the *risk* and *complexity* of the project, its "*innovation potential*", its *size* and *duration* as well as the *Transport sector* to which it belongs and whether it *builds on previous R&D efforts*. The third category of factors related to the research-context of the project. More specifically, we examined factors that relate to the technology/system that is under investigation in the project, such as its *maturity* and *relevance*, the *cost of adoption*, and related *privacy* and *standardization* requirements. Also, factors that relate to the implementation environment where the technology/system will be implemented were also examined. These covered the requirements for additional *personnel*, the *availability*,

and *quality* of required *data*, the requirements for *customization* and the *involvement* of *stakeholders*.

The findings of our analysis indicate that in terms of the effects of the "firm-related" factors, the *assimilation* and *exploitation* dimensions of the absorptive capacity of the Organisation, *previous collaborations/familiarity* with project partners, as well as the *size* of the Organisation have statistically significant impacts on the innovation potential of the Organisation. Furthermore, in terms of the "project-related" factors, while the *size* of the project was found to have statistically significant bearing on product innovations, the *risk* and *complexity* of the project, the *Transport sector* it belongs to and whether the project *builds on previous R&D efforts* were not found to have statistically significant impact on neither product nor process innovations introduced. Finally, for what concerns the "research-context" related factors of our analysis, the *relevance* of the technology/system, its associated *costs for adoption*, and requirements related to the *standardization* and *customization* were found to have statistically significant impacts on the innovation potential of the Organisation.

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1 Introduction

1.1 Definitions and Importance of the Exploitation of Research Results and the Creation of Innovation

In its oldest and simplest definition, the notion of "innovation" is defined as: "*the commercial exploitation of new ideas*"[1]. A more recent definition can be found in the Business Dictionary, as "*The process of translating an idea or invention into a good or service that creates value or for which customers will pay*"[2]. From these definitions, it is evident that the source of "innovation" can be a simple idea, or invention, or – as in most cases – the result of specific research. *Research and technological development* (*RTD*) is, therefore, the necessary first step of "innovation" and has to be followed by a series of actions and activities before its results are "translated" into a good or service that "creates value". RTD has been accepted by governments and the society alike, as the fundamental pre-requisite for economic, technological and social development and wellbeing and until recently, large sums of funding have been devoted to RTD activities. The stated aim of such (RTD) funding is, invariably, to improve competitiveness levels and create "innovation" as an essential condition for human and societal progress.

However, RTD alone is not "innovation". In all human inventions from the initial invention of fire to bronze to iron and steel production, as well as to the internal combustion engine and mechanized agriculture and to the transistors and microchips, the production of innovation required an initial idea, testing it, and then - by risk-taking and entrepreneurship - transforming it into a "product". Today, the "initial idea" is largely replaced by research and development work within large-scale research programmes. This being the case, the RTD project structures and RTD Programme architectures should allow for the development of an entrepreneurial spirit and the willingness to accept the risk that will trigger or induce the RTD processes to focus more on the exploitation of results and lead to innovation. In other words, innovation cannot be created through a "deterministic" process, i.e., by decrees of policymakers in support of innovation without at the same time putting in place the required

[1] This definition was given by Joseph Alois Schumpeter (1883 - 1950) - economist and one of the 20th century's greatest intellectuals - in his 1934 book "The Theory of Economic Development". He is the economist that became best known for his 1942 book "Capitalism, Socialism, and Democracy". See (Schumpeter, 1934) and (Schumpeter, 1942).

[2] More in: http://www.businessdictionary.com/definition/innovation.html.

policies and enabling the necessary measures and supporting mechanisms. Such measures and supporting tools should start at the stage of the research project and aim at creating the conditions for inducing implementation of its results.

Unfortunately, when looking at European or US, research Programmes over the last 20 years or so, one realizes that although their creators pay lip service to "create innovation" as a main aim, the mechanisms to facilitate research results implementation and initiate the innovation processes are simply not there. As it is documented in our literature review, relatively little attention is currently paid to the necessary steps for the *exploitation of research results*. Building the environment that will facilitate the exploitation of research results within a research producing entity and investigating the factors that will affect it, becomes therefore, an important and necessary step and a *precondition* for the ultimate production of innovation and enabling its positive effects on development and societal wellbeing.

These are issues that need a closer look and investigation as they have not been given enough attention in the past (see our literature review chapter). Such "closer look" and investigation could change the rather loose "implementation management control" of the current RTD processes and replace it, in the future, by more entrepreneur-like thinking and actions. Doing so will ensure the continuation of the work after the end of the RTD activities in order to produce and demonstrate the benefits of innovation that can accrue from this research to the end user and also - at least partially – to those conducting the initial research. This need for closer investigation of the issues that will induce more exploitation of research results seems to be recognised now more and more in the new EU funded research and innovation Programmes. It is characteristic of this new approach that in the planning of the new *Horizon Europe*, 9th Framework Programme for *Research and Innovation* of the European Commission, the expression that is used in place of the term **RTD** (Research and Technological Development), is **R&I** for *Research and Innovation* (European Commission, 2018c).

In the following sections of this Chapter, we further substantiate the above, we pose the research questions that prompted this research study, and we justify our focus on *Information Technology* (IT) applications in the *Transport Sector* – that is embodied in the so-called *Intelligent Transportation Systems (ITS).* First, however, we describe briefly the overall innovation-related results of the current EU Framework Programme, the *Horizon 2020,* and then we give the main characteristics and elements of the new EU Framework Programme for R&I, *Horizon Europe* as they are known at the time of writing this PhD Thesis.

1.2 Innovation-Related Impacts of the EU Research Programmes

We are now at the end of the Horizon 2020 research Framework Programme of the EU and there are several mid-term evaluations as well as impact assessment studies that we can use to draw some useful insights on the results and experience of this most recent European Framework Programme. We focus on research exploitation issues and the more general impacts, based on the findings of the impact assessment study of the Horizon 2020 Programme (European Commission, 2018a). As it is stated in this study:

a) The Horizon 2020 research projects have created high added-value. Such "value-added" was defined in terms of[3] strengthening the EU's scientific excellence through competitive funding; the creation of cross-border multidisciplinary scientific networks; the pooling of resources to achieve critical mass for tackling global challenges; and developing the evidence base to underpin policymaking. Overall, as the study states, these issues increase the EU's global attractiveness as a place to carry out R&D, strengthen its competitiveness and contribute to growth and jobs.

b) The "implementation" of the current Programme is considered largely as a success. However, in spite the claims to high value-added achievements and other implementation related impacts, it is also stated (in the same study) that a number of relevant stakeholders as well as other evaluations and opinion papers by relevant European Organisations [namely: (European Commission, 2018b), (European Parliament, 2017), (European Economic and Social Committee, 2016), (Committee of the Regions, 2017)] point to the need *for more emphasis to achieving value-added and stressing that EU added value must be the primary driver for the design and implementation of the next Framework Programme*.

c) The quality and visibility of EU's scientific excellence were strengthened as shown by the fact that EU-funded peer-reviewed research publications are cited more than twice the world average. They are also almost four times more represented in the world's top 1% of cited research, compared with the overall publication output of the 28 EU Member States. Compared to 1.7% of national publications, 7% of publications arising from European Research Council-funded projects are among the top 1% highly cited in the world by field, year of publication and type of publication.

[3] Although one would expect to find more quantified data to justify this claim in the report, such data are not given.

d) Collaborative projects that were funded within the H2020 have helped to achieve "critical mass" for breakthroughs when research activities are of such a scale and complexity that no single member-state can provide the necessary financial or personnel resources. Through such "critical mass" global challenges such as migration, security, climate change, health, etc., were better addressed and this means that solutions can be found more quickly and efficiently than through national R&D activities.

e) The EU's scientific human capital has been reinforced as some 340 000 researchers have been fully or at least partly been involved in EU funded research activities. It has also been reinforced through the mobility of researchers and training actions in such as in the case of the Marie – Curie Programme actions. Here, evidence shows that the research impact of internationally mobile researchers is up to 20% higher than for those opting to stay in their home country.

f) EU R&D activities have helped build cross-sectoral, inter-disciplinary R&D networks which reach across and outside Europe. This is crucial for bringing knowledge quickly to market and gaining industrial leadership. Based on a counterfactual analysis, EU funded R&D teams had, on average, 13.3 collaborations versus six collaborations for non-EU funded ones. The beneficiary teams also have built almost two times as many collaborations with partners from outside the EU (on average, 3.6 partners from third countries versus 2.1 partners for non-EU funded).

g) EU R&D activities increased the competitive advantage of participants, for example through international multi-disciplinary networks, the sharing of knowledge and technology transfer and access to new markets. Compared with non-EU funded R&D teams, EU-funded teams grow faster (11.8% more) and are around 40% more likely to be granted patents or produce patent applications. In addition, patents produced through the EU programmes are of higher quality and potential commercial value than similar patents produced elsewhere.

h) New market opportunities were created through collaborative multi-disciplinary teams and dissemination of results. This reduces commercial risks, for example through the development of common standards and interoperable solutions and by bringing together existing markets. EU open access policies enabled quicker and broader dissemination of results to users, industries, firms (SMEs in particular) and citizens.

i) EU funded R&D activities induced the private sector to invest more of their funds than under national funding schemes, with one analysis showing a 24.6% difference in this

respect. Involving key players from industry helped to ensure that research results and solutions were applicable across Europe and beyond. This also enabled the development of EU-wide and global standards and interoperable solutions and their exploitation within the EU market of 450 million people. Based on preliminary data, public-private partnerships (PPPs) were expected to attract between 0.90 and 2.17 Euros from private actors for each Euro of EU funding invested.

The above are quite positive and impressive results that are claimed to have resulted by the existing H2020 Programme. In this respect, it is worth noting that in the H2020 the only "results exploitation" instruments that were used, were conventional dissemination activities such as workshops, Conferences, websites and similar, while there were also specialized "results exploitation" Work Packages in almost all R&D project contracts. These "results exploitation" Work Packages were evaluated during the technical audits of the projects, but there was no provision or instrument with which to monitor their implementation after the research project's contract ended. Equally important is the fact that in the first three years of Horizon 2020, only 11.6% of the research proposals could be funded. This low success rate was explained by the high attractiveness of the Programme, which led to a sharp increase in the number of eligible proposals as compared to the previous research Framework Programme FP7 (European Commission, 2018a). This underfunding represented a waste of resources for the applicants who – according to the study - spent an estimated 636 million Euros a year preparing proposals! It furthermore deterred excellent R&D players from applying and deprived the EU of the full potential of the Programme. A success rate of 15-20% and funding for at least 30% of high-quality proposals is stated as the ideal.

The continuation of the ongoing H2020 Programme is the *Horizon Europe* Programme. This is the EU's 9th Framework Programme for investments in research and innovation and covers the period 2021 to 2027. According to the planning documents of this new seven-year Programme, it is expected that through its execution the EU will (European Commission, 2018a):

- ✓ Generate more new knowledge and technologies, promoting scientific excellence and significant scientific impact.
- ✓ Continue to facilitate cross-border collaboration between top scientists and innovators, allowing for trans-national and cross-sector coordination between public and private R&D investment.

- ✓ Result in positive effects on growth, trade and investment flows, quality jobs and international mobility for researchers in the European Research Area.
- ✓ Bring an estimated average GDP increase of 0.08% to 0.19% over 25 years, which means that each euro invested can potentially generate a return up to 11 euros of European GDP gains over the same period.
- ✓ Directly generate an estimated gain of up to 100.000 jobs in research and innovation activities in the investment phase (2021-2027).
- ✓ Foster an indirect further gain of up to 200.000 jobs over 2027-2036, of which 40% are high-skilled jobs, through the economic activity generated by the Programme.
- ✓ Generate significant social and environmental impact. This is expected to happen directly through the dissemination, exploitation, and uptake of scientific results translated into new products, services and processes, which in turn contribute indirectly to the successful delivery on political priorities.

For the first time, in the new *Horizon Europe* Programme, innovation activities and tasks are taking specific and deliberate action. It is characteristic that creating innovation and supporting the "uptake of innovative solutions" is one of the five main objectives of the new Programme, which are the following. To:

1. Support the creation and diffusion of high-quality new knowledge, skills, technologies, and solutions to global challenges;
2. Strengthen the impact of research and innovation in developing, supporting and implementing Union policies;
3. Support the uptake of innovative solutions in industry and society to address global challenges;
4. Foster all forms of innovation, including breakthrough innovation and strengthen the market deployment of innovative solutions;
5. Optimize the Programme's delivery for increased impact within a strengthened European Research Area.

There are three main *Pillars* that are defined within this new Programme structure that are quite indicative of the emphases given and its main focus:

Pillar 1 - Open Science. This will focus on excellent science and high-quality knowledge to strengthen EU's science base through Actions such as the *European Research Council*, *Marie-Skłodowska Curie*, and *Research Infrastructures*. This is a "bottom-up", investigator-driven pillar, which is intended to continue to give the scientific community a substantial role. The *Open Science policy* in the EU Framework Programme is a way of strengthening scientific excellence, benefiting from citizen participation, achieving better reproducibility of results and increasing knowledge circulation and the re-use of research data, hence accelerating the take-up of R&D knowledge and solutions and enhancing the EU policy and societal impact of the Framework Programme. Overall, there is a shift in the new Programme towards a more open, collaborative, data-intensive and networked way of doing research and sharing research results, enabled by developments in ICT and related infrastructures and the increasing proliferation of data. Open access to publications will be mandatory, while open access publishing is encouraged and associated costs eligible. Beneficiaries will be encouraged by guidelines to keep enough (copy)right to self-archive but are not legally empowered to do so.

Pillar 2 - Global Challenges and Industrial Competitiveness. This Pillar will address EU policy priorities and support industrial competitiveness by integrating the *Societal Challenges* and *Leadership in Enabling Industrial Technologies* sections of the previous Horizon 2020 Programme, into five ***clusters*** as follows:

a) Health;
b) Resilience and Security;
c) Digital and Industry;
d) Climate, Energy and Mobility; and
e) Food and natural resources.

The clusters are intended to support the full spectrum of the Sustainable Development Goals, and increase collaborative research and innovation across sectors, disciplines and policy fields – boost flexibility, focus, and impact. Due to its policy focus, the pillar will be implemented "top-down", through a strategic planning process ensuring the involvement of stakeholders and society, and alignment with Member States' activities. It will also give appropriate visibility to the essential role of the industry in achieving the Programme's objectives and developing key enabling technologies for the future.

Pillar 3 – Open Innovation. This Pillar is intended to offer a one-stop shop for high-potential innovators with the *European Innovation Council* and increase cooperation with innovation ecosystems and actors. This pillar will integrate and reorganize innovation related Horizon 2020 activities, such as *Innovation in SMEs* (the SME instrument), *Fast Track to Innovation*, as well as *Future and Emerging Technologies*. As stated explicitly in the relevant documents: "Innovation will continue to be supported throughout the whole Programme, not just in this innovation-focused pillar". Especially the *European Innovation Council* is intended to help place the EU in the lead for breakthrough market-creating innovation. It will support high risk, market-creating innovation projects that do not (yet) generate revenues, to bridge the "valley of death" between research and commercialization and help companies scale up. The tailor-made support to innovators will be channeled through two main funding instruments:

- ✓ The *Pathfinder for Advanced Research* which will provide grants from the early technology stage (proof of concept, technology validation) to the early commercial stage (early demonstration, development of business cases and development of strategy).
- ✓ The *Accelerator* will support the further development and market deployment of breakthrough and market-creating innovations, to a stage where they can be financed on standard commercial terms by investors (from demonstration, user testing, pre-commercial production and beyond, including scale-up). It will place a particular emphasis on innovation generated within the *Pathfinder*, although it will also fund projects from other parts of the Programme, such as the European Research Council or the Knowledge and Innovation Communities.

The expected implications of the role played by the *European Innovation Council* include more innovation that creates the new markets of the future, more companies that scale up in Europe, higher growth among SMEs, and more entrepreneurship and risk-taking.

From the above brief description of the main features of the new *Horizon Europe* research Framework Programme, it is evident that the emphasis on innovation production is much more pronounced and substantiated through specific instruments.

1.3 Motivations for the Research and Open Research Issues

Innovation production and its related "research implementation actions" are taking a new emphasis and weight in the coming European research Framework Programme *Horizon Europe.* It now seems to form a regular part in the related policies of the governments of EU member states in support of development and societal well-being.

The first set of motivating factors for this PhD research study were *Policy-oriented*, i.e. they relate to the need to provide policy makers (at governmental as well as company levels) with the necessary scientific evidence to support research implementation and innovation policies.

The relevant "open" research issues in this respect are as follows:

i. What are the policies that can be used to promote the application of *new concepts and value-adding research results* in publicly funded research Programmes?
ii. What are the *incentives* that can be provided to research performing entities to participate in publicly funded collaborative research projects?
iii. What are the *benefits* that can be found in international cooperation in research performance and funding?
iv. How can research implementation strategies *stimulate economic growth and development*?
v. How can the number of research proposals and/or research performing entities that get funded, be maximized?

The second major set of motivating factors for this PhD research was *Academic*. These relate to the need to investigate the broader academic aspects of R&D, i.e. the elements that influence the quality of the research performed and its academic – scientific outputs as well as its implementation.

The relevant "open" research issues in this respect are as follows:

i. What are the factors that can induce the research performing entities to pursue the exploitation of the results of their research *feasibly and effectively*?
ii. What are the factors that can contribute to *post-R&D stage positive results* in creating successful commercial "products"?

iii. How can we *maximize the "value added"* of research producing entities, i.e., the value created for the Organisation producing the research?
iv. Can we define *measures of performance*, for the "exploitation potential" of a research-performing Organisation or entity?
v. How can the processes or pre-requisites for implementation of research results be *harmonized* with the need to achieve "scientific excellence"?
vi. How can we *"measure" the benefits and costs* of research result implementation actions to enable proper evaluation of such activities?

The above "open" research issues take their full meaning for *publicly funded research* and for *collaborative research projects*[4] rather than privately funded research performed by a single or a small number of private companies that are utilizing their funding for such research. We have therefore chosen to focus on these cases (i.e., *publicly funded research* and *collaborative research projects*) in this PhD research based also on the following considerations:

a. The notion of "implementation of research results" applies mainly to publicly funded collaborative research projects as it is there that most of the difficulties exist. In privately funded research projects, i.e., those performed for one individual entity or its affiliates, they are by definition oriented to implementation as this is the very reason for funding the research in the first place.
b. Privately funded research is primarily focused on the maximization of economic value-added, i.e., it is related only to question number three above. So, for the rest of the "open" research issues, we need to turn mainly to publicly funded research.
c. Collaborative research projects (which are the norm in publicly funded research) provide opportunities for better syntheses and synergies of capabilities, expertise, and combination of resources. Thus, investigating the conditions for their success is more likely to bring tangible results.
d. Data and information on which to build a sound research methodology are mainly available for publicly funded research as most usually the privately funded research results are kept confidential for the use and benefit of the entities that fund them.

[4] i.e. involving many partners who form research consortia for the execution of the specific research contract.

The time period in which this PhD research is being performed is an especially appropriate period for collecting data and addressing most of the above "open" research issues. This is because we are in the final stages of a major EU Framework Programme with a wealth of results from EU funded collaborative research projects. We are also in the planning stages of the new Framework Programme, and thus we can visualize the new policies and the points of emphasis. These EU related Framework Programmes have – for many decades now – set the pace so to speak of European research, and the relevant EU policies are likely to be followed by most member countries (as well as by others) in their research funding programmes and policies.

1.4 The Focus on the Transport Sector

Transportation is one of the most innovative sectors worldwide. The level of innovation in many areas of Transport is stunningly of a revolutionary nature. New ideas and beliefs come to the fore thereby changing our perceptions of what is possible both technologically and socially. If uniformly and adequately implemented, progress in Transportation has the real possibility of bringing changes on a scale and importance tantamount to the 19th century industrial revolution. The consequence is that we can "see" far deeper and with more acuity, the future of Transport innovation as compared to other sectors.

Furthermore, the case of Transport innovation undoubtedly follows the broad lines of development and is influenced by the same or similar factors like innovation in any other fields. However, the Transport sector also depicts some specific, internal, characteristics. For one, it is an area where there is a strong and long-term commitment of the public sector (as well as of the private sector). Its interest fuels Transport innovation whereas other sectors generally rely more on the private sector to proceed. Transport innovation is also unique in that it remains hampered by legacy systems and outdated practices.

The Transport sector is quite an essential sector in the European economy. It is one of the largest economic sectors in Europe as it accounts for 4.6 % of Gross Domestic Product (GDP) and more than 5% of total employment with more than 10 million people working in this sector (JRC, 2018). It has a substantial impact on growth and development as it enables accessibility to underdeveloped areas and regions, and it allows the transport of products to their markets (JRC, 2018). It consequently has held a pronounced position in all

EU research Framework Programmes since the 1990s. In the last two such Framework Programmes (the FP7 and H2020), the so-called Transport "challenge" was the second largest in terms of funding of the seven societal "challenges" in terms of the allocated budget. In the H2020 Programme, it accounted for 8.3% of the total H2020 funding and €6.3 billion in EU contribution.

Within the field of Transport, *Information Technology* (IT) is a fundamental enabler and the basis for creating the *Intelligent Transportation Systems* (ITS) of the future. ITS can be defined as *the applications of advanced Information Technologies and Artificial Intelligence that aim to provide innovative Transport services mainly for the "informed", safe, well-coordinated and "smart" use of Transport networks*[5]. ITS is about the:

- Application of information, data processing, communication and sensor technologies to vehicles (cars, trucks, trains, aircraft, and ships).
- Application of IT to Transport infrastructures in order to increase their environmental performance, safety, and resilience.
- Integration of all this, through the C-ITS[6] applications - for greater efficiency of the Transport system and service to the users.

Transportation Research in Europe is, therefore, an appropriate field for studying the "research implementation" issues. It is driven by broad EU based policies that cut across national borders and at the same time at the national level – by national governments or authorized Organisations - where research agendas are generally established to reflect national priorities. There is also significant integration between the strategic research agendas developed at the EU level and the national Transportation research agendas. EU based policy-making has a steadily increasing influence on national Transportation policy-making in Europe. We can, therefore, be confident to find the necessary data and information on which to base this PhD Thesis' methodology. The current author is very familiar with the Transport sector and ITS applications, as it is there that most of his professional experiences lie.

[5] This definition is a combination of the ITS definitions given in the two references:
   a. (EU, 2010), Article 4, and
   b. (Edwards & Zunder, 2018)

[6] Connected ITS.

1.5 Research Objective/Questions and Utilization of Theories

Based on the above, we can now define as the main research objective of this PhD study: *To investigate the factors and conditions that influence the exploitation of research results (and the consequent creation of innovation) in the context of collaborative research projects in the Transport sector.* In doing so, we will focus on research projects that involve applications of Information Technologies in the Transport sector that are collectively known as "Intelligent Transport System" applications.

Within this overall objective of this Thesis, several more focused research objectives/questions – that strongly relate to the open research issues that we identified earlier – can also be defined. These are the following:

- To examine whether Organisations that possess a strong innovation history, as reflected in *R&D related activities, past innovation performance, repeated participation in such projects and strong integrative capabilities* will be more likely to gain in terms of innovation from their involvement in collaborative publicly funded Transport R&D projects.
- To identify the extent to which project-level characteristics, such as whether the project *builds on past R&D activities* and *the uncertainty (risk and complexity)* that is inherent in the research project, relate to potential innovation impacts realized by participating Organisations.
- To examine whether the effects of *the technology and the environment* where the research outcome will be implemented (i.e., *the research-context effects*) relate - and to what extent - to the innovation realized by the implementing Organisation.

In pursuing the above research objective/questions, we will utilize well-established Theories originating from several academic literatures trying to take advantage of their combined use. As shown diagrammatically in Figure 1.1, Theories were mostly drawn from the academic literatures of *Innovation Management*, *Strategic Management*, and *Information Technology*. More particularly we utilized, the:

- *Innovation Management* literature for the study of the process of creating value in the Organisation through the application of innovation;

- *Strategic Management* literature for the study of resources and capabilities that the Organisation can create or draw upon to efficiently and successfully implement innovation and create competitive advantage;
- *Information Technology* literature for the study of the effects of information technology on the behaviour of Organisations and more particularly focusing on the impact that the IT artifact has on the business value and innovation of the Organisation.

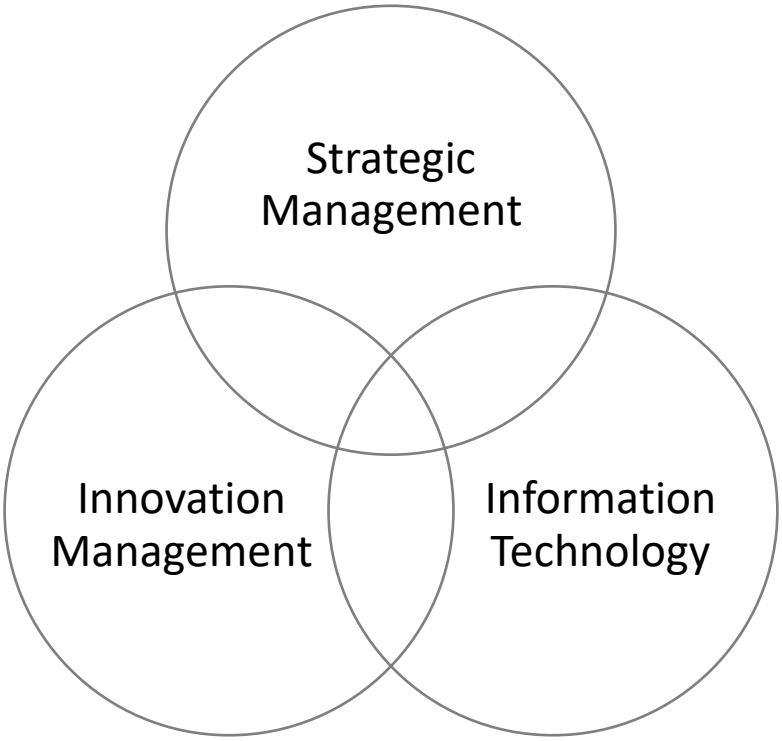


Figure 1.1: The overlapping of academic disciplines that will be employed in this PhD study.

1.6 Outline of the Thesis

The Thesis is structured as follows:

Chapter 1 – Introduction

The introduction section found above lays the foundations of the Thesis. Firstly, important definitions related to the subject area are given, and the importance of the exploitation of research results and the creation of innovation is articulated. Next, by focusing

on several mid-term evaluation and impact assessment studies, we draw some useful insights on research exploitation issues and experience of the most recent European Framework Programme (Horizon 2020). Following that, we establish the motivations for the research and formulate the main research questions of the Thesis. Lastly, we explain the choice of the context of our research, i.e. the Transport sector and present the main research objectives of the Thesis.

Chapter 2 – Literature review

The Literature review sheds light on the current practices and "state-of-the-art" of the R&D exploitation and implementation research areas, both with regards to the specific context of the Thesis, as well as for other related contexts. Furthermore, we review the literature on the importance and impacts of IT innovations, since the main focus of this Thesis is the exploitation of IT research results and the subsequent creation of innovation. Finally, we justify the need for the research by identifying important gaps in the literature that are open to further investigation.

Chapter 3 – Preliminary research and motivation

Chapter 3 includes a preliminary research on the subject, utilizing the personal working experience of the author. Five research projects / implemented products (that resulted from collaborative R&D projects) are presented in detail, focusing on the issues that were relevant to their implementation and the overarching issues that are open to further analysis.

Chapter 4 – Methodology and the research model

In this Chapter, the research methodology, the theoretical background and the research model employed are presented. In terms of the research methodology employed, we elaborate on the different phases, research methods and data collection tools that were applied for conducting the research. For what concerns the theoretical background, we present the main theoretical premises that were adopted in this Thesis, to "guide" the observation, measurement, and evaluation of our results. As for the research model, we present in detail the origins and operationalization of the dependent, independent and control variables included in our model.

Chapter 5 – The quantitative empirical study

This Chapter elaborates on the design, execution, and results of the quantitative research method employed in our research, i.e. the questionnaire survey. More specifically, a description of each part of the questionnaire survey is given together with information related to the data collection effort (i.e., sampling method, population, etc.). Following the above, we provide a quantitative summary of our sample in the form of descriptive statistics and present the statistical analysis technique utilized to evaluate the structural relationships in our research model. Lastly, we present and discuss the results of our statistical analysis.

Chapter 6 – The qualitative study based on in-depth interviews

Chapter 6 presents the findings of the qualitative research method employed in the Thesis. The results of two rounds of in-depth interviews with Transport experts (which were conducted at the exploratory and explanatory stages of the Thesis) are presented in detail, with tables summarizing the individual results at the end of each section.

Chapter 7 – Conclusions and further research

Finally, Chapter 7 presents the conclusions, contributions, and limitations of the Thesis, as well as the potential directions for further research.

2 Literature Review

2.1 Information Technology Business Value and Innovation

2.1.1 The Impact of IT in Organisations

Information Technology (IT) has typically been found to have a crucial role in assisting Organisations in conducting their business more efficiently and effectively. The implied "value" that results from the adoption of IT is known as "IT business value".

The business value resulting from the use of IT has been and still is one of the major research topics for researchers in the field of IT and IS. Most of the early studies in the specific research area have failed to find substantial evidence to support a positive correlation between the adoption of IT and increased business value, suggesting that Information Technologies provide little, or no, value to the adopting Organisation.

On the contrary, although most recent studies, seem to provide robust evidence and arguments that IT provides Organisations with both operational and strategic "value", the causal relationship between IT adoption and business value remains partly unexplained (Baker, Song, & Jones, 2008). The research area of "IT business value" is complex and it involves a great deal of uncertainty, that stems from the fact that the core constructs of "IT" and "business value" are conceptualized and interpreted each time differently, depending on the specific research context.

Defining "IT"

Information Technology (IT) as a concept can be defined in several ways. According to Orlikowski and Iacono (Orlikowski & Iacono, 2001), the IT "artifact" can be defined in terms of five different conceptualizations as summarized below:

a) The "tool view". This view sees IT as an engineered tool that does what its designers have intended for it, for example enhancing productivity. In this definition, the technology used and the technical matters that define IT (separate, definable, unchanging, and over which humans have control) are the parameters that define IT. This view first was introduced in (Kling, 1987) and (Latour, 1987). The "tool" view was represented in the literature in four different ways: as a tool for labor substitution,

a tool for enhancing productivity, a tool for information processing, and a tool for changing social relations.

b) The "proxy view". This view is based on the assumption that the critical aspects of IT can be captured through some set of (usually quantitative) measures. These measures can be classified as referring to:
    - *Individual perceptions*, i.e. IT as viewed by individual users. In Moore and Benbasat (Moore & Benbasat, 1991) an instrument is developed for assessing individual users' perceptions of the so-called "new technologies", mainly IT.
    - *Diffusion rates*, i.e. measures of diffusion and penetration of a particular type of IT such as electronic mail, within some socio-institutional context such as a firm, industry, or society.
    - *Dollars spent* to cover the costs associated with the IT tools themselves (e.g., dollars spent on hardware and software), or on the information systems infrastructure (e.g., dollars for the IT department budget).

c) The "ensemble view" which was developed to meet and satisfy criticism of the previous two views and the need that IT should be looked upon as one element in a "package," which also includes the components required to apply that technical artifact to some socio-economic activity (Kling & Dutton, 1982; Kling & Scacchi, 1982). In this view, also known as the "web of computing", additional resources such as training, skilled staff, support services, and the development of organisational arrangements, policies, and incentives to enable the effective management and use of new technologies, are included.

d) The "computational view". This view concentrates on the computational power of Information Technology being interested primarily in the capabilities of the technology to represent, manipulate, store, retrieve, and transmit information, thereby supporting, processing, modeling, or simulating aspects of the world (Orlikowski & Iacono, 2001). There are two types of the "computational view" found in the literature: The first involves the actual development of algorithms and the production of running code as applied to particular domains. The second involves the development and use of computational capabilities to create models that represent or simulate specific social, economic, or informational phenomena of interest (e.g., decision-making) (Orlikowski & Iacono, 2001).

e) Finally, the "nominal view". This view refers to IT being invoked by name only, but not in fact. Typically, in this view, the terms "information technology", "information system", or "computer", are used in the literature with no reference to the technology per se. They are used either incidentally or as background information (for more see (Beath & Orlikowski, 1994)).

Defining "Business Value"

The notion of "business value" has also been interpreted and conceptualized differently depending on the context in which it is analyzed. Researchers have used notions such as "economic value", "economic benefits" and "economic impact" of IT when attempting to define and conceptualize what "business value" is, but there are also non-financial notions that should be considered and used, to define and understand it. Such measures include the "organisational capabilities", "organisational performance", "strategic position" that a firm can adopt due to the business value gained by IT.

The concept of "IT business value" refers to the "value" that is attained by the adoption of IT by the Organisation and its definition and measurement has given rise to several research streams in the literature, the most prominent of which are presented in the following section.

Before reviewing the research streams that have focused on the conceptualization of IT business value, we should mention that there are usually three levels of consideration that play a significant role for the identification and measurement of IT business value. These are:

a) *The level of examination*, i.e. whether we refer to the individual unit level, or the firm-level, or the whole industry or the (national) economy as a whole. In each level, different variables can be taken into account as "measures" of business value. For example, at the firm-level the "IT business value" has been defined as the impact of IT on firm performance (Mukhopadhyay, Kekre, & Kalathur, 1995). Others have used the effects on productivity of the investing Organisation (Brynjolfsson & Hitt, 1996) or the creation of different profitability ratios such as the Return on Sales (Bharadwaj, 2000), and so on.
b) *The object of evaluation*. This level refers to what is explicitly being evaluated in a specific context, i.e. what will be the element that generates business value. Many researchers have focused their research on evaluating operational level variables such

as capacity utilization of specific strategic business units or broader higher-level variables such as market share (Barua, Kriebel, & Mukhopadhyay, 1991).

c) *The time of the evaluation.* This level also plays an integral part in the type of impacts that will be measured. For example, a pre-implementation assessment will provide information on potential impacts and attributes that can be defined before IT implementation and will aim to provide support to decision makers to help them decide on which of the different options they should act. A post-implementation evaluation will provide information about the actual impacts that were created by the investment.

Other than the discipline of Information Systems, the academic disciplines that have contributed to the IT business value research are the disciplines of Economics, Strategic Management, Accounting, and Operations Research. The diversity of academic disciplines scientific approaches, has greatly facilitated and enriched our knowledge in the research area but as a consequence, a shared understanding and consensus about fundamental notions has been hampered, making it very difficult to draw definitive conclusions (Melville, Kraemer, & Gurbaxani, 2004; Schryen, 2013; Wade & Hulland, 2004).

2.1.2 The Research Paradigms for Examining the Business Value of IT

The research paradigms and the theories that have been employed by researchers to draw conclusions regarding IT business value are summarized in the section below:

The Microeconomics Paradigm

- Theory of Production

From the Microeconomics paradigm, researchers have often employed the theory of production to draw conclusions about the business value that IT creates for the Organisation. By understanding in depth the production process that takes place within the Organisation, and the processes that are involved in the conversion of inputs to outputs, researchers have conceptualized the processes involved and have provided a plethora of empirical specifications that enable for the estimation of the overall economic impact of IT.

Erik Brynjolfsson in his study titled "The Productivity Paradox of Information Technology" (Brynjolfsson, 1993) utilized the theory of production to investigate the effects that IS spending had on the productivity of the Organisation. His work shed light on the reasons behind the emergence of the "IT productivity paradox" (i.e., the negative or non-existent relationship between IS spending and productivity). The results of Brynjolfsson's research were twofold. On the one hand, the author's research revealed that the shortfall of IT-related productivity that had been identified was a result of the combination of several different factors that affected productivity and not attributed solely to IT investment. On the other hand, he identified four of the leading explanations for the productivity paradox effect, namely the mismeasurement of productivity gains, the time-lags related to the realisation of value from IT adoptions, the redistribution of value among investing firms and finally the mismanagement of IT.

- Growth Accounting Theory

Another theory that has its roots in the Microeconomic paradigm and is mostly employed in industry and economy wide-level research is the growth accounting theory. In the context of IT business value, the growth accounting theory is usually adopted to identify the contributions and impacts that IT has on the economic growth of the adopting Organisations. One of the studies that employed the growth accounting theory is that of Brynjolfsson and Hitt (Brynjolfsson & Hitt, 2003). In their paper titled "Computing Productivity: Firm-level Evidence", the authors focused on the analysis of the effects of computerization on the productivity and output growth of Organisations. Based on the additional benefits that arise when computerization is combined with complementary organisational investments and change, the authors argued that the long-term benefits of IT in most cases exceed the short-term contributions. According to the authors, this is because complementary investments to IT (such as organisational investments) require time to "grow" and deliver their true potential.

Furthermore, by applying standard growth accounting and productivity measurement techniques, the authors examined the relationship between growth in computer spending and growth in output and multifactor productivity. Supporting their argument, their results revealed that over short periods of time (i.e., 1-year) the estimated contribution of computers is just equal to their initial costs (i.e., they contribute to output growth but not to productivity growth). On the contrary, as the period of time increases, the contributions from computerization also

increases substantially above the cost of the initial investment, suggesting that computerization in the long-run does contribute to multifactor productivity.

- Consumer Theory

Also based on the Microeconomic paradigm, the consumer theory has been employed by several IT business value researchers, to estimate the value from the perspective of the consumer. By doing so, researchers derived estimates of IT business value through the total value/benefit that consumers gain from the investment since they are able to purchase a product or service for a price less than the highest price that they would be willing to pay.

Brynjolfsson (Brynjolfsson, 1996) has implemented and empirically tested the consumer theory, to derive results about the value of IT in his paper titled "The contribution of Information Technology to Consumer Welfare" (Brynjolfsson, 1996). By applying four different approaches for the measurement of consumer surplus the author provided a new perspective in the IT value debate. Through the results of his study, Brynjolfsson supported his main research argument that "improvements in IT lead to large annual declines in IT effective price" and as a result, "new uses become productive, and old uses become even more productive".

Furthermore, another author that has employed the consumer theory is L. Hitt (Hitt & Brynjolfsson, 1996). The authors explained the theoretical relationships among principal measures of IT's economic contribution as well as focused on applying these diverse models in similar data sets, to address any discrepancies between them. One of their main findings was the assertion that profits, productivity, and consumer surplus are not equally equivalent. The results showed that IT appeared to enable increased productivity and a substantial set of benefit to end consumers, but there was no clear empirical connection between these benefits and higher profits or stock prices for the Organisation. The importance of these finding was that this indicated that at least some of the apparent discrepancies among earlier conclusions about IT business value were not due to differences in data sets as it was previously assumed.

The Industrial Organisation Paradigm

The industrial organisation paradigm has offered valuable insights to business value researchers as to how and why firms jointly interact in IT adoption decisions and how the resulting benefits are divided among them.

- Game Theory

In his 2001 study titled "Oligopolistic competition, IT use for product differentiation and the productivity paradox", Belleflamme (Belleflamme, 2001) employed game theory, to give explanations for the over-investment in IT that had been documented over the years and the productivity slowdown. According to this author's research, there are two factors that when combined, provide an alternative explanation for the productivity paradox.

The first factor relates to the fact that when IT investment takes place before the associated output is produced, Organisations may be in a position to use an investment in IT for strategic purposes, rather than merely to minimize costs. The second factor relates to the fact that, according to the authors' research, a growing slice of IT spending is increasingly devoted to product differentiation rather than making existing production more efficient. The analysis was based on a two-stage game model which resulted in three separate propositions which presented alternate explanations of the productivity paradox. The results of the author's research confirmed the notion that, when Organisations utilize IT for purposes other than cost reduction, it is more likely that a fall in total factor productivity will occur when the latter usage is preferred to the former.

- Agency Theory and Transaction Cost Theory

By building on two existing organisation theories, i.e. the agency theory and the transaction cost theory, Gurbaxani and Wang (Gurbaxani & Whang, 1991) created an elaborate framework to examine the impact that IT had on two main attributes of Organisations, namely size and allocation of decision rights. The authors investigated in detail the effects that IT had on the factors mentioned above, among various actors within an Organisation. These two factors were chosen by the authors mainly because the study was based on the notion that Organisation size and the allocation of decision-making authority among the various actors are

determined by the costs that are associated with acquiring, storing, processing and disseminating information. Although the theoretical framework was not further analysed or validated, their research revealed that the allocation of decision rights depends heavily on Organisational and environmental factors such as the culture and the role of IT within a specific Organisation context. Finally, further research by the authors also indicated that an Organisation would be more likely to grow horizontally and vertically if IT was used for the reduction of internal coordination costs.

- Organisational Behaviour Theory

Organisational behaviour theories have been adopted to investigate the impacts that IT has on performance and the combined effect of technology and BPR on the performance of the adopting Organisation.

Devaraj and Kohli (Devaraj & Kohli, 2000) have applied the organisation behaviour theory in the context of the health-care industry in their paper titled "Information technology payoff in the health-care industry: a longitudinal study". The substantive issue investigated in their research was the link between technology and process reengineering with profitability and quality, as well as the combined effect that technology and process reengineering have on Organisational performance. After accounting for the fact that time-lags play a crucial role in the realization of the increase of profitability and quality from investments in IT, the authors' results showed that IT contributed significantly and lead to both increased profitability and quality. Similarly to time-lags, the benefits resulting from BPR initiatives according to the findings of the study do not manifest immediately, while BPR was not proven to increase on its own profitability within the hospitals. On the contrary, the combination of IT and BPR initiatives were shown to have significant effects on the profitability of the Organisation, which only goes to show the significance and importance of such a relationship.

Strategic Management

Researchers that have employed the strategic management paradigm have in general viewed IT as a means of increasing the firm's competitive advantage or as a necessity to avoid a disadvantageous position (Croson, Fox, & Ashurkov, 1998).

One of the most prominent ways to examine the business value created by IT investments is to investigate how IT or the capability that is created by it, specifically relates to one or more profit mechanisms of the Organisation. By extending this business-level theory classification of firm profit mechanisms to the MIS domain, researchers have managed to identify the most prominent integration areas between the different strategic management theory perspectives and a variety of IT activities (Drnevich & Croson, 2013).

Four different core business-level strategy theories can be identified within the Strategic management paradigm, and these are briefly described below:

- Collusion/Coordination perspectives

Collusion/Coordination-based perspectives stipulate that an Organisations choice of, positioning and focus within an industry can greatly affect its profitability and together with its abilities to collude, coordinate, and cooperate with its rivals act as the main factors when determining the Organisations overall productivity (Porter, 1980, 2008).

In the context of this perspective, IT at the firm-level can be utilized to enhance a firm's competitive ability to create and capture value through the positioning advantages it can offer in the firm's industry and the coordination advantages in its value chain (Porter, 1980). One of the most prominent roles of IT at the industry level is that of adjusting industry/market entry and exit barriers to sustain an industry structure that is favourable to positive price-cost margins for all firms in the industry (Drnevich & Croson, 2013). Furthermore, large-scale IT investments can also act as barriers both to entry and exit (Croson et al., 1998). As entry barriers since they require significant initial capital investment from new industry entrants which may not be recovered in time and thus become damaging to the new entry, and as exit barriers since they offer very little salvage value since they are highly specialized investments.

- Governance perspectives

Governance-based perspectives suggest that the efficient organisation of the different transactions that an Organisation undertakes is the main factor that significantly affects the profitability and efficiency of the Organisation, with the main focus being in the minimization of particular costs that relate to the deviation from the ideal governance structure. An ideal

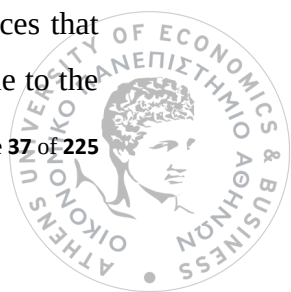
governance structure efficiently partitions activities, separating those that should be performed inside the Organisation from those that should be performed outside of it.

One of the roles of IT in the context of governance-based perspectives and theories is the actual functional use of IT to increase the efficiency with which the management of supplier networks and the monitoring and contract performance is carried out. Another role of IT that researchers have identified in this theory perspective is related to the ability of IT to change the relative and absolute size of key costs that in turn determine different governance trade-offs. Lastly, while focusing on the allocative efficiency of delegating tasks to outside agents versus the reduced profitability that occurs for the Organisation when the surplus is captured by the outside agent, many researchers have focused on examining the role of IT on the optimal number of suppliers to contract with, while accounting for performance incentives.

- Competence perspectives

Competence-based perspectives focus on the resources and capabilities that the Organisation can create or draw upon to create and capture value. An Organisation may variously inherit different types or resources and capabilities from its history, by chance or by building them through appropriate managerial action, to take advantage of the benefits they bring to the Organisation. Consequently, the focus of the theories involved within this perspective is on the effective utilization of the resources and capabilities at the firm-level, that in turn determine the profitability and efficiency of operations of the Organisation.

One of the most important theories identified in this perspective is the theory of the resource-based view. The resource-based view suggests that the basis for the competitive advantage of an Organisation lies primarily in the application of a bundle of valuable tangible or intangible resources at the Organisation's disposal (Barney, 1991; Bharadwaj, 2000; Kraaijenbrink, Spender, & Groen, 2010; Wernerfelt, 1984). Profitability in the context of the resource-based view lies in the Organisation's ability to balance between how much value it creates and how much of that value it captures. One of the roles that IT takes in this context is the support of both the creation and capture of value through its ability to digitally enhance an Organisation's existing resources and capabilities or enable the creation of new digital capabilities. The IT resources and capabilities cannot be easily imitated since when they combine with other complementary investments, they create a unique pool of resources that cannot be easily matched by rival Organisations, thus ensuring that the value is unique to the



implementing Organisation (competitive advantage). Furthermore, another important role of IT that has been emphasized by researchers is its ability to "magnify" the effects of existing inimitable and rare internal resources and capabilities and thereby increase the profits that can be created and retained from adopting such non-IT capabilities.

- Flexibility perspectives

Lastly, flexibility-based perspectives emphasize the ability of the Organisation to quickly respond to change. On the one hand, this is achieved by improving in terms of its efficiency of doing tasks (minimize the cost of adapting to a new situation), e.g. reducing the total costs of creating a product or service that delivers a given level of consumer value. On the other hand, this is achieved by improving its effectiveness (enabling the Organisation to seize an opportunity for profit), e.g. creating a new or improved product or service, thus increasing the value gained by the consumer and repricing to capture this value.

One of the theories that have been employed in the context of the specific perspective is the theory of dynamic capabilities which according to Teece (Teece, 2007; Teece, Pisano, & Shuen, 1997) emphasize on "the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments".

Furthermore, another theory that has been widely used in the context of the flexibility-based perspective is the real options theory which enables a firm to evaluate its IT investments under high uncertainty, thus providing the firm with a characterization, regarding the inherent flexibility of the firm's stock of resources. In the above setting, IT supports an Organisation to identify and exploit new opportunities. This is achieved by providing more information to decision makers while more importantly, by supporting the Organisation with the necessary complementary information regarding which opportunities should be pursued and which should be avoided.

2.1.3 IT and Innovation

One of the first attempts to relate the level of IT investment in a firm with its innovation potential was the research reported in (Kleis, 2004). This work, involved the collection of data from a questionnaire survey among some 500 firms and the analysis, by regression, of the

correlation between IT investment and the "R&D productivity" as measured by the number of patents issued weighted by the number of citations given to the published R&D results. The outcome of that research indicated that there is a negative marginal impact of overall IT investment upon the productivity of R&D. The same research states as the main reason for IT investment in a firm the increase of profit-making or to facilitate a new business strategy. These results were surprising, given the information-intensive nature of innovation, but were explained (by the authors themselves) by the fact that: a) in the survey it was not clear what portion of overall IT investment was devoted to R&D; b) there are always complimentary investments that may affect considerably the R&D results implementation; and c) patent statistics may be useful as an index of output but do not tell the whole story of a firm's innovative capacity. However, they may express the initial state of affairs as, since then, the nature of innovation has undergone considerable change in most industries. Digital technologies are being embedded into an ever-increasing range of products and services, expanding the role and relevance of IT in any innovation.

Not surprisingly, these trends are reflected in the research conducted on IT and product or service innovation after 2004. In a 2012 publication, Kleis et al, analyzing annual information from 1987 to 1997 for a panel of large U.S. manufacturing firms, found that a 10% increase in IT input is associated with a 1.7% increase in innovation output for a given level of innovation-related spending (Kleis, Chwelos, Ramirez, & Cockburn, 2012). This relationship between IT and innovation production is robust across multiple econometric methodologies and is found to be particularly strong in the mid to late 1990s, a period of rapid technological innovation. Further work referring to this period also provided empirical evidence regarding the impact of IT as an innovation enabler (e.g., Durmuşoğlu & Barczak, 2011; Pavlou & Sawy, 2010).

A somewhat narrower focus was adopted by certain studies which applied specific IT concepts and constructs to understand better the collaborative structures and work processes that underlie product development (e.g., Bardhan, 2007; Chen, 2007). In these studies, IT appears as a catalyst for better organizational structures that in turn facilitate R&D implementation, exploitation and ultimately production of innovation. Different studies of the same period have focused on how specific IT tools and applications[7] are deployed to enable various product development activities. These studies have helped to establish the empirical evidence necessary to support the view that the use of appropriate IT tools and applications can

[7] For example: Product Lifecycle Management - PLM, data mining tools, decision support systems, etc.

enhance the efficiency and effectiveness of product development activities in a firm through the interaction between these digital tools and other organizational resources and mechanisms in the product development context (Hewett, 2009; Malins & Liapis, 2009; Nambisan & Baron, 2010).

The whole concept of the interaction between IT and innovation was put in a practical conceptual and operational framework by Prof. Nambisan of the University of Wisconsin-Milwaukee, who developed such a framework concerning the role of IT in creating product or service innovation (Nambisan, 2013). This framework is shown schematically in Figure 2.1. It considers the dual roles of IT as *operand* and as *operant* resource of innovation. *Operand* resources (often tangible and static) are those that an actor acts upon to obtain support for executing a task. *Operant* resources are those (often intangible and dynamic) that act on other resources to produce effects, i.e., they act or operate on other things rather than being operated on[8].

IT's role as Operant Resource	***Digital tool as a trigger***	***Digital component as a trigger***
IT's role as Operand Resource	***Digital tool as an enabler***	***Digital component as an enabler***
	Impact on Innovation Process	***Impact on Innovation Outcome***

Figure 2.1: The frame of examining the role of IT in innovation according to (Nambisan, 2013).

Figure 2.1 shows the two roles of IT as operant and operand and as "tool" or "component" and how it relates to *Innovation* as a *process* or an *outcome*.

Prof. Namibian's analysis revealed the advance that has been made in understanding the role of IT as *operand* resource of innovation and the considerable opportunity that exists to explore the emerging roles of IT as an *operant* resource in innovation. It also emphasized the need to make careful choices regarding the research topic and its theoretical perspectives (when

[8] For a more detailed explanation of *operant* and *operand* resources, see (Vargo & Lusch, 2004).

performing R&D within a firm) in order to enhance the potential impact on, and contribution to, the product/service innovation process (Nambisan, 2013).

Focusing now on the IT and innovation dynamics for the Transport and Logistics sector (TLS), an interesting study has been reported in 2010 based on a collection of data from a number of Spanish TLS companies and their analysis using regression within the conceptual framework of the so-called SCP model (Structure-Conduct-Performance) (Hidalgo & Albors, 2010). Based on evidence from this study, it was reported that:

a. Changes in the share of employees with a higher University degree positively affect the likelihood of conducting ICT-enabled innovations.
b. Similarly, employing IT practitioners significantly increases a firm's propensity to use ICT to develop new products and services.
c. ICT intensity increases the propensity to outsource business activities and this, in turn, enables companies to redefine their make-or-buy decisions and to outsource business activities that were previously done in-house.
d. The use of applications and practices supporting the electronic exchange of information between companies (e-Collaboration tools) positively affects the likelihood of conducting ICT-enabled innovations.
e. Software use and IT drive organisational changes (as opposed to hardware). The intensity of ICT applications use and in particular IT-skilled employees are the primary drivers of organisational change in TLS firms. IT usage leads to skill-biased technological change and is an advantage for TLS firms in adopting and using innovation.
f. The implementation of new ICT and complementary investments can lead to innovations and innovations are positively associated with turnover growth. In other words, innovative firms are more likely to grow.

On the evidence of the existing literature and the results of the relevant studies reported there, there seems to exist an apparent correlation between the investment and use of Information Technologies within a firm and its innovation performance. Such "performance" is expressed both in terms of its ability to participate, absorb and implement the results of R&D and also in terms of its ability to adopt organizational structures that in turn facilitate R&D implementation, exploitation and ultimately production of innovation. This correlation has become more evident during the last 15 years or so when the process of innovation production

has become much more open, global and collaborative and involves a diverse network of partners working together and interacting within an innovation ecosystem.

2.1.4 Intelligent Transport Systems

Focusing more within the Transport sector, in the *Intelligent Transport Systems* (ITS) subsector which forms the core element of consideration within this PhD study, we need to look in more detail on how the various *Information Technologies* will relate and to a large extent enable the *Intelligent Transport Systems* (ITS) of the future. ITS have been defined as *advanced applications of IT, telecommunications, data collection and intelligent algorithms for the optimization of all travel and transport activities* (EU, 2010)**.** ITS is therefore inherently connected with IT and digitalisation, to enable the safe automation and the seamless integration of all transport and travel activities in all modes. It applies information, data processing, communication and sensor technologies to both vehicles (including cars, trucks, trains, aircraft, and ships) and transport infrastructure and transport users to increase the effectiveness, environmental performance, safety, resilience and efficiency of the transport system (EU, 2010).

Several key IT fields that are of immediate relevance and use to primary operations of ITS. The following main areas of IT applications can be stated as directly relevant to ITS in all transport modes (EU, 2010):

1. *Data access, sharing, and re-use* for the support of "connected-cooperative transport systems". The "cooperative" transport systems provide mobility, transport, and logistics services by exchanging data and information between the vehicles (V2V communication), between the vehicles and the infrastructure (V2I), and between transport infrastructures (I2I).
2. *Data handling and analysis for the functioning of the autonomous vehicles*, which will need to collect and analyse significant amounts of data from the surrounding environment through the ITS to steer safely and efficiently.
3. *Data handling and analysis for the functioning of the new shared transport services* that will be part of the future mobility-as-a-service packages in the future urban mobility landscape.
4. *Common data models and interfaces* for paperless document and data sharing and reducing administrative burdens for freight transportation operations serving the

various supply chains. The electronic handling of documents in the logistics and supply chain industries is an important step for greater efficiency and safety of future freight transport services.

5. *Effective and efficient web-based interconnection platforms* between all relevant stakeholders for the various ITS related transport services from port community systems to airport operations and ground handling.
6. *Data protection and privacy* issues will be a necessity for all ITS related applications (as also recently required by the General Data Protection Regulation of the EU).
7. *Protection against cyber-attacks* which threaten transport services as well as businesses.
8. Finally, the development of the *internet of things (IoT)* which is a vital new element in the IT landscape, will also be an essential element in the ITS of the future enabling transport managers to have a clear understanding of both the load and the vehicle's whereabouts.

There is no doubt that "intelligent" transportation is a service system based on modern information technology and that Intelligent Transportation Systems are the direction of development for future transportation systems (Jain, Zhao, Balas, & Shi, 2019). They are the model for integrating advanced information technology, data communication transmission technology, electronic sensing technology, control technology, and computer technology into a comprehensive ground, sea, and air traffic management system for all transport modes (Jain et al., 2019).

It is characteristic that the long-term vision of the European Council and the European Commission for the creation of the European "Single Transport Area" is largely digital and depends on IT. According to this vision, the *Single European Transport Area* will entail the full unification and seamless interoperability of all transport services within the EU (European Commission, 2018d). Steps have already been taken toward this direction and key examples of such steps, are the 4th Railway Package; the Blue Belt initiatives for maritime transport; the proposed Single European Sky II+ package for aviation; and the NAIADES Programme for inland waterways. In all these "packages", IT applications are referred to as the necessary and essential prerequisites.

A significant part of the *Single European Transport Area* will also be a fully responsive and "personalised' traveller information system available at real time. The extent of the developments on traveller information systems and the magnitude of the benefits will depend on factors such as market acceptance of available IT technologies to deliver information, user-perceived accuracy of the information provided and high level of accuracy in the personalized information provided (Shaheen & Finson, 2004). Ultimately, the integrated ITS and IT vision will provide the necessary operational efficiencies that will result in the comprehensive and improved transport system services expected for the future.

2.2 Transport R&D Implementation

The quest for the implementation of research results in the field of Transport (Transport R&D) started relatively late and mainly for publicly funded research. For privately funded research, results implementation is not so much of an issue because in the vast majority of cases private companies invest in research to utilize its results for their commercial interests, thus – almost by definition - implementation and exploitation for own funded company-led research is usually implemented as is most commonly the norm. The issues of Transport research implementation (for both public and private sector research) were thoroughly discussed - perhaps for the first time by public administrations that fund Transport research in a thorough and comprehensive way - in 2014 in a 2-day workshop organized by the European Commission's DG R&D and the Office of the Assistant Secretary for Research and Technology of the U.S. Department of Transportation (Transportation Research Board – TRB, 2015). Part of the proceedings of this interesting workshop were presentations of specific case studies involving cases of Transport research results implementation. Eight main "lessons" were identified by these case studies as follows:

1. *Stakeholder involvement*. Key stakeholders should be involved early and continuously in the process of implementation planning. Stakeholders play a role in communication and are often early adopters, so planning for stakeholder involvement at the outset helps implementation.
2. *Resources for implementation*. Resources for implementation should be secured. Researchers tend to focus on the up-front costs of research and not to think about the

implementation side. In a most interesting case mentioned, the US/SHRP[9] 2 Program, the research contracts devoted funding and resources to implementation, from the outset. The funding allowed was for activities such as training, pilot studies, and outreach, as well as for staffing resources.

3. *Post research Development*. Post research development is critical. Specifically, technology is often not "market ready." Technology needs pilot testing, but if there is no funding for pilots, the research stalls. The then responsible officer for the SHRP 2 Programme and current Executive Director of the TRB, Neil Pedersen, stated that funding for development should be two to three times the level of research funding to get the research market ready.
4. *Early adopters and champions*. Early adopters are valuable in getting the word out early and showing early successes of the research. Early adopters help catalyze more adoption.
5. *Overcoming institutional barriers*. Researchers should plan to address institutional barriers. Multiple layers of approval procedures, standards as well as procurement rules and regulations, come into play. Implementers of successful projects think early on how to overcome those institutional barriers and stakeholders can helpful overcome some of the barriers.
6. *Government leadership*. Government leadership can be valuable as a catalyst for change, to accelerate innovation. For example, the *Every Day Counts* program of the US/FHWA[10] shows the benefits of having the federal government play the lead role in getting research results implemented and innovation adopted.
7. *Communication*. Communication, both internal and external, should start at the research phase to get the word out and create a *pull* factor that generates demand and plants the seeds of implementation.
8. *Market readiness*. Market readiness is an important factor to exist. It is the soil, so to speak, which needs to be ready for the "seeds" of research to grow. If it is not, it is important to prepare it somehow, to implement the research.

Of interest also – and worth mentioning here – were the results of two breakaway discussion sessions in this Workshop. In these sessions, the participants discussed the

[9] SHRP: Strategic Highway research Programme.
[10] FHWA: Federal Highway Administration.

(Transport) research result implementation factors and conditions of success from the point of view of two major research stakeholder groups: the *researchers* and the *funders* of the research. The results – recommendations of these sessions, were as follows:

FROM THE RESEARCHERS' POINT OF VIEW:

1. There is a need for *funding for the implementation of research*, not just the research itself.
2. The *research and implementation stages need to be linked*. This means that the plans for implementation should ideally already begin when the research begins. Then the implementation stage should be funded to start so as to partly overlap with the research stage. This can be achieved better if one or two of the researchers are also involved in the implementation demonstration and pilot application stages.
3. Strengthen the *dissemination of the research results outside the research community*, to decision makers and end users. Publicizing the implementation and making it visible to the public is important because a knowledgeable public is likely to support the implementation.
4. The *implementation strategy* should be included in the scope of the research project as one of the "standard" work packages.
5. The *final payment* on a research project could be made available only after an "end user" is convinced of the utility of the research product and commits to its implementation!
6. Arrange for a *trusted third-party evaluation* of the research results to provide potential end users with the confidence necessary to undertake the risk of implementation.
7. Give *incentives for monitoring* the way that research outcomes are "treated" (or not treated) for a sufficient length of time after the end of the research project.
8. Facilitate *funding and admin arrangements* for the securing of Intellectual property (IP) rights. Such rights should go to individual researchers or their research Organisations and not to the (research) funding agency.
9. Provide *specialized training to all relevant stakeholders* (e.g., research designers, contractors and decision makers) on the processes and tools needed to help implement Transportation research.
10. *Perhaps most important of all*, change how the academics are evaluated and include research implementation elements in their evaluation.

FROM THE FUNDERS POINT OF VIEW

1. *Involving (implementation) stakeholders from the start of the research*. This is essential for identifying priorities and drawing up the research implementation agenda. Facilitating a close-knit partner community of funders, researchers and implementation stakeholders is of paramount importance[11].
2. *Involving researchers in the deployment of the research.* Besides involving implementation stakeholders in the research stage, the opposite is also true, i.e., to involve researchers in the deployment and implementation stages. Such, researcher participation could encourage implementation stakeholders to take or share risks. Also, the researchers could assist in setting correct priorities.
3. *Emphasizing the importance of the policy context*. The current policy context (for research implementation), is very important. It involves political stability, long-term policy perspectives and the existence of a sound regulatory environment. The obstacles to creating an innovation-friendly policy environment include the lack of enabling legislation, standards and general political uncertainty[12]. In this context, it is also important to fund research to reach standards or to affect legislation so that legislation and standards are innovation-friendly.
4. *Recognizing the importance of communication*. The need is, not just to disseminate success stories but also to raise public awareness and nurture a culture of innovation. Researchers should not just publicize the "beauty" of their research in abstract terms, but they should try to redefine the outcomes of their research in terms of representing solutions to specific societal problems.
5. *Using innovative financial tools to bridge the valley of death*. Bridging the economic "valley of death" was noted as particularly important. This can be done perhaps through loans or equity resources and by linking the research funding with implementation funding so that the funding does not stop at the doorstep of deployment[13]. For example, there could be *implementation agencies* that operate alongside research agencies. Distinguishing between demand-driven and supply-driven loans could be another way to facilitate funding over the (economic) valley of death.

[11] For example, *Transport for London* mandates that research projects must have an "implementation sponsor" in order to obtain funding.
[12] All these elements are very applicable to Greece.
[13] This was also noted in the researchers' comments.

Finally, two of the most valuable comments were also noted in this workshop:

a. Procurement activities that are based on the lowest-bid can hamper implementation. There is a need for such procurement to be based on performance rather than on compliance with technical standards. Public procurement of innovation should encourage risk-sharing among procurers.
b. For IPR (Intellectual Property Rights) the need was stressed to reconcile openness (for the public benefit of the public investment) with the protection of the intellectual property so that partners can invest in commercializing the innovation.

Focusing now, on ***privately funded Transport research***, we refer to a significant study of R&D investment of private sector companies in the European Transport sector that was performed by the *Institute for Prospective Technological Studies* (IPTS) of the *Joint Research Center* (JRC) of the European Commission – JRC/IPTS. The report of that study titled: "*Mapping innovation in the European Transport sector: An assessment of R&D efforts and priorities, institutional capacities, drivers and barriers to innovation*", was published in 2011 (Wiesenthal, Leduc, Cazzola, Schade, & Köhler, 2011). Parts of this report together with findings from other EU funded research projects were also published in a *Transport Policy* magazine paper, in 2015 (Wiesenthal, Condeço-Melhorado, & Leduc, 2015). According to the results of this study, almost 70% (65-70%) of the nationally funded research and innovation activities in Europe are performed by the private sector – mainly the auto manufacturers[14]. To give two indicative examples, the Mercedes-Benz company has invested heavily (approximately €20 billion by 2018) in electric and autonomous vehicles in Europe[15]. Likewise, Volkswagen will have committed nearly €40 billion to electric cars, autonomous driving and new mobility services by the end of 2022 (Cremer & Schwartz, 2017).

While car (and airplane) manufacturing demonstrate elevated R&D intensities[16] the rest of the Transport sub-sectors show much lower intensities, so there is a very high variation in research-affinity between the various Transport sub-sectors. According to the same JRC/IPTS study, Transport service providers and companies involved in the construction of Transport

[14] Overall, the nationally funded research effort in Europe represents almost 90% of the total research and innovation funding. The rest 10% is covered by the EU's research funding programs. So, the private sector, primarily the auto and airplane manufacturing sectors, is a major funder of Transport research and innovation activities in Europe and these activities are performed mainly by large or medium sized companies.

[15] At the same time, they have also invested approximately $1 billion in electric vehicle production in the United States (Lambert, 2018).

[16] Defined as the ratio of the R&D investment to the total firm net sales.

infrastructure have limited R&D intensities, which can well be explained by their different market environments and knowledge creation processes. More specifically, the contribution of innovative products (i.e., new to the market or new to the Organisation) to the turnover of European Transport (private) sector companies is between, 21% in the Transportation and storage sector and 41% in the motor vehicles manufacturing sector (Wiesenthal et al., 2015). For the automotive industry, the overall R&D intensity was found to be around 5%[17]. Manufacturers of civil aeronautics equipment are the second largest R&D investor in the EU Transport sector having by far the highest R&D intensity (7.8% in 2008 and 6.5% in 2011). In the waterborne Transport sector, equipment manufacturing industries invested in their R&D from 3.3 to 4.1% (in 2011). For the rail equipment manufacturing sector the aggregated R&D investments (for the 15 largest EU-based rail equipment manufacturers and suppliers) the R&D intensity ranged from 3.9% (in 2008) to 3.6% (in 2011). Overall, the JRC/IPTS study showed that the centre of gravity for Transport research and innovation investment in Europe is not in the public sector but on the private one.

However, the magnitude of R&D investments cannot fully capture the non-technological innovations that might be created as well as the exploitation of tacit knowledge, which can be relevant in particular for Transport service providers and construction companies. Thus, the level of R&D investment does not always provide an indication of the *nature* of the innovation carried out and the effort devoted to the initial stages of research result exploitation. Certain authors argue that despite the large research funding activities by car manufacturers, their innovatory research results are not fully exploited (Wiesenthal et al., 2011; Zapata & Nieuwenhuis, 2010).

For ***publicly funded Transport research***, the implementation of research results is a very much sought-after issue, with a lot of attention being paid to it in recent years. EU-funded Transport research represents a small percentage of the total publicly funded research in Europe, but it is nevertheless a "leading" public research effort in the sense that it sets the "Agenda" for many national programmes and defines the overall policies to be followed. The principal DGs in the EC that are involved in Transport research are the DG R&D&I (Research Development and Innovation) and DG MOVE (Mobility and Transport). The EC is assisted in its role as a funder of Transport research by several special bodies that advise it on matters of Strategic planning, as well as of programming and monitoring. These principal among these,

[17] At the same time there is a concentration of auto vehicle manufacturing to a few large firms (12 players altogether) which accounted for almost 90% of the total investment in 2008, and 80% of the total in 2011.

are the four *European Technology Platforms* (ETPs) in the Transport sector, the *Transport Advisory Group* (TAG) and the *Transport Programme Committee*. The ETPs that are involved in Transport research are the: *European Transport Research Advisory Committee* (ERTRAC)[18], *European Rail Research Advisory Committee* (ERRAC)[19], *Advisory Council for Aviation Research and innovation* (ACARE)[20] and Water*borne*[21] for maritime research. The *Transport Advisory Group* advised on overall Work Program contents and formulation while the *Transport Program Committee* is the official body that comments and approves the Transport research Work Program for each call. The Transport research and innovation production system of the EU is unique in the world. It is both independently driven – mainly by the relevant sector policies that are translated to "Strategic Research Agendas" - while at the same time respects and accommodates the national priorities and interests of its member countries.

Within this overall Organisational context, it is of relevance to this PhD study to refer to the results of a 2-day workshop on research implementation issues that was held on October 25th, 2013 by the Directorate General for Research and Innovation of the European Commission (Division H – Transport). The convening question of this workshop was: "*What, and at which stage of the research cycle, can we do to make better use of the results from research projects and to increase the impact of Transport research on innovation?*". The report of this workshop contains an excellent record of research implementation ideas and suggestions (European Commission, 2013). These are summarized in Table 2.1 below.

Table 2.1: Ideas and suggestions for actions to induce innovation-oriented work in research project contracts in the Transport sector[22].

PRE-PROJECT PHASE	
Proposal evaluation	➢ Evaluation criteria should consider the exploitation potential/capacity of the project. ➢ Experts with business/market expertise to be included in evaluation panels. ➢ Evaluation reports should challenge projects on their exploitation potential. ➢ Proposals should put more emphasis on exploitation and market take-up in the work plan.
Description of Work document (DoW)	➢ Road map for use of results (business plan) should be compulsory in the proposal and the Description of Work document.

[18] See: http://www.ertrac.org/ (accessed June 2018)
[19] See: http://www.errac.org/ (accessed June 2018)
[20] See: http://www.acare4europe.org/ (accessed May 2018)
[21] See: https://www.waterborne.eu/ (accessed June 2018)
[22] *Source: Newsletter issued after the workshop* (European Commission, 2013).

	➢ Work package dedicated to exploitation to be part of the work plan. ➢ Partners in the consortium should declare what will be the benefit of the results for them. ➢ Clarity on IPR arrangements as a key factor for effective exploitation of results.
Partner search	➢ Use of European Enterprise Network (involvement of SMEs). ➢ Use of European Innovation Partnerships (inclusion of application-oriented partners).
Work Programme	➢ Policy objectives should be stated clearly and possible ways to reach them indicated in the Work Packages. ➢ Expected impact to be defined and possibly quantified; ➢ Key Performance Indicators and reference baselines should be included as far as possible. ➢ Work program definition should include expected effect from deployment of results. ➢ Involvement of stakeholders: conditions for partnerships defined in the item/topic.
Partnership in consortia	➢ To include end-users (a minimum representation of 25% recommended). ➢ End user participation could be indicated as compulsory. ➢ Specific roles and competences to be requested: IPR, business, market.
PROJECT IMPLEMENTATION PHASE	
Role of Project Officer (PO)	o Create a virtual team of Project Officers (PO) and reviewers to monitor exploitation. o Added value of PO in improving the quality of the project. o Continuity of PO in follow-up to projects. o Should PO's be better trained to help with exploitation? o Allow 'qualitative' project management and more attention to the quality of information. o Improvement of templates for final and publishable report to better highlight exploitation.
Specific support to be provided	o Include a business reviewer in the loop. o Exploitation seminars and workshop during the life-time of a project. o Should there be a service available for projects to help them? o Specific support to be called in halfway. o IPR manager as specific role in the project. o The *Enterprise Europe network* (EEN) can supply market/commercial expertise.
Flexibility to be introduced	o Changes in the project work plan to facilitate an easier exploitation. o Development of standards. o Review: mid-term and final review key moment to assess the exploitation capacity of projects. o A responsible for valorization in the project team. o Link to users should be compulsory. o Link to users (industrial) is essential. o Stakeholder involvement
Exploitation plan	o Exploitation plan is crucial and should be mandatory at mid-term review. o Draft business plan as a mid-term result, to be finalized at the end of the project.
Acceptance of failure	o Research project should be allowed to fail with no major consequences.
POST-PROJECT PHASE	
Overarching issue	✓ Overview of overall program outcome.
Monitoring	✓ Ex-post impact assessment on the content (1-2 years after program).

Distinguish Project types for their: **Support to exploitation of results in different ways** **Instruments**	✓ Ex-post evaluation of program management. ✓ Follow-up of projects (1-2 years after project). ✓ Uptake of ideas/results into policy. ✓ Uptake of ideas/results in the market. ✓ Feed-back to EIP (*Enterprise Information Portal*) or EEN (*Enterprise Europe network*). ✓ Exploitation brokerage events. ✓ Prizes for good examples of exploitation. ✓ Contest for best projects in exploitation. ✓ Special call for post-project exploitation. ✓ Special financing for post-project exploitation.

2.3 R&D Results Exploitation

For the other sectors, besides the Transport sector, there are several publications on the evaluation of R&D. Two examples of such publications are of interest here. The first is (Hall & Rosenberg, 2010) which concentrates on the assessment of results of R&D performed at firm or industry-level for various types of firms using cross-sectional as well as temporal data[23]. The second is (Donselaar & Koopmans, 2016) where the authors present the results from 38 empirical studies in the EU, the US, China, Japan, and South Korea[24]. In almost all of the 38 cases examined, the impact of R&D investment was estimated to be significant and positive to boost final firm output and indirectly, innovation production[25]. For micro-level studies (i.e., at the level of the company), output R&D elasticities[26] ranged from 0.02 for a study of US companies, to 0.25 for the whole of the five regions. The mean output elasticity was estimated at 0.1. In other words, an increase of 10% in R&D investment in a company, results in an increase in sales (or value added in some of these studies) of a range between 0.2% and 2.5%, with a mean increase of 1%. At the macro-level (i.e., the economy as a whole), the mean R&D elasticity on productivity growth was between 0.11 and 0.14, i.e., an increase of 10% in R&D investment would result in an increase between 1.1% and 1.4% in productivity levels.

[23] Of interest in this reference, are its Tables 2a and 2b which give a series of results concerning R&D elasticities of output and rates of return. According to these Tables the elasticities of R&D investment (with regard to sales or value added) are ranging from 0.01 to 0.25, centered on 0.08. This means that for one Euro investment in R&D a firm should expect something like 8% increase in sales or value added (whatever the case may be).

[24] On the whole, these studies are based on meta-analyses of output elasticities of privately funded R&D, using standard techniques from basic Ordinary Least Squares (OLS) to OLS with equal weights, including random effects or random effects with equal weights.

[25] Private sector investment in R&D is not, however, always synonymous with innovation. As pointed out in (US National Science Board, 2012) many US firms introduce new products without investing in R&D.

[26] Defined as increases in sales revenue or value added, following an increase in private R&D investment.

A prominent feature in the research implementation landscape of the EU, are the various reports and Communications of the European Commission aimed at bringing together the research production and research implementation sides of the European innovation ecosystem. In 2012, the European Commission (EC) published a guidance document titled "*Evaluation of Innovation Activities: Guidance on methods and practices*" (European Commission, 2012). This document gives guidelines on the methods and practices for the evaluation of innovation activities including implementation of research results. It contains guidelines and methodologies in the following areas:

- ✓ The assessment of innovation activities by type.
- ✓ The (innovation) intervention logic and expected results.
- ✓ Indicative indicators that can be used (these are linked to the intervention logic and objectives).
- ✓ Guidelines on how to design and manage the evaluation of innovation producing interventions by type of intervention.
- ✓ Primary methods of (research implementation and innovation production) evaluation.
- ✓ A summary of key 'pointers' to keep in mind.

A more recent EC document describes the economic rationale for publicly funded research and innovation funding with specific mention of the research implementation aspects (European Commission, 2017b). Of interest also is a Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions simplifying the implementation of the research framework programmes (European Commission, 2010). This document describes the possibilities for further simplification of the research conducting rules and procedures for R&D funding and auditing that the Commission planned to implement under the then (i.e., 2010) existing legal and regulatory framework but it also described its intentions for the future, i.e. more far-reaching changes. These more far-reaching changes are of interest here as they include a "*results-based"* model of research funding using lump sums. The interested reader can find all the details in the *Strand 3* section of (European Commission, 2010). If such type of funding is introduced (and it is discussed for implementation in the next EU Framework Programme "*Horizon Europe*") then it will be easier to introduce the type of "research implementation" special funding that has been suggested and discussed in earlier sections of this state-of-the-art review.

For the research implementation (i.e., post-R&D) stage of the innovation cycle, there are also several evaluation studies that can be found in the literature in relation to the data gathered in the *Community Innovation Surveys (CIS)*. See for example, (Mairesse & Mohnen, 2004, 2010; Mairesse, Mohnen, & Kremp, 2005). The CIS surveys take place regularly in many countries. For EU countries they are carried out every two years and are called *European Social Surveys – ESS* (Eurostat, 2016). The EU-member countries' CIS refer mainly to innovation activities in enterprises and the private sector. They provide statistics broken down by country, type of innovator, economic activity and firm size. These have been used as the primary source of data to calculate the "innovativeness" of various economic sectors, by type of enterprise and to perform econometric analyses for the value of innovation as a whole. So, in a sense, these analyses are the closest we have on the overall assessment of research implementation activities in the EU (for a thorough review, see (Perkmann, Tartari, McKelvey, et al., 2013).

An earlier EU funded study called Innovation Impact (*INNO IMPACT*) assessed the factors at company-level that affect "product" and "process" innovation through a survey of 500 companies. The analysis of this survey's results was reported in (Kostopoulos, Spanos, Soderquist, Prastacos, & Vonortas, 2015; Spanos & Vonortas, 2011; Spanos, Vonortas, & Voudouris, 2015). They are summarized below in that the factors affecting company-level innovation were found to be:

1. *Integrative capability*. This capability reflects the ability of the Organisation to integrate a new technology – that is successfully developed - with other technologies within or outside the Organisation before it is a finished product that delivers functionality for commercial application. It reflects the effectiveness of an Organisation in appropriating and further developing new knowledge through pre-existing, in-house, innovative capabilities and accumulated investment in own R&D.
2. *Appropriation capability*, i.e., the ability of the Organisation to protect its innovation producing position from rivals. This is normally done through legal and competitive means (e.g., patents, trademarks and other ways of defending critical knowledge from imitation).
3. "*Project uncertainty*", defined as a combination of the "*novelty*" and "*complexity*" of the new technology. The "novelty" of technology, refers to the degree of change that the technology brings relative to prior technologies and the extent of familiarity that exists with it. The "complexity" refers to the degree of interdependence between the

subcomponents in the technology, the degree of interdependence between the technology and elements external to it, as well as the scope of the technology.

4. *Previous experience* of the company with R&D is also an important influencing factor. Building on past R&D activities makes it more likely that the research results will be further exploited in terms of innovation. Other factors that were found to have a positive correlation, although rather weak, included the:
   - ✓ Role of the company within the research consortium;
   - ✓ Size of the company (smaller companies are more likely to obtain innovation impacts); and
   - ✓ History of collaborations i.e., whether the Organisation had previous collaborative relations with one or more of the other partners in the research consortium.

Finally, specific mention should be made to a most interesting approach at inducing research implementation and industry-lead innovation in all its research funding, by the *Funding Agency for Technology and Innovation* of Finland (known by its initials in Finish: *TEKES)*[27]. An interesting and innovative (in its own right) publication that expresses this spirit of industry-led innovation and post R&D implementation in Finland can be found in (Carleton, Cockayne, & Tahvanainen, 2013). The approach in Finland is becoming quite typical in other European countries as well.

2.4 Need for the Research

From the review of published work in the field of innovation creation – summarized above – we can see that the bulk of the existing published work refers to the Research and Technological Development stage itself, i.e., the factors influencing the development of the research products and not so much their exploitation. They also may refer to the wider impacts of the R&D stage on the economy as a whole or within a specific geographic area or ecosystem and to the extent that these impacts are made through the "exploitation of the research results" stage, one can infer the extent to which such exploitation takes place and the factors that affect it. There is even less work evident by way of evaluation or assessment of the whole innovation cycle, i.e., until the production of the commercial products.

[27] TEKES runs some 20 national technology programmes in Finland, which involve about 2000 companies and 500 research units.

We also note that there is a distinct difference in the degree of interest shown and the amount of relevant work being done, for the analysis of the research exploitation phase, depending on whose viewpoint we take or who is financing the research. If it is the private sector that funds the research, it is taken almost for granted that the research results will be exploited – one way or another – since the main objective, in this case, is the commercial exploitation of the research results. If it is the public sector that finances the research, then there is a lot of interest in analyzing the factors and conditions that will affect research result exploitation and creation of innovation, since in publicly financed research the work stops after the final research report has been submitted. Most public (and to some degree also private) sector R&D funding is now being evaluated by the funding and governance bodies in terms of its potential and steps to be taken for the exploitation of its results. This is why they are now using more and more the term R&I (Research and Innovation) instead of R&D (Research and Development). The aim is to encourage research results utilization and its full market application.

However, there is little work done to analyze and quantify the factors that may influence the exploitation of the research results. The need to focus on a better-defined field of research as well as the need to further quantify and update results for this type of work was the first and primary need for this present research. By focusing on the Transport sector and using the existing experience and results of previous studies (were available), to improve and extend the theory and practice of the factors affecting research results exploitation, we are covering an existing gap in the current knowledge, and we give evidence and data for further work to be done in the future. Important questions that apply here are: How does one (funding Organisation) identify the R&D results that are likely to produce successful innovation (from the bulk of research reports and results, deliverables and outputs)? What are the influencing factors of the exploitation of the results and how can one quantify their influence? How can these results be translated into practical and well-quantified guidelines for research result exploitation?

The complexity of the overall innovation process within a sector or area, where literally tens or hundreds of stakeholders are involved (firms, contractors, equipment manufacturers, consultants and so on) makes it more suitable to concentrate in one specific sector and this present work is the first such work that focuses in one particular sector. Furthermore, the methodology used is based on a substantial collection of qualitative and quantitative data from both private as well as public sector Organisations that are involved in collaborative research

projects (in the Transport sector) in the last five years, and this can form a sound basis for future further work.

As already shown in the previous sections, the potentially positive effects of publicly funded collaborative R&D projects on the (research) participating Organisations have been studied fairly extensively (Czarnitzki, Ebersberger, & Fier, 2007; European Commission, 2017a; Hemphill & Vonortas, 2003; Spanos et al., 2015). The quantification of the innovative activities and performance that results for such research though has been rather scarce. These results tend not to be very practical in terms of their potential use by research funding Organisations. For example, among the findings of existing studies are the following factors affecting the exploitation of research results: scientific excellence of the partners involved in the research consortium; better formalization and orientation of the innovation processes especially for small and medium-sized companies; lower research risks for start-ups; enabling participating Organisations to achieve the critical mass required for breakthroughs when research activities are of such scale and complexity that no single Organisation can undertake with its own resources, knowledge or technology; etc. There is clearly a need, here, to define better and quantify such statements and give more concrete influencing factors that make for practical application of the results in terms of policy formulation, etc.

Within, therefore, the overall context of the current state-of-the-art we can say that there is a need for:

a. Clear and well-defined quantitative analysis that will define the most influencing factors for research result exploitation and will quantify the strength of their influence and impact.

b. Clear and well-justified classification of the various cases of research result exploitation within the specific field (in our case Transport / ITS).

c. Defining the conditions under which the influencing factors apply (e.g. types of research projects, funding conditions, size of consortium etc.).

d. Examining the feasibility and defining important “indicators” concerning the “exploitation potential” of a research-performing Organisation or entity.

e. Providing guidelines (based on the above) for the definition of incentives and policies on behalf of the research funding authorities that can be used to “induce” the research

providers to proceed with research result implementation actions after the end of a research project or projects.

These are the items that have caused, and fully justify, this research and these are reflected in the main research questions that were also formulated in Chapter 1.

3 Preliminary Research and Motivation for the Thesis

3.1 Involvement with Five Intelligent Transport Systems RTD Projects

The research theme selected for this PhD research is the result of the author's five years of working experience in two well-established consultancy companies involved in developing IT applications and performing planning, evaluation and design studies in the field of Transportation[28]. Part of their work involved execution of research under contracts with a funding authority - usually the European Commission (EC) or the General Secretariat for Research and Technology (GSRT). The research projects were assigned to them individually or as part of a consortium. The results of these research projects were many and varied but could mainly be classified into two types:

- ✓ New algorithms and procedures for increasing the efficiency of Transport processes, and
- ✓ New electronic platforms and software offering a specific service to users.

The normal cycle of activities involved the execution of the research work within the provisions of the contract, and when the research project ended, and the requirements of the research contract were fulfilled, the company usually turned to another project (research or otherwise) and continued to produce results according to its contracts. Any consistent follow up action on the company's research projects was usually turned down by the management due to lack of financial and human resources that were necessary to pursue the essential activities of real-life demos, business plans for the exploitation, marketing and promotion activities, IPR, etc. All these stages would have to be pursued from within the company's own resources. In some cases, these stages were possible to be executed within the frame of other relevant projects or through financing by interested users. However, in most cases, a publication in the form of a paper published in a scientific magazine or a Conference were the main follow up actions before the company moved on with the next project.

[28] The names of these companies were:

a. *Trans-European Consultants for Transport Development and Information Technology – TREDIT SA* (www.tredit.gr)
b. *Infortrip SA* - Ευφυή συστήματα μεταφορών (currently SWARCO Hellas SA).

When the circumstances were favorable - either through co-financing from related new projects, or through other sorts of financing - the management either invested additional seed money to promote the implementation or further development of a "product". A small number of such follow-up actions have turned up successful commercial products which the company has exploited commercially for many years - and still is.

To demonstrate better the issues involved, we describe in more detail five examples of research projects or implemented products that resulted from such projects. I was involved in all of them either directly during the initial research stage or at later stages in maintaining and servicing the implemented solutions – commercial products. These examples can also be thought of, as the "use cases" that provided the necessary impetus for this PhD research. They are presented in a similar format, i.e. first a general description of the product or project and secondly a brief section with comments and discussion of the issues that affected the outcome, or non-outcome (in terms of implementation or non-implementation). The cases are the following:

I. ***GIFTS***, A web-based platform for intermodal travel in freight Transport;
II. ***POD***, Proof of delivery software;
III. ***MyRoute***, an integrated portal for traffic conditions monitoring and trip planning;
IV. ***FRETIS*** – ***IFT***, Intermodal Freight Terminal Operating System;
V. ***ENVIROPORT,*** Environmental planning for ports operation.

3.2 GIFTS: A Global Intermodal Freight Transport Platform

Description

The GIFTS project aimed to develop a fully Integrated Operational Platform for managing door-to-door freight Transport in an intermodal environment (i.e., using all modes). Its initial, ambitious, tasks involved setting up a system providing a full service to freight Transport operators with applications for the operational, as well as all the e-commerce functions of a door-to-door freight Transport chain. It would include, for example, track - trace and monitoring functions for the door-to-door journey, aid in trip and fleet management as well as order matching, e-document transfer and e-payment functions. The project involved:

- Design and development of Integrated Operational Platform for door-to-door freight Transport;
- Design and development of a Central Freight Data Communication System including major functionalities and applications; and
- Demonstrations of functionalities emulating from the above GIFTS based systems.

As this project was in effect the basis for many innovations developed by the company I was working with, in later years, it deserves a more detailed description which is given below. The GIFTS Integrated operational Platform (the *GIFTS-GIP*), consisted of three main layers as follows (see Figure 3.1):

User/Client interface	This layer provided the GIFTS user/client with access to the system functions;
Application/Layer	This, included all the system functions (administration; e-commerce; operation, monitoring, and control) and the relevant software applications and data; and finally, the
TeleCom-TLC platform	This platform provided users with a basic "intercommunication" service between the already available fixed/mobile, terrestrial/satellite data communication and positioning technologies (terrestrial: GSM, and satellite: Eutelsat / Euteltracs, Orbcom, GPS, UMTS-S, Galileo).

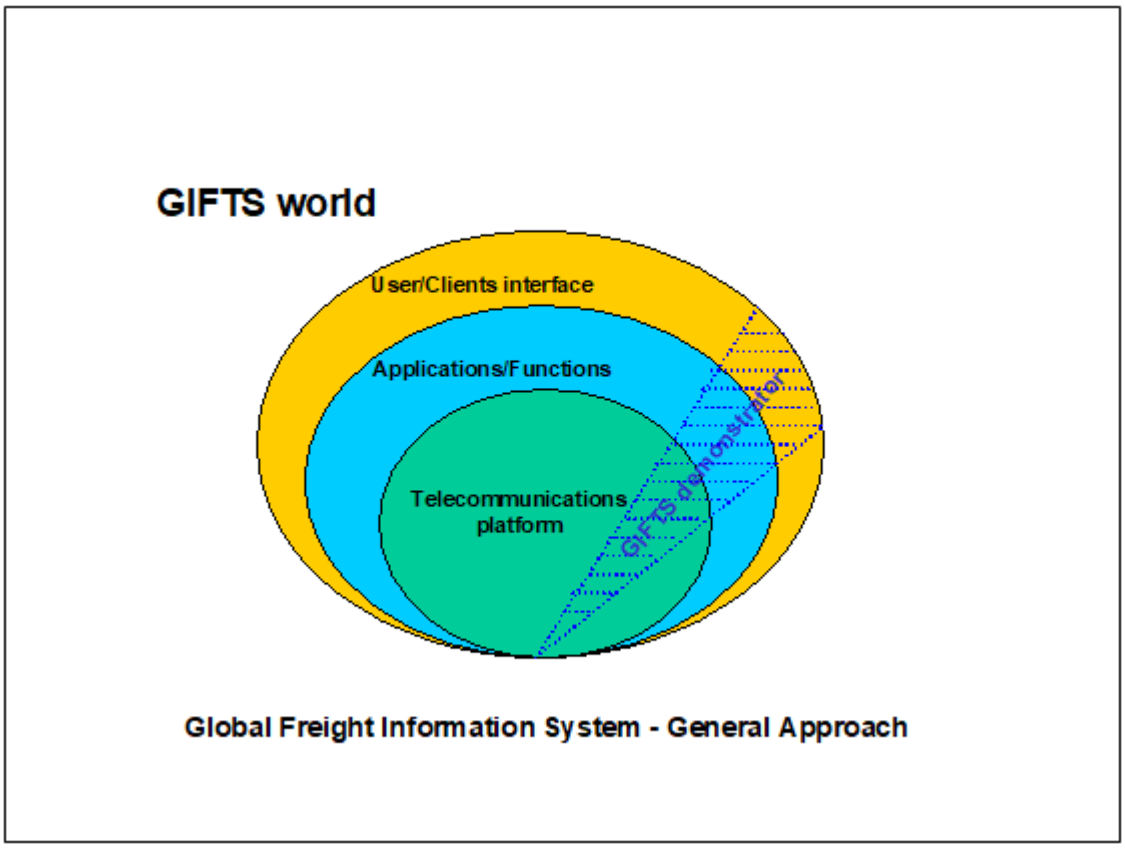


Figure 3.1: The three layers of the Gifts platform.

The overall GIFTS architecture, which followed the concept of the three layers described in Figure 3.1, is depicted in the diagramme of Figure 3.2. As shown there:

- The GIFTS user accesses the system by means of end-user terminals (mobile -GSM, satellite or a personal computer).
- The *user interface* manages the requests addressing the applicable functions in the *applications/functions* layer. In this layer, a user request is fulfilled by the software applications utilizing, as appropriate, the *data services* information (real word) that have been previously simulated in…
- …the *virtual representation mobile operators' environment* by means of a dedicated software. In the *virtual representation mobile operators' environment,* the vehicles/goods are represented by sets of information (databases) identifying univocally the status of vehicles/goods (position, type of goods, routes, etc.).
- Finally, the *links with other platforms* grant connections among other existing GIFTS.

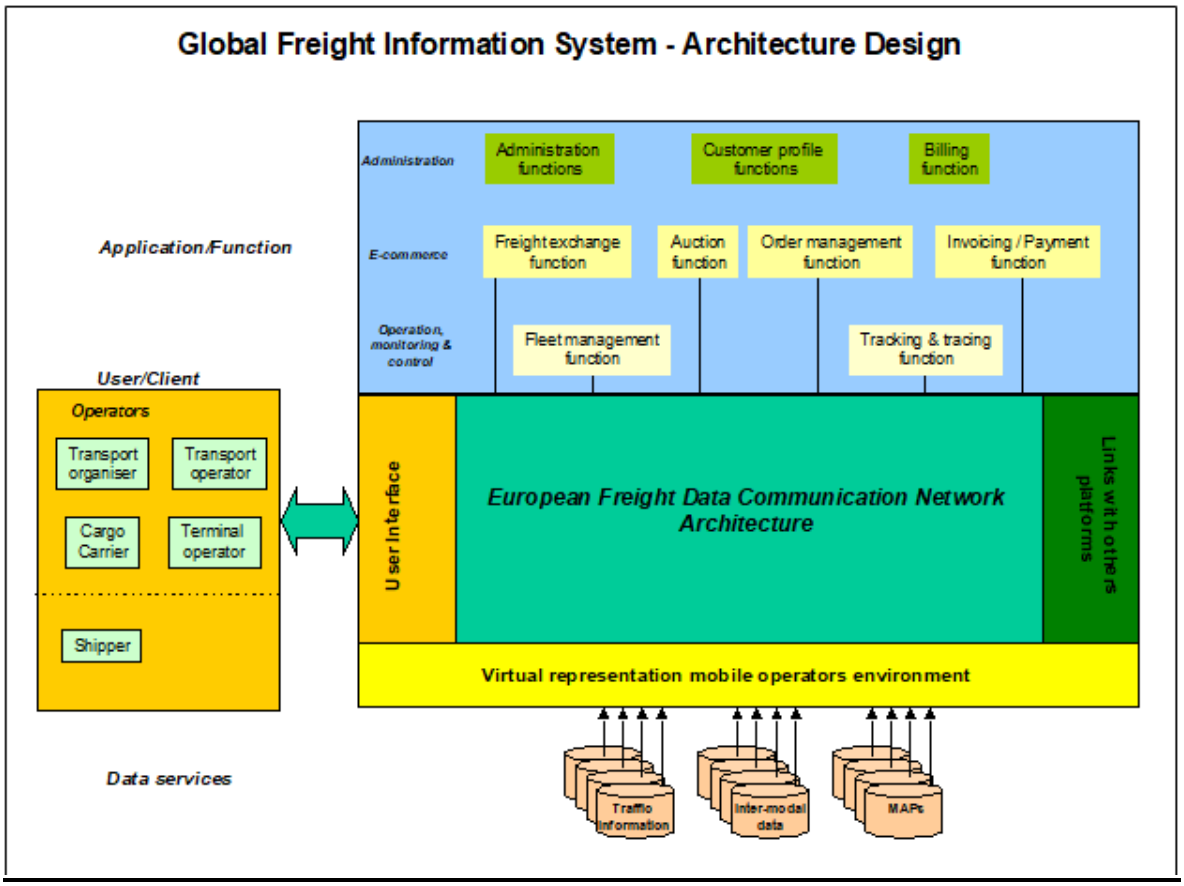


Figure 3.2: The overall architecture of the GIFTS Platform.

Three Pilot applications and trials demonstrated the functionalities and capabilities of the GIFTS platform. The first Pilot was related to the road/sea Transport corridor starting from Greece crossing the Adriatic/Ionian Sea corridor to central Europe and ending in North Europe. The second Pilot was related to a rail corridor starting from North Europe crossing the Balkans and ending in Greece. The third pilot was based on a subset of clients of a major European e-commerce, Transport insurance, and services company.

As it can be seen from the pilot trial corridors, Greece was a central point in this project and TREDIT SA – together with the Hellenic Institute of Transport which was the other Greek partner in this project – was very much involved. TREDIT SA developed a large number of the functionalities of the GIFTS platform, and it was the company that utilized this research project to create commercial innovations later on.

Issues regarding implementation

GIFTS was an earlier (2001-2003) research project, co-financed by the EC. As such, I did not have the opportunity to participate in it but retrieved it from the company's archives several times during my involvement in similar projects of latter day, as it was one of the most "fruitful" projects in terms of "implementable" results. At the time of its execution, however, its results were not pursued to produce any visible implementation in terms of a commercially attractive product, but this project influenced a number of sequel research and other projects of the company which in this way, perfected its results and later implemented them. One of these results is the FRETIS Terminal Operating System (to which I did participate) which is also described in following sections. So, as it turned out, the GIFTS platform and the Freight Data Communications Network that it developed were not implemented at the time. The part of the work that was prescribed in the contract and related to the "dissemination of the results deriving from the GIFTS approach to the relevant users" was fulfilled through the organisation of a workshop and the end-project Conference. All dissemination activities ceased after the end of the project's term simply because there was no funding for their continuation.

In effect, the main benefit to the companies involved (and in this case TREDIT SA) was the hands-on expertise that they obtained in developing an Internet-based platform and testing its various connections using terrestrial/satellite mobile communication links between a Service Centre and many user-terminals. The fully operational administration system for the GIFTS platform that was supposed to handle registration, authentication, audit trails, security, billing, and other functions was never tested in practice.

The second benefit for the company was that this project (together with some additional but limited previous experience) has put the company on the trail to work on Intermodal Freight Transport (or IFT) issues. This was done both internally (i.e., without external financing) but also externally i.e., aided from participation in additional relevant research projects. A significant contribution to the successful continuation of the company's work in this field was the cooperation it established with several related industrial stakeholders and most notably with the port of Thessaloniki - the Thessaloniki Port Authority (ThPA). This cooperation was mainly performed through joint participation in new EU funded research projects. So gradually, the attention of the company was turned to developing "GIFTS related" innovative applications for the facilitation of specific port or terminal operations – as parts of an integrated Transport chain. So, the GIFTS project acted as the seed that resulted eventually in implementations.

The main innovatory elements of the project which formed the basis for the actual creation of innovation in this field in this company in later years were the following:

1. *Innovation in the concept:* The main innovatory item was the very GIFTS concept, i.e., the "Global, reliable and open system for the integration of information, telecommunication, and management of the complete freight Transport chain". This concept, enabled for the first time, all major activities that occur along a door-to-door freight Transport chain to be included within one platform. The "openness" of the system was achieved through an innovatory design which consisted of modules sitting on a platform, with fully interoperable interfaces so as to effect integration, although they could also operate as self-standing packages in their own right.
2. *Innovation in the technologies used:* The way that the GIFTS Platform was developed and connected seamlessly to the whole spectrum of telecommunication systems that were available at the time, employed innovatory techniques in many ways. Conversion to XML format for internal communication and the GIFTS extranet was to be applied within the project.
3. *Innovation in Tracking, Tracing and Positioning:* The GIFTS Platform employed – at the time – very innovative solutions for the Tracking and Tracing of a vehicle using the satellite technologies of the European Galileo system (one of the leading partners in GIFTS was also a leading partner in the GALILEO project).
4. *Innovation in e-Commerce applications:* The GIFTS system also enabled the development of e-business and e-commerce through the logical order of events that comprised the end-to-end commercial aspects of Transport. GIFTS offered a flexible package of e-commerce functions namely: load matching, pre- and post-order processing by use of e-paper transfers, insurance brokerage, billing and payment through bank transfers and other ground-breaking functions that later became standard functions in related platforms.
5. *Innovation in Travel time forecasting by use of real-time road traffic data:* This was another "first" for this project as it recognized that regardless of all the advanced technologies for tracking and tracing or e-commerce, the problem of making correct travel time forecasts especially in road Transport poses a significant challenge for the freight carrier. The GIFTS project tested a travel time prediction formula based on real traffic data reported by a National Highway traffic control center.

3.3 POD: Proof of Delivery, Management and Monitoring Software

Description

The *Proof of Delivery or POD,* software is a product developed under funding by an interested freight Transport and Logistics operator in Greece (Proodos SA). The product was designed to fill the information gap that existed at the time during the delivery and reception process of the goods from a customer, offering real-time information about the:

- Time and place of delivery;
- Correct delivery of the products; and
- Invoicing (on-line) of the service.

The system exploited the latest PDA[29] technology and the full capabilities of both GPS - regarding information for the delivery time - and GPRS/4G wireless technologies for faster and more secure data transmission. It also provided:

- ✓ PDA with integrated barcode reader and interface;
- ✓ Ability to connect via mobile phone (GPRS/3G);
- ✓ Ability to connect to wireless networks (WI-FI);
- ✓ Bluetooth;
- ✓ Camera;
- ✓ Document Scanning;
- ✓ Integrated GPS and electronic compass;
- ✓ Accelerometer for recording vibrations;
- ✓ Use of web services to communicate with both the base of the integrated system and with the respective customer bases (WMS);
- ✓ Delivering of shipping invoice, quantity type, and individual product level;
- ✓ On-line supervisory and management tools.

The overall architecture for the POD system had the following characteristic elements (see also Figure 3.3):

1. PDA with integrated Barcode Reader and easy to use interface.
2. Possibility for connection via mobile telephony (GPRS/3 or 4G).

[29] Personal Digital Assistant.

3. Use of web services for communications.
4. Development of interoperability standards for future connections with other systems.

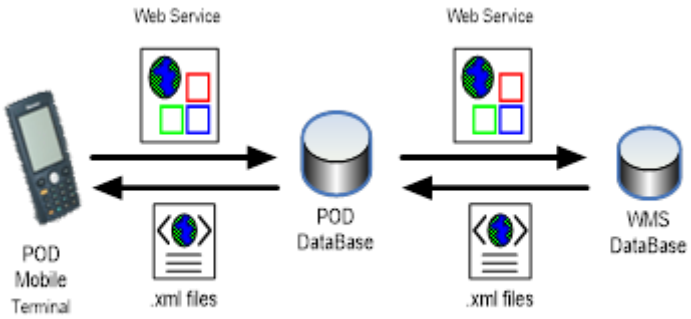


Figure 3.3: Outline of the POD system.

Issues regarding implementation

This is an example of a research product that was the result of research assigned by the company that was interested in its use and commercial application. Its implementation was therefore secured from the beginning. It is nevertheless a case of "research implementation" and not simple consulting in the sense that:

a. the outcome of the research was not certain that it would be exactly what the funding company wanted and thus it was not obliged to implement it, and
b. during the research phase there were also additional research results that were produced and presented to the funding company for implementation, but which they were not certain that they would be accepted and implemented.

The innovative prospects and potential of this project were related to the following elements of the POD system idea that consisted of the initial POD functions (see also Figure 3.4):

- After the loading of a truck and the issuance of the transport documents the aggregated list of deliveries is created by the Warehouse Management System (WMS).
- The list is automatically loaded on to the PDA of the truck's driver, and the WMS considers the loading procedure finished with no further control.
- The driver can perform checks, by scanning the barcodes of the parcels or other freight items during or after the loading process via a specific interface developed.
- The list is also sent automatically to the central POD control platform.

- The truck starts its round of deliveries. Each time the driver delivers a parcel, he/she scans the code of each delivered package, and then the system automatically generates and delivers a message that is sent to the central POD control platform.
- The central POD control platform issues automatically the invoice and this invoice is sent – again automatically – to the client's system electronically.
- The system supports electronic signing by the receiver for further proof and security of the whole operation.

This was a case of implementation of research results that created another interesting "use case" to have in mind. The weak point of this case was that the results that were developed and implemented had a "copyright" on them in the sense that the company assigning the research, for obvious competition issues, prevented the further dissemination and application of the research products to other applications and potential customers.

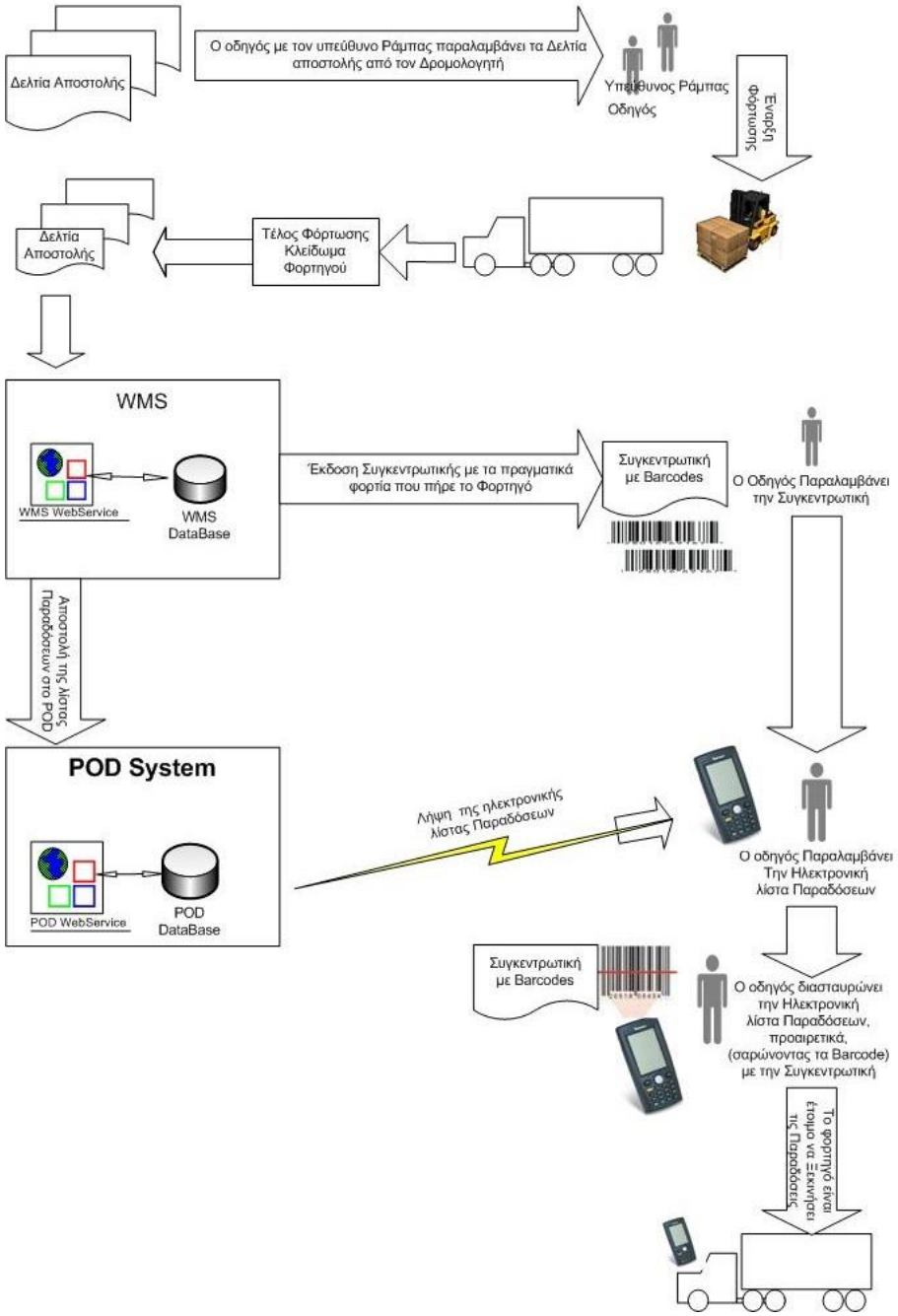


Figure 3.4: Diagrammatic representation of the innovative functions of the POD platform that was eventually developed into a full commercial product in the Greek market.

3.4 MyRoute: The Traffic Conditions Monitoring and Trip Planning Portal

Description

The MyRoute portal was a state-of-the-art portal that was developed before my work at the related company, but I oversaw its maintenance and operation for a considerable period of time. It is a web-based multi-modal routing application that was designed for travel planning with intermodal routing for car, pedestrians, and public Transport. Its main features included:

1. The users can search for routing services from any point to any other by one or more Transport means of their choice.
2. The point of arrival/departure can be any address or point of interest (POI).
3. Real-time information on road network closures, incidents and other causes for delays (e.g., severe congestion).
4. Finding the shortest route by car or public Transport or intermodal transportation by considering real-time information.
5. Calculation of travel times based on current traffic conditions and historical records.
6. Presenting all relevant info to the user in a user-friendly way.

The system used data on traffic incidents and accidents, work in progress (by the various utility companies), demonstrations or other road closures and additional related information. The data and information were provided by the Ministry of Public Works with a fee. The input data were manipulated by the MyRoute platform to produce information and data of actual utility to a large variety of users such as radio stations, newspapers, magazines, or travellers. In its heyday the system was used by, e.g., the Sky network, the newspaper Kathimerini, or magazines such as the Auto Triti and others.

The overall structure of the MyRoute platform is shown in Figure 3.5, and there, one can see that the innovative or potentially innovative features of the MyRoute system were many and involved items that are now standard features of similar systems, namely:

- Web application for finding POIs (Points of Interest) and related photos;
- The capability of informing the users by sending SMS and MMS;
- Also, the capability of supporting a full IVR (telephone exchange system).

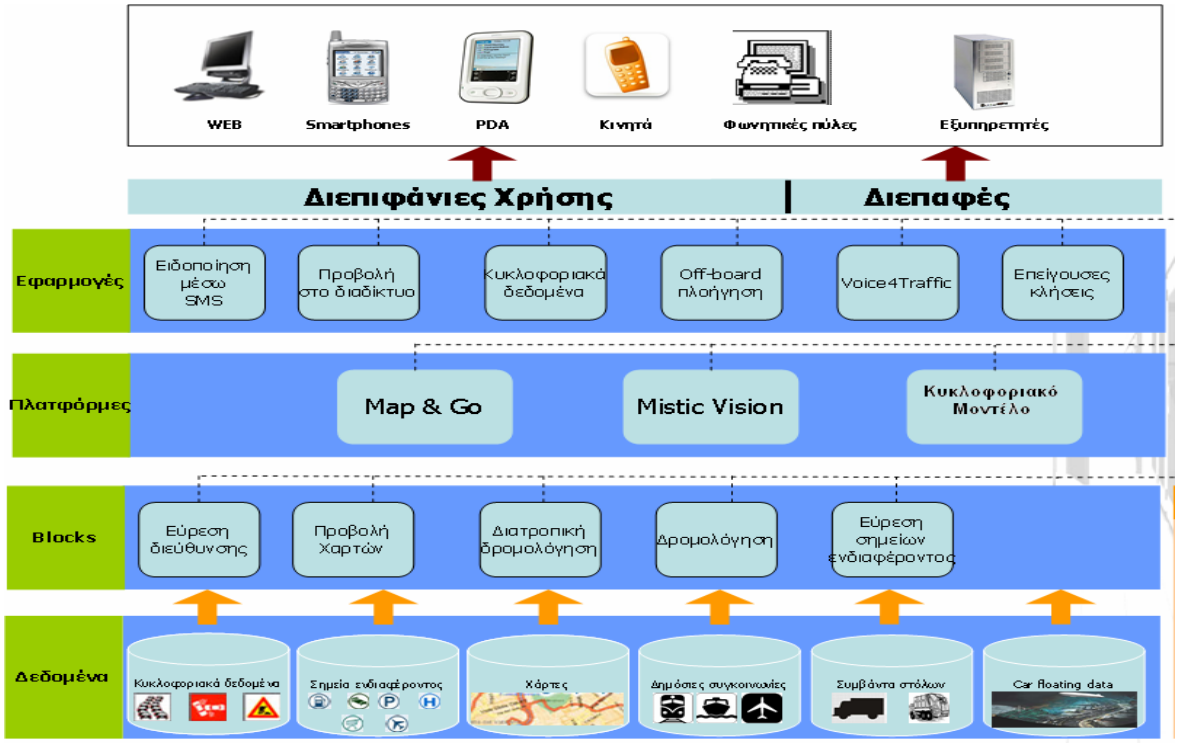


Figure 3.5: The overall features of the MyRoute platform developed by Infotrip SA.

Issues regarding implementation

The *MyRoute* portal resulted from research performed in the frame of several research projects that were assigned in the period 2000-2008 primarily by the DG Information Society of the EC and subsequently by the General Secretariat for Research and Technology of the Greek Ministry of Education (then Ministry of Development). It was applied only for Athens because that's where reliable information on traffic and road conditions was regularly available at the time. Its main advantage, over the competition (which included the famous Google maps route finding software), was that it contained information on road incidents, work in progress and other impediments to traffic flow and took them into account to calculate travel times and routes.

The company that developed and marketed it was Infortrip SA who saw in it a potential commercial success and committed to it, funding for its implementation. It is probably a rare example of a Greek private company committing the necessary expenses to fully develop and implement a research product that was the combined result of a number of its research projects. Part of these expenses was the annual fee payable to the Ministry of Public Works for the raw data. This fee, instead of being low and rather nominal as it is the case for similar data in other countries, it was very high amounting to several tens of thousands of Euros. These higher than

usual fees and other expenses together with a reduced interest for such service, as the result of the economic crisis, finally made the entire application uneconomic and not sustainable.

3.5 FRETIS-IFT, Intermodal Freight Terminal Operating System

Description

From the work of several research projects in which the company that developed and maintains FRETIS (i.e., TREDIT SA) participated, came the idea of developing an integrated package for the intermodal freight chain operation. As already mentioned, the starting point was the 2002-3 EU funded research project GIFTS. The FRETIS-IFT package (the acronym stands for *FREight Transport Information Technology Solutions – Intermodal Freight Transport*) was gradually created by developing unique state-of-the-art software packages that covered – initially – all the functions within a Container Terminal. By using advanced Information Communications Technologies (ICT), the FRETIS-IFT would provide cost-effective solutions for the management and control of Intermodal Freight Transport operations either in Terminals or along the physical Transport links.

The priority was given to the implementation of the *Container Terminal* operating module because the conditions were ripe for such implementation in the container Terminal of the port of Thessaloniki. The resulting FRETIS-IFT TOS (*Terminal Operating System*) was composed of eleven interconnected and integrated modules that are worth to be described briefly here (see also Figure 3.6 and Figure 3.7):

1. **Entry/Exit Control**: The system allows the control of the entrance/exit to the Terminal through received pre-announcements. The individual checks that can be performed on the container ID (as well as vehicle and driver ID) lead to the permission of entrance to incoming trucks as a result of a successful check. This operation is performed almost automatically by use of OCRs and other technologies to read the container numbers, etc.
2. **Yard Planning**: The Yard Planning module offers effective yard utilization and minimizes the lead time associated with the stacking activities. It also has an advanced housekeeping function, which maximizes the available space by concentrating sparse containers. With the Yard Planning system, container placement decisions are made

quickly and easily using the system's Geographical Information System as a user interface. A variety of planning rules and controls support the execution of the port terminal operational objectives.

3. **The Geographic Information System**: This is a standard GIS that has been incorporated into the system.
4. **Resource Management**: The Resource Management module performs the automated organisation, dispatching and monitoring of all container movement activities within the Terminal. With a user-friendly interface and an array of intelligent tools, Container Handling Equipment - CHE (e.g., straddle carriers) are distributed according to the operational needs. Using a wireless local area network (WLAN), it exchanges messages and commands in real-time with the equipment operators. The Resource Management Application allows for better utilization of existing CHE for minimum carrier idle time. It also contributes to reductions in operating costs and improvement in performance level.
5. **Loading/Unloading Control**: The loading/unloading control module handles the control and electronic storage of data relating to the loading and unloading of either ships or trains. It comprises of a set of client-server applications, which check loading/unloading rights and track all relevant activities.
6. **Yard Inventory Control**: The Yard Inventory module provides the ability to "walk the yard" collecting electronic data, thus eliminating all possible human errors. It comprises of a GIS-based central management application and a batch application for handheld terminals.
7. **Electronic Document Submission (e-Doc):** This module sends and receives electronic documents in multiple ways, ensuring total business flexibility. XML versions of all standard container-based EDIFACT messages are used for commercial transactions.
8. The **Customer Service module** offers an interactive web-based application, providing accurate and real-time information to all Terminal customers through the Internet. The application enables the port clients to monitor their cargo status as it progresses through the operational/administrative steps in the port activities chain. This module enhances the port into an added-value service provider.
9. **Customs & Administration support system:** The electronic Customs & Administration support system reduces the volume of paperwork required for the movement of containers through the Terminal. Critical administrative operations such as issuing transfer/cargo permits, maintaining logistics warehousing records, electronic

storing of customs documents and several more, are carried out through a user-friendly environment.

10. **Invoicing System**: The Invoicing Application is fully integrated within the FRETIS-IFT TOS and allows for timely and automatic calculation of the clients' financial obligations to the Terminal. It covers ship and quay services, as well as those related to stuffing, stripping and shifting of containers within the terminal.
11. **Central Information management system**: This is the central nerve of the whole FRETIS-IFT. It comprises the central platform through which all modules are controlled, monitored, and the entire system is managed by the administrator and controller.

Each module, or group of modules, can be installed and operated independently. The technologies applied in the FRETIS suite, include EDIFACT software messages, XML messages, web services, GIS/GIS over the web, hardware GPS RFID, barcode, smart card readers, handheld devices, onboard units, communications GPRS/WLAN, security (SSL/PKI).

Figure 3.6: The eleven modules of the initial FRETIS – IFT system (today there are also the ship berthing and the ship loading modules added.

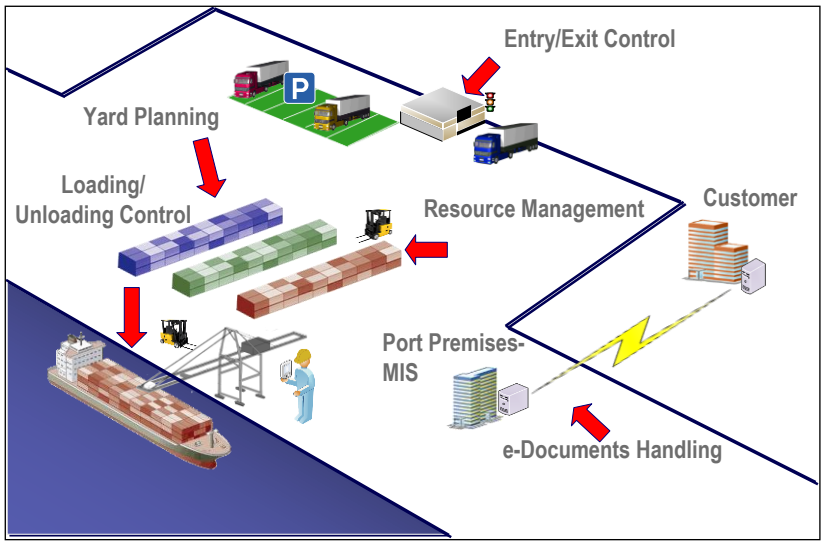


Figure 3.7: Diagrammatic positioning of the eleven FRETIS-IFT initial modules regarding the container Terminal.

Issues regarding implementation

The FRETIS-IFT system was first installed in the container terminal of the port of Thessaloniki in 2006. It has, since then, operated continuously until today and has been upgraded, enlarged and adapted to the changing requirements of the port and its clients, several times. In subsequent years, various modules of the package have been installed and operate in various other ports in Greece.

A measure of FRETIS' success, is the fact that the system has achieved well-established and tested operational interoperability with several other related Terminal Operating systems and related infrastructure vendors. For example, to date, the FRETIS-IFT system (through relevant cooperation agreements of its parent company, TREDIT SA) has established:

- ✓ Interfaces to the world-known CATOS terminal operating system of the Korean company TSB which is considered the no. 2 such system in the world. The connection concerns mainly the Vessel Planning operations in a container terminal.
- ✓ Interfaces to Gate Operating Systems-GOS and Weigh-in-Motion systems of other vendors (e.g., CAMCO). The FRETIS-IFT has developed interfaces and can exchange data with GOS systems from known vendors establishing fast-lanes at the container terminal gates as well as interfaces to Weigh-in-motion systems.
- ✓ Information exchange on overweight containers. The system is capable of receiving information from the weighing systems of the cranes. This enables early identification of overweight containers and permits follow-up with respective operational rules (e.g., checking on trucks' permit allowance for overweight container loading).
- ✓ Creation of billing information (e.g., vessel/quay operations and container handling in the yard), i.e., creating billable transactions which may be forwarded to respective ERP and Accounting systems. FRETIS-IFT has already established interfaces to SAP and selective Accounting applications in the Greek market.
- ✓ Integrated scanning and OCR data. Administrative documents may be scanned, and OCR-provided information is directly fed into the system to avoid errors occurred through manual data entry.

This use case is a true success story. It concerns the implementation of research results that took place over several years (approximately, 15). The process began with the initial (theoretical) development of the background algorithms and architecture (that took place basically within the GIFTS research project). These were tested – in prototype form – in the

three pilot applications (demos) that took place within that project. Subsequently, the company continued its involvement in this area via its participation in other relevant research projects while at the same time steadily maintaining, enlarging and deepening its knowledge of the operational processes within a container terminal. The cooperation between the developer and the potential user (i.e., the port of Thessaloniki) was helpful for its eventual implementation at the port of Thessaloniki.

The critical decision that tipped the scale towards the full commercial implementation of the FRETIS-IFT package was the decision of the Thessaloniki Port Authority, in 2006, to implement the first set of modules of the entire package. This first implementation was successful, and it initiated further development to guarantee that the system was fully tailored to the needs of the particular user. So, the process in the case of the FRETIS innovation was a continuous innovation creation process that continues to date. I was involved in this "continuous innovation" process of the FRETIS system for several years and appreciated the difficulties involved. My participation in this process caused several questions which incentivized me further in researching this theme in my PhD. For example:

- Why was TREDIT SA so successful in implementing this area of its research activities while the same company has not been so successful in other areas?
- What are the critical factors that enabled TREDIT to persuade the port of Thessaloniki to install its system in the first place?
- What were the main factors that caused the port authority to cooperate and support further development and growth of the system especially if one notes that the relevant decisions took place by different port administrations over more than a decade?
- Given that the port of Piraeus has installed an imported (American made) terminal operating system, what is the real benefit or value-added gained by the port of Thessaloniki in installing an original package (besides the cost of purchase and installation which in the case of Thessaloniki is approximately ten times lower)?
- What is the role of the individuals (managers and other decision makers) in the implementation of research results?

3.6 ENVIROPORT: Environmental Planning for Ports Operation

Description

This was a research project undertaken within the bilateral call for research work between Greece and China. It involved research and application of Intelligent Transport Systems (ITS) for Green Port Operation. More specifically it involved:

- The optimisation of the port terminal operations within the yard by efficiently integrating Terminal Operating Systems (TOS) with ITS.
- Enabling environmental intelligence in container handling procedures by considering energy saving potentials.

This research project developed two "research products":

a. ***EcoRoute*:** The fleet Management module interfacing with the TOS for container movement assignment orders; and
b. A new **Gate Appointment System – *GAS*** that is interfacing with the TOS to avoid congestion, smooth truck arrivals peaks (at the gates) and reduce service times.

The ***EcoRoute*** module enables the monitoring and Fleet Management of the container movement assignment orders to the CHE (Container Handling Equipment) so that the overall movement is optimized with respect to air pollution or energy consumption. It uses location-based rules and other pre-determined rules for CHE movements. It is all performed within a GIS environment, and for this, it needs the detailed GIS layer of the yard. The overall architecture of the ***EcoRoute*** module is shown in Figure 3.8.

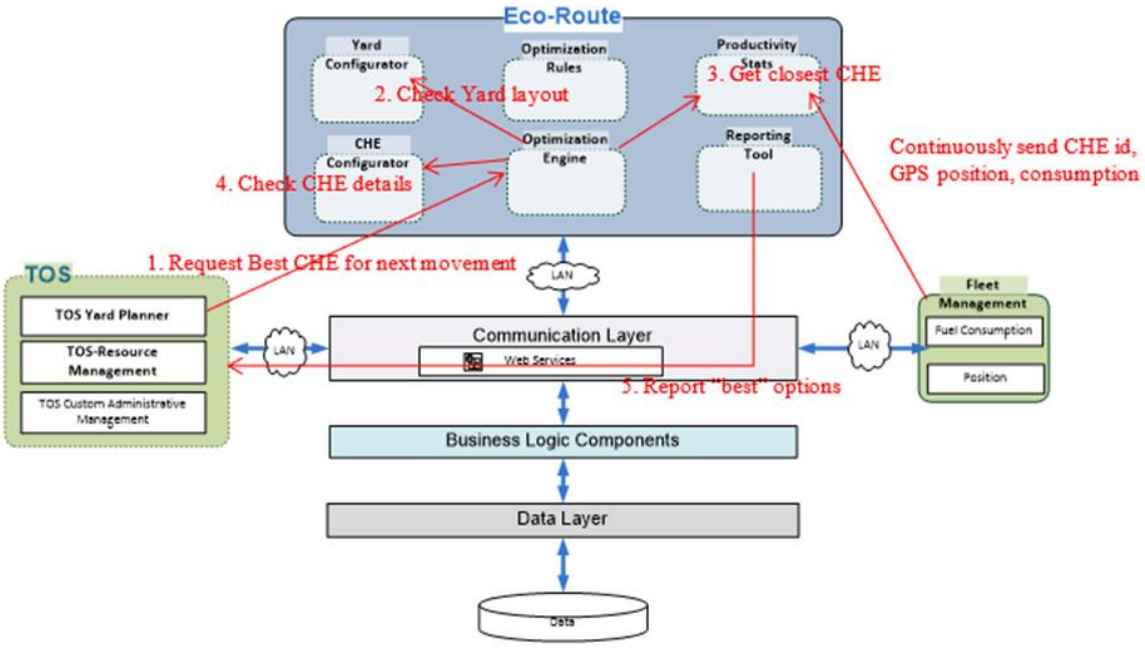


Figure 3.8: The EcoRoute module of the ENVIROPORT project that enables the ecological (i.e. environmentally friendly) container movement assignment orders within he container yard.

The **Gate Appointment System – *GAS*** that is intended to interface with the overall Terminal Operating System - TOS, to avoid congestion, create smooth truck arrivals peaks (at the gates) and reduce service times, is also another innovatory item developed in this project.

Its overall structure is depicted in Figure 3.9. The main elements are:

- The truck appointment module that is:
  - Based on gate operating hours,
  - Definition of hourly entry quotas,
  - Reservation of time slots through the web (by the customers sending the trucks)
- The TTPP – or Tariff / Toll pricing policies that may include setting high fees on peak times and lower in off-peaks.
- The definition of VDTW – or Vessel Dependent Time Windows. This is based on:
  - Partition of truck entries in groups (based on the vessel),
  - Assignment of time windows to groups.

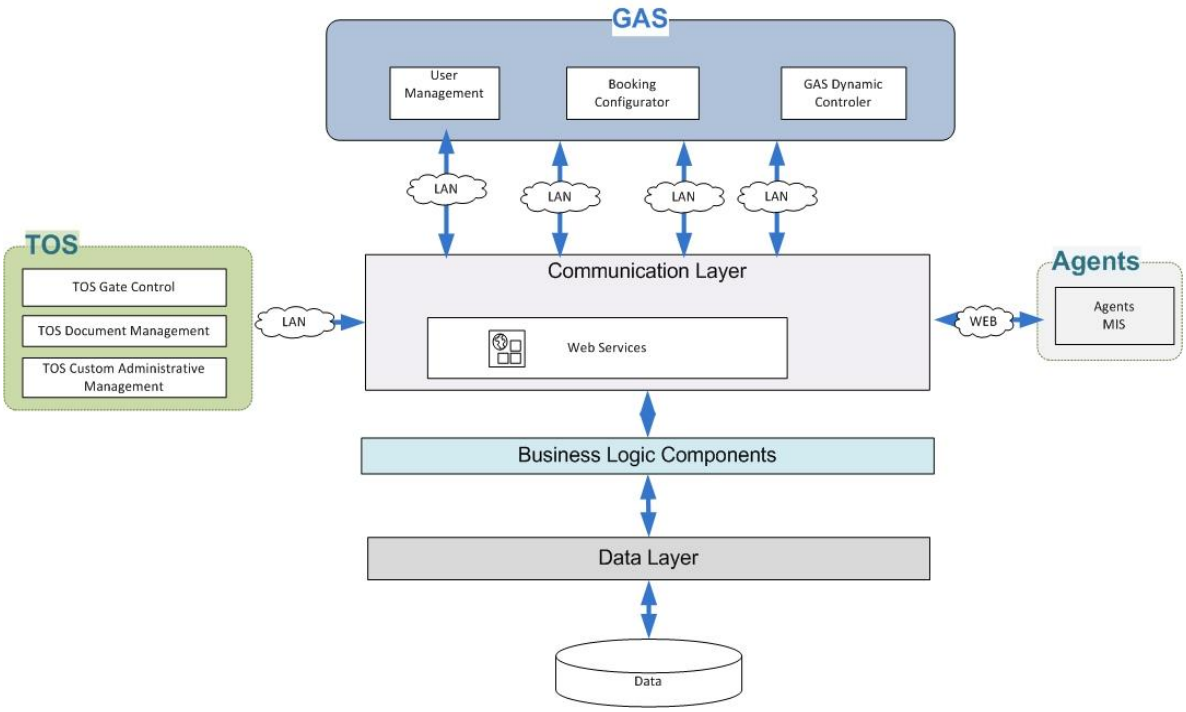


Figure 3.9: The Gate Appointment System – GAS of the ENVIROPORT project that optimizes the entry procedures to the Terminal.

The two ENVIROPORT modules were tested in a pilot application in the port of Ningbo in China (Ningbo is a medium-sized city of 6 million, south of Shanghai). After the end of the project work, the port of Ningbo was asked to further finance full implementation of the developed package but after several months of negotiations, interactions and clarifications, the whole process was stalled. This created an added impetus for me to investigate the reasons for the non-implementation of these valuable research results.

Issues regarding implementation

The case of the ENVIROPORT project is a case where innovative research results did not (at least not so far) succeed in becoming implemented and thus create "innovation". There may be several factors that hindered such implementation.

Perhaps the main one may have been the differences in technical capabilities and management "cultures" between the port of Ningbo Authority and that of a European port that would be an alternative user. The environmentally sensitive European port administrations might have been more sensitive to implementing operations that would bring environmental gains, and this would make the difference.

Another factor may have been the difference in language and general communication abilities between the two collaborating sides. A further one could be the need to connect the newly developed modules with the rest of the port's terminal operating systems which would create substantial costs while the benefits would mainly be qualitative (i.e., environmental benefits).

The ENVIROPORT results stay for the moment "dormant", at its creating company, awaiting a suitable chance to be applied in practice, hopefully through also taking advantage of the findings and recommendations of this PhD research work.

3.7 Open Issues for Further Analysis

My involvement and participation in the work and activities of such research projects, has given me both the incentive to formulate the questions that form the research theme of this PhD and the insights to try and answer them through the work and methodologies that were developed or followed in this PhD.

Examples of questions that I developed at the time I was working in these companies include the following and are summarized in Table 3.1.

a. What makes a research result suitable for implementation?

The research results derived from complex R&D projects are not always suitable for commercial exploitation. This depends on a variety of factors some of which are relevant to the research Organisation and others which the Organisation cannot control and plan for. For example, the research results of the GIFTS project were mostly focused on providing an initial (theoretical) development of the background algorithms and architecture that would be required for the creation of an Integrated Operational Platform for managing door-to-door freight Transport in an intermodal environment. Although innovatory, a decision to implement the project's results was not made at the time, since it was decided that further internal development and transformation would be required before the research results of the project could be included as commercial products to the Organisation's portfolio. Contrary to this, in the case

of the traffic conditions monitoring and trip planning portal – MyRoute – the research Organisation saw an opportunity to combine results of several of its research projects, to justify the full development and implementation of a commercial product. Taken collectively, these two examples show that a primary factor could be the decision-making mentality, suitability and risk taking of the management of the research owning company or the research potential implementing company.

b. What are the factors that affect a company's ability to implement research results?

First and foremost seems to be the decision and the ability of the research results owning Organisation and its management to successfully navigate the implementation and exploitation process. One of the cases that highlights the impact that such a factor can have on an Organisation's ability to implement research results is the case of the FRETIS-IFT system. As it was mentioned earlier, the conception and implementation of the FRETIS system resulted from exploiting research results that took place over several years. The implementing Organisation's (i.e. the port of Thessaloniki Authority) constant involvement and participation in related research projects enabled it to accumulate the required knowledge and expertise, to identify critical needs and weigh them against the price and benefits to be derived from the implementation. On the contrary, a far "simpler" but equally important factor - affecting negatively in this case - the ability of an Organisation to implement research results can be found in the example of ENVIROPORT. In this case, major differences in technical capabilities and management "cultures" between stakeholders of the end-users of the commercial product hindered the immediate exploitation of potentially highly innovative and impactful research results.

c. How can the management of an interested company proceed to promote a specific result towards implementation?

The involvement and pressure from top management to proceed with the implementation and commercial exploitation of research products are crucial, since it fosters an "exploitation mentality" within the Organisation. Having this mentality allows for key stakeholders of an Organisation participating in research projects to actively seek and identify potentially exploitable results that can benefit the Organisation and more importantly do so,

throughout the different stages of a project, thus increasing the likelihood that the resulting research outcomes will suit the business needs of the Organisation. The importance of fostering an exploitation mentality by top management was evident in the case of the traffic conditions monitoring and trip planning portal *MyRoute*. The drive for research implementation and exploitation that the Organisation's top management maintained over the years, eventually translated in a single commercial product that consisted of numerous exploited research results. The successful combination and utilization of seemingly independent and unrelated research results were achieved by the Organisation, because every key stakeholder involved, actively sought to promote research that could potentially be implemented and commercially exploited by the Organisation. Another research project that exemplifies the efforts of the top management of the Organisation to promote the exploitation of research results is the GIFTS project. As mentioned in the description of the project, at the time of its execution its results were not transformed to commercially attractive products due to financial reasons. Despite that, the management of the Organisation saw the potential for exploitation and acted by establishing critical collaborations with related industrial stakeholders that eventually enabled the Organisation to commercially exploit the project's results and more importantly to identify and reap the benefits of an entirely new business opportunity, i.e. the development of the FRETIS – IFT applications.

d. How can the management of a company become interested in financing suitable implementation actions;

Committing resources and financing implementation actions can often introduce a large amount of risk for Organisations – especially for Organisations working in unstable economic environments such as the one of Greece – since in most cases, an implementation does not automatically translate to a successful and profitable commercial exploitation. To minimize the risks involved, Organisations must carefully select which research results will undergo the transition to products and plan effectively for their commercial uptake. For example, the success of the FRETIS-IFT system was heavily attributed to the fact that the Organisation reasonably early in the implementation process managed to establish strong cooperation with several related industrial stakeholders and most notably with the Thessaloniki Port Authority (ThPA). By doing so, the Organisation mitigated many of the risks involved (mainly the risk of attracting potential competitors for the product) early in the implementation and exploitation

process and thus became more motivated to finance suitable and relevant implementation actions, since the exploitable outcomes could more efficiently and effectively be commercially utilized in the market. Similarly, in the case of the Proof of Delivery (POD) product, the fact that the implementation of the research was in essence "guaranteed" (as the research was assigned by another Organisation interested in the application of the research outcome) enabled the Organisation to commit financial resources to yield additional research results. These were partly outside the scope of the project at hand, but still useful for the rest of the Organisation's product portfolio.

e. Who should be involved and to what extent?

As evidenced by the cases studies, the direct involvement of every key stakeholder is of critical importance for the success of the implementation process and the subsequent commercial exploitation of research project results. Implementing Organisations should always make an effort to include all relevant stakeholders in every stage of the process, from the initial inception of the research project to the commercial rollout of the finished product. Doing so reduces the likelihood that their efforts and strategic targets are misaligned with those of their stakeholders, which would most likely result in an unsuccessful commercial exploitation effort. In the case of the ENVIROPORT, for example, one of the main reasons that successful implementation of research results was not achieved, could be attributed to the fact that many of the key stakeholders, such as the European port administrations, were not actively involved in the different stages of the project which in turn harmed the implementation of the project's results. In the same sense, the additional research results that were produced in the Proof of Delivery project created potential for further exploitation "use cases" which ultimately did not materialize, since relevant stakeholders that could benefit from them were not part of the initial phases of the research project.

Table 3.1: Open issues from preliminary research.

	GIFTS	*POD*	*MyRoute*	*FRETIS-IFT*	*ENVIROPORT*
Suitability of research results implementation	Further **internal development and transformation** would be **required** before the research results of the project could be included as commercial products to the Organisation's portfolio.		The Organisation saw an opportunity to **combine results** from a number of its research projects, **in order to justify** the full **development and implementation** of a commercial product.		
Factors affecting implementation				**Constant involvement and participation** in relevant research projects enabled **for the accumulation of required knowledge and expertise**, in order to identify critical customer needs and subsequently create a highly functional and competitive product.	**Differences** in technical capabilities and management "cultures" **between project stakeholders and end-users** of the commercial product **hindered the immediate exploitation** of highly innovative and impactful research results.
Promoting the implementation in the Organisation	The Organisation saw the potential for exploitation and **acted by establishing critical collaborations that** eventually **lead to commercial exploitation and** more importantly presented **a completely new business opportunity**.		**Every key stakeholder** involved, **actively sought to promote research** that could potentially be implemented and commercially exploited by the Organisation.		

Promoting the financing of implementation actions		**Implementation** of the research **was** in essence **"guaranteed"** which **enabled** the Organisation **to commit further financial resources** for **additional, exploitable research results**.		The Organisation **mitigated risks involved early in the research process** thus became more **motivated to finance implementation actions,** since these could be **more easily and effectively be commercially utilized**.	
Stakeholder involvement		**Additional research results** produced created potential for further exploitation "use cases" but **did not materialize**, **since stakeholders** that could benefit from them **where not part of the project.**			**Implementation** of research results **was not achieved**, because **many key stakeholders were not actively involved** in the different stages of the project.

4 Methodology and the Research Model

4.1 General Outline of the Research Method

The methodology employed to address the research objectives of this PhD Thesis consisted of two discrete phases as shown in Figure 4.1.

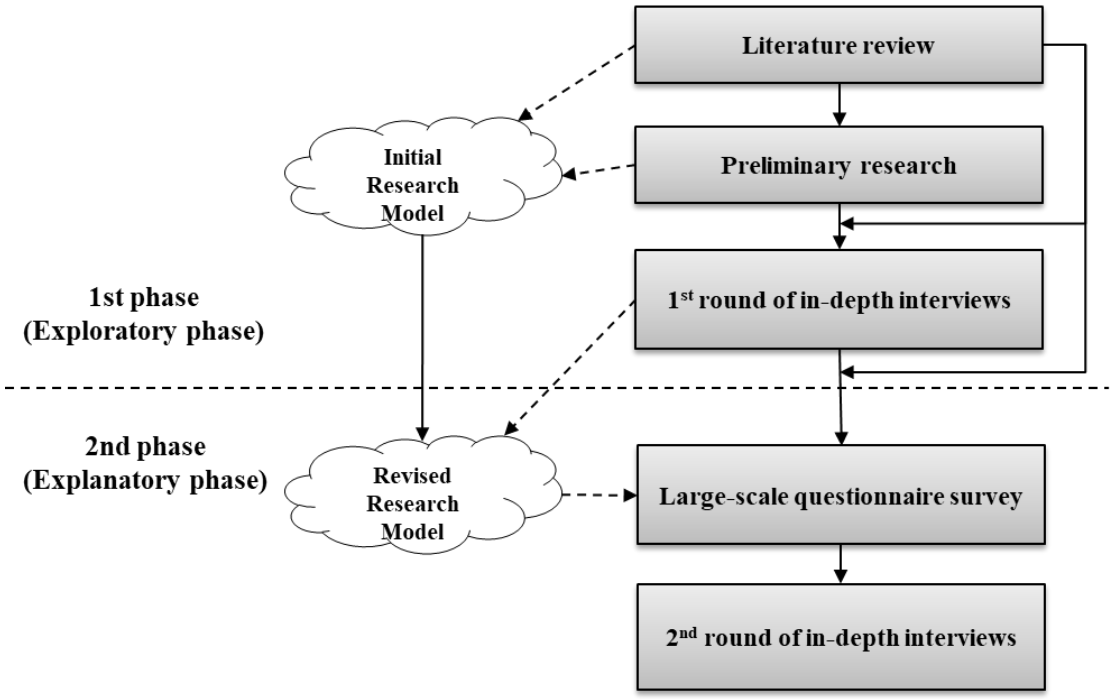


Figure 4.1: The two phases of the research methodology.

In the first phase of the methodology, qualitative research methods were utilized to identify the boundaries of the research area and relevant research aspects that had to be considered, to address the research objectives of this Thesis. Furthermore, during this phase, the context of the research was further identified and explored, to obtain expert knowledge regarding the various "context-related" issues involved. The second phase of the methodology utilized the results of the initial exploratory phase and primarily focused on employing a mix of quantitative and qualitative methods, to provide explanatory and confirmatory evidence to the research claims of this Thesis.

4.1.1 Exploratory Phase

The first phase of the methodology was exploratory in nature and primarily employed qualitative research methods. This phase initially focused on reviewing the literature on the broad subjects of implementation and exploitation of research results and the creation of innovation. The main objective of the literature review was to improve our understanding regarding the process that Organisations follow when implementing research outcomes to create innovation. More importantly, it focused on identifying key factors that significantly hinder or enable the ability of the Organisation to transform research results into marketable innovations successfully. Based on the results of the literature review, a conceptual model including several possible influencing factors was created, to act as the guide for our analysis. Specific emphasis was given throughout this phase to the scope, nature, and applicability (in terms of ease of definition and measurement) of the factors identified.

Following the literature review, we utilized five real-life examples of Transport research projects or implemented products that resulted from such projects, to conduct preliminary research on the subject. These were drawn from the previous working experience of the author and their analysis aimed at further examining and identifying the plethora of issues involved with the implementation and exploitation of research results.

Additionally, during this first exploratory phase, eight semi-structured in-depth interviews were conducted with relevant and very well-known experts from the Transport sector. The interviews took place during the 2017 Transportation Research Board (TRB)[30] annual meeting. This "annual meeting" is a major conference, the most widely known and attended around the world in the field of Transportation. It attracts more than 13 000 transportation professionals from around the world, and thus it was relatively easier to find there and meet the appropriate experts in a short period of time. Furthermore, the TRB conference is a forum that promotes innovation in the field of transportation and addresses a variety of topics of interest to policymakers, administrators, practitioners, researchers, representatives of government, industry and academic institutions.

The participants of the interviews which were conducted for this study were identified through the author's previous work experience in two consultancy companies involved in developing IT applications and performing planning, evaluation and design studies in the field of Transportation, as well as through appropriate scouting in the compendium of papers

[30] TRB Annual Meeting website: http://www.trb.org/AnnualMeeting/AnnualMeeting.aspx

presented in this conference the years before. The experts were approached via email prior to the conference, in order to request their participation and inform them about the subject and objective of the interview. Once they agreed an appropriate time and space was defined. All interviews were conducted during the conference. The interviewees selected consisted of a mix of academic/research and business/consulting professionals, highly experienced in the subject of product and process innovation in the Transport sector. Each interview was semi-structured and informal and lasted approximately two hours in duration. The framework of themes explored was relevant to the conceptual model of the study and more specifically to the variables that were identified as applicable to the subject through the literature review.

The purpose of the interviews was to utilize the knowledge and experience of the experts interviewed, in order to identify additional contextual factors that potentially affect the exploitation of research results in the Transport sector. Furthermore, the potential explanatory power of the identified conceptual model was discussed with the experts, in order to improve our understanding regarding the different relationships that may exist between factors and to determine the extent to which our model accurately reflects the Transport sector. Consequently, this procedure also enabled us to conduct a preliminary "validation" of our initial conceptual model and to gather more information and specialized input regarding the relevance, validity, and importance of the influencing factors previously identified from the literature review.

4.1.2 Explanatory Phase

The second phase of the methodology was explanatory in nature. The initial part of the explanatory phase was built on the results of the literature review and the first round of in-depth interviews with experts from the Transport sector. It came after the conceptual model of the research was established and improved (through the interviews). This phase of the research consisted of a mix of qualitative and quantitative methods that were employed to provide confirmatory evidence, regarding the magnitude of the effects that each factor has on the innovation potential realized by the Organisations conducting or exploiting research.

The primary tool employed during this phase was a large-scale web-based questionnaire survey, aimed at gathering data and information regarding the whole range of factors identified as determinants of successful exploitation of results in collaborative publicly funded Transport R&D projects. This quantitative research approach was chosen, due to the availability of a large sample of Organisations and individuals that could provide the required information and more

importantly because it allowed for a thorough empirical analysis of the relationships and effects identified in the conceptual model of the research.

The final part of the explanatory phase came after a preliminary quantitative analysis of the results of the questionnaire survey. It involved a second round of semi-structured in-depth interviews with a subset of the experts from the Transport sector that were interviewed during the first phase. This part was critical since it enabled us to obtain a more objective and authoritative evaluation of the results collected from the web-survey. In addition, it allowed us to validate and interpret the results in the context of the operational and business environment of the Transport sector and in the light of the experts' experience.

4.2 Theoretical Background – Theories Employed

4.2.1 Innovation Diffusion Theory

One of the main theories about the way that innovation and technology is adopted and diffused is that of E. M. Rogers that is known as Innovation Diffusion Theory – IDT (Rogers, 2003; Venkatesh, Morris, Davis, & Davis, 2003). In his publications, Roger defines "innovation" in a more simple and straightforward way as "*an idea, process, or technology that is perceived as new or unfamiliar to individuals within a particular area or social system*". He also defines "diffusion" as "the process by which the information about the innovation flows from one person to another over time within the social system". According to the Innovation Diffusion Theory, there are four main determinants of how an IT innovation is diffused and adopted successfully. These are (Rogers, 2003):

1. The *communication channels* used for the dissemination. This determinant refers to the mechanism through which people obtain information about the innovation and perceive its usefulness. It involves both media and interpersonal communication as well as other means of communication (that we can also extend to modern day media such as the internet or the various social media platforms).

2. The *attributes of the innovation*, i.e., items related directly with the particular innovation and the way that it is formulated. These "attributes" have been further specified as including the following:

- ✓ *Relative advantage*, this has been defined as the degree to which the user perceives benefits or improvements upon the existing technology by adopting the innovation;
- ✓ *Compatibility*, i.e., the extent to which an innovation is consistent with the current technical and social environment. Prospects for diffusion and adoption are higher when an innovation can blend or coincide with existing values, experience and the needs of potential adopters (Moore & Benbasat, 1991; Tornatzky & Klein, 1982);
- ✓ *Complexity*, i.e., the degree to which an innovation is perceived to be challenging to understand, implemented or used. A less complex innovation is more likely to be rapidly accepted by end users. (This is also mentioned by Moore & Benbasat, 1991; Tornatzky & Klein, 1982);
- ✓ *Trialability*, i.e., the ability of an innovation to be put on trial without total commitment and with minimal investment (Rogers, 2003). Higher trialability highly correlates with adoption (Moore & Benbasat, 1991); and finally,
- ✓ *Observability*, i.e., the extent to which the benefits of an innovation are visible to potential adopters. According to (Moore & Benbasat, 1991) only when the results of an innovation can be observed and perceived as beneficial, such innovation will be adopted.

3. The *characteristics of the adopters*, i.e., those that adopt the innovation and make good use of it. These are the individuals of a social system that will accept or not accept an innovation, and this relates to a number of their characteristics that Rogers has recognized in five categories as follows:
   - ✓ *Innovators*, representing approximately 2.5% of the population in a social system. They have the ability to understand and apply complex technical knowledge essential for bringing in the innovation from outside the social system.
   - ✓ *Early adopters*, who are a more integrated part of the social system than the innovators and tend to be well informed about the innovation, well connected with the new technologies and more economically successful.
   - ✓ *The earlier majority*, and the *later majority* which are essentially the same major group of adopters that comes after an innovation has initially been adopted by

some and which is realized at two different time period “earlier” and “later”. According to Rogers, the two groups account for up to 68% of the population;

- ✓ Laggards. This is the latest 16% of the individuals that are the strongest resisters to the adoption of an innovation, and most likely they tend to become non-adopters either because of their limited resources or lack of awareness or knowledge of the innovation.

4. Finally, *the social system* that exists in the area of adoption is also an important determinant of adoption of an innovation. By “social system” Rogers meant the distinction between the market-oriented and the more state-controlled societies – a factor that has been shown to be of importance as the market-oriented economies and societies tend to adopt change and innovation more easily.

4.2.2 Dynamic Capabilities Framework

In studying the factors that will be likely to influence the exploitation of the research results, it becomes necessary to find more about the way that the firm behaves as an Organisation and how it is influenced in its decision-making process. One theory that can help us understand better the competitive behaviour of firms and how they can achieve and sustain their position over time is the *Resource-based View* – RBV (Barney, 1991; Penrose, 1995; Peteraf, 1993). According to this theory, the strategic decisions of the firm that will position it well against its competition and will give it a competitive advantage will be based on specific *bundles of resourc*es, competencies, and capabilities (Spender & Grant, 1996; Wernerfelt, 1984). These resources are usually heterogeneous in their distribution across firms and persist over time (Amit & Schoemaker, 1993; Mahoney & Pandian, 1992; Penrose, 1995; Wernerfelt, 1984). They are also *valuable, rare, imperfectly imitable & substitutable* or *VRIN* (Barney, 1991; Rumelt, 1987). According to Barney (Barney, 1991), a "...firm’s resources include all assets, capabilities, organisational processes, firm attributes, information, knowledge, etc.; controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness”.

Another useful concept that is building on RBV, in the study of the behaviour of firms, is the concept of *Organisational Knowledge* (see for example Kogut & Zander, 1992; Nahapiet & Ghoshal, 1998). According to the *Organisational Knowledge* concept, firms have been

described as "*repositories of knowledge*" (Conner, 1991; Conner & Prahalad, 1996) that is embedded in assets (Teece, 1998), *rules* (Levitt & March, 1988), *routines* (Nelson & Winter, 1982), *standard operating procedures* (Cyert & March, 1963) and *dominant logic* (Bettis & Prahalad, 1995; Prahalad & Bettis, 1986). In fact, there are some researchers that support the view that successful firms integrate the "knowledge" element with the "organisational capability" element i.e. they can integrate and coordinate the specialized knowledge held by individuals into collective, organisational knowledge that resides within the firm (Grant, 1996; Spender & Grant, 1996). In this way, they can have the advantage that "firm-related" knowledge is difficult to copy and thus get in the hands of rivals.

The resource-based view distinguishes between IT assets and IT systems. IT assets refer to the infrastructure owned by the Organisation, while IT systems refer to the combination of different assets and related capabilities of the Organisation that aim towards the productive use of IT (Wade & Hulland, 2004). Research has suggested that sustained competitive advantage in relation to IT is achieved through superior deployment and use of IT-related capabilities, in combination with IT assets (Aral & Weill, 2007). Furthermore, IT investments generate business value for the Organisation through their impact on IT and non-IT resources and capabilities of the Organisation (Sherer, Kohli, & Baron, 2003). This impact facilitates the creation of new IT-enabled capabilities, enhancement of non-IT capabilities, increase of the magnitude of the impact of resources and capabilities as well as by the multiplication of existing resources and capabilities (PA Pavlou, 2002; Sawy & Pavlou, 2008). These consequently create and capture business value by altering the set of strategic alternatives and value creation opportunities an Organisation can pursue (Bharadwaj, 2000).

An extension of the RBV theory is the *Dynamic Capabilities* (DC) framework which is based on the view that a firm's existing resource base can be renewed in the face of changing markets and environments, i.e. in the face of the fact that resources evolve over time and thus the competitive advantage of the firm may be difficult to be sustained (Teece, Pisano, & Shuen, 1990). Dynamic capabilities extend the RBV view in that they consider the firm also (i.e. besides its "resources") as a "mechanism" that learns and accumulates new skills and capabilities, capable of limiting the rate and direction of this process. Dynamic capabilities help explain why firms are able to display "timely responsiveness and rapid and flexible product innovation, along with the management capability to effectively coordinate and redeploy internal and external competences" (Teece & Pisano, 1994). The role, therefore, of the strategic management within a firm can be about "adapting, integrating and reconfiguring internal and

external organisational skills, resources and functional competencies toward the changing environment" (Teece & Pisano, 1994). This dynamic nature of the capabilities of a firm is also related to its R&D activities and allows it to be more susceptible to exploiting its results in order to have a competitive advantage. According to (Leonard-Barton, 1992) it may also help firms to avoid developing core rigidities which inhibit development, generate inertia and stifle innovation.

One of the oldest and original publications in terms of the definition of innovation and the first analyses of its development and promotion is the paper by Schumpeter of 1934 (Schumpeter, 1934). In this paper, Schumpeter places external sources of information on par with internal information as an essential driver of innovation and growth. Later on, Cohen and Levinthal (Cohen & Levinthal, 1989, 1990, 1994) suggested that the ability of a firm to recognize the value of new, external information and assimilate it and apply it to commercial ends is critical to innovation. They call this ability, a firm's *absorptive capacity* and suggest that it is mostly a function of the firm's level of prior related knowledge. As explained in (Lane, Salk, & Lyles, 2001) this "prior related knowledge" depends on the previous relevant activities of the firm as well as its involvement in research and innovation activities (i.e., its "innovation record"). This puts the emphasis on the investments in R&D, and as it is argued in (Cohen & Levinthal, 1990) through deliberate investments in R&D, firms develop their knowledge base as an outcome of ongoing scientific and technological research. This knowledge base, in turn, allows the firm to develop a capability for assimilating new external knowledge (i.e., develop absorptive capacity) that is related to its existing knowledge base. Over time, the firm develops processes, policies, and procedures that facilitate sharing that knowledge internally. The firm also becomes skilled at using that knowledge to forecast technological trends, to create products and markets, and to exploit the results of its R&D investments strategically.

The notion of the *absorptive capacity* of a firm is a well-established construct with clear linkages to the RBV and DC theories. In (Zahra & George, 2002) a relevant review of the literature reveals that the *absorptive capacity* can be conceptualized as a dynamic capability that can be distinguished between *Potential Absorptive Capacity* (or PACAP), which includes the first two capabilities of *acquisition* and *assimilation*, and *Realized Absorptive Capacity* (or RACAP), which includes *transformation* and *exploitation* capabilities. They also specify and elaborate on the internal processes, such as *activation triggers* and *social integration mechanisms* which aid the movement of knowledge within the firm. Activation triggers may include both internal crises and external market changes while social integration mechanisms

can consist of social structures that promote more significant employee interaction and knowledge management systems. The *absorptive capacity* notion, which was introduced by Cohen and Levinthal, as already mentioned, has been integrated into several research streams including this present one as it is explained later.

4.3 The Research Model and the Relevant Factors

4.3.1 The Preliminary Research Model

The research model of our study was initially formulated from the literature review and the preliminary research from the author's professional experience. This initial research model is shown in Figure 4.2 below.

For our variables, we considered factors that were found to be relevant in affecting the implementation potential of the Organisation and the subsequent creation of innovation. In the preliminary version of our research model, we identified determinants of innovation impacts, for publicly-funded Transport R&D project participants by analyzing data at two levels of analysis, that refer to the factors related to the *firm* and the factors related to the *"reference" project*. These were primarily drawn from related research work on the Innovation Diffusion Theory and the Dynamic Capabilities Framework.

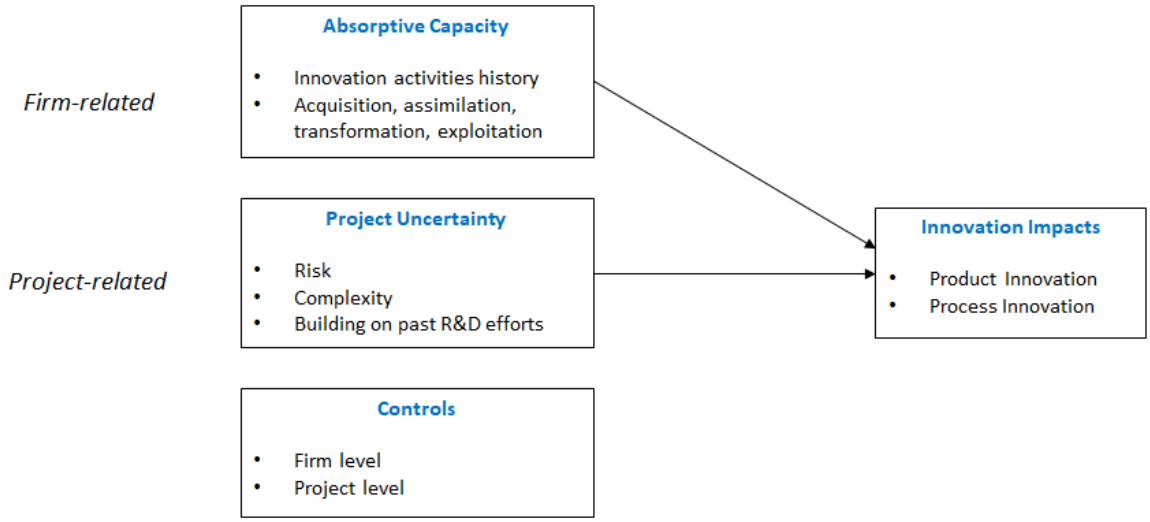


Figure 4.2: Preliminary research model.

a) Dependent Variables

The dependent variables in our analysis were two, namely the innovation impacts related to *product* and *process* innovation. Following previous work from the harmonized survey questionnaire of the Community Innovation Surveys (CIS) (Eurostat, 2016), we measured innovation impacts by asking the questionnaire respondents to indicate the extent to which their Organisation has produced new or significantly improved product and process innovations as a result of their participation in a "reference"[31] project. To better inform our dependent variables, we also asked respondents to rank the "reference" project's significance, innovativeness, clarity of project objectives, the ambitiousness of work undertaken, innovation potential, coherence of work plan, efficiency and effectiveness of leadership. In addition, we asked respondents to assess the success of the exploitation of project results in terms of the importance, value, and benefit they believed the exploitation brought to their Organisation. Doing so enabled us to gauge the respondent's perceived success of the "reference" project, which in turn created a clearer image of the impact the project had on the Organisation when combined with the reported innovation impacts. Lastly, we collected information regarding the timeframe within which the exploitation took place (i.e., whether the exploitation took place within the first five years after the project was completed) and whether the exploitation of results happened in combination with research results originating from other relevant research projects.

b) Independent Variables

Firm-related factors

Several factors that relate to the firm's internal environment were candidates for inclusion as independent variables in our analysis. In order to select the variables that we would further examine, we consulted previous related studies that have focused on this level of analysis have found compelling evidence for their impact and effect (Ahuja & Katila, 2004; Cohen & Levinthal, 1990; Damanpour, 1991; Leonard-Barton, 1992; Spanos et al., 2015). These factors primarily relate to features that characterize the internal environment of the firm

[31] Respondents were asked to complete the questionnaire survey while "referring" to a "research project" related to the Transport sector from their recent (within the last three years) project portfolio.

that are likely to motivate and induce innovation and allow for the exploitation of research results and their transformation into innovative products and services.

Absorptive Capacity

As mentioned above, according to Cohen and Levinthal, a critical component for innovation is "the ability of a firm to recognize the value of new, external information and assimilate it and apply it to commercial ends". The a*bsorptive capacity* of the Organisation is used to express its ability to absorb and further develop externally acquired knowledge into commercial products (Cohen & Levinthal, 1989, 1990, 1994). The importance and impact of absorptive capacity with regards to the exploitation of research results was highlighted by Spanos et. al. (Spanos et al., 2015) which argued that even if a new technology is successfully developed in the context of a research project, it is usually just part of a more complex web of developments that complement it and together provide the required functionality. By conceptualizing absorptive capacity as an asset of the Organisation (i.e., a knowledge base) (Roberts, Galluch, Dinger, & Grover, 2012), Spanos et. al. attribute the effectiveness of a participant firm's attempts to assimilate and further develop "knowledge spillovers" generated by the project on "sufficient levels of pre-existing in-house innovative capabilities and accumulated investment in own R&D" (Spanos et al., 2015).

For the conceptualization of absorptive capacity, we adopted this view of absorptive capacity as an asset and we examined the Organisation's *past innovation record*, as reflected in *past R&D activities* and *prior innovation performance* which will influence its capacity to derive impacts from collaborative R&D projects (Spanos et al., 2015). In order to assess the Organisation's record of innovation activities we utilized relevant measurement items from the harmonized survey questionnaire of the Community Innovation Surveys (CIS) (Eurostat, 2016). More specifically, respondents were asked to indicate the degree to which their Organisation has been primarily involved with in-house and external (relevant activities that have been contracted to other parties) R&D activities. In addition, to obtain a better understand of the prior innovation performance of the Organisation, we also utilized Likert-type items asking respondents to indicate the extent to which their Organisation has been mainly focusing on introducing innovations that are new to the market or new to the firm.

Furthermore, to capture the capability view of absorptive capacity we also conceptualized it as a set of routines tapping on the focal Organisation's ability to acquire,

assimilate, transform and exploit knowledge gained from external sources (Flatten, Engelen, Zahra, & Brettel, 2011; Malhotra, Gosain, & Sawy, 2005; Paul. Pavlou & Sawy, 2006).

More specifically:

- *Acquisition* refers to the ability of the Organisation to identify and obtain knowledge. This was measured by asking respondents to indicate the extent to which a) searching for relevant information concerning the industry is considered an every-day practice in the Organisation, b) top management motivates employees to use information sources within the core industry and c) top management expects that employees deal with information beyond the core industry.

- *Assimilation*, (i.e., the Organisation's ability to develop processes and routines useful in analyzing, interpreting, and understanding externally acquired knowledge) was measured by asking respondents to indicate the extent to which: a) there is cross-departmental communication of ideas and concepts in the Organisation, b) top management emphasizes cross-departmental support to solve problems, c) there are quick information flows throughout the different business units of the Organisation and c) top management demands periodical cross-departmental meetings to interchange new developments, problems and achievements.

- *Transformation* relates to the development and refinement of routines that facilitate combining existing knowledge with acquired and assimilated knowledge for future use. In order to gauge the transformation capacity of the Organisation we asked respondents to indicate using Likert-type items the extent to which they believe that employees working in the Organisation have the ability to a) structure and use accumulated knowledge, b) are used to absorb new knowledge as well as to prepare it for further purposes and make it available, c) successfully link existing and newly acquired knowledge and d) are able to apply new knowledge to their practical work.

- *Exploitation* denotes an Organisation's capacity to improve, expand, and use its existing routines, competencies, and technologies to create something new based on the ''transformed'' knowledge. The Organisation's knowledge exploitation capacity was measured by asking respondents to indicate the extent to which they believe that a) their Organisation reconsiders technologies and adapts them according to newly acquired

knowledge and b) their Organisation has the ability to work more effectively by adopting new technologies.

Project-related factors

A significant set of factors that have been associated with a firm's ability to exploit research results and innovate, relate to the characteristics of the research project. We have therefore considered a number of "project-related" factors that have been found to have relevance in past studies (Harder, 2014; Kostopoulos et al., 2015; Wiesenthal et al., 2015) and we have added others that were identified as relevant by interview participants. We have also introduced explicitly in our questionnaire survey the element of "reference project". In other words, the respondents were asked to write their answers to the questions posed with reference to a specific project in which they were involved during the last 3 years or so. The extent to which the "reference" project built upon prior R&D efforts was measured by asking respondents to indicate the extent on a Likert-type scale.

In relation to the "reference" project, a number of "project-related" characteristics were examined in our questionnaire. They included items, such as the:

- ✓ *Project Risk* that is related with the new product or service (see below);
- ✓ *Project Complexity,* (see below);
- ✓ Size and duration of the reference project (control variable);
- ✓ "Innovation potential" of the project (see below);
- ✓ Thematic area and the Transport sector in which it fits (control variable); and
- ✓ Number of partners involved in the consortium (control variable).

Regarding the *(project) risk*, according to previous research (Kostopoulos et al., 2015; Stock & Tatikonda, 2000), "risk refers to the degree of change in the technology (under investigation by the project) relative to prior research projects the focal Organisation has been involved with and the extent of familiarity with it". In this present research study, we take "risk" to mean not only the commercial risk that a firm faces when introducing a new product into the market but also the technical risk to develop and put in place all the technical elements, components, sub-components etc. that are necessary for the new product. There is also a

managerial risk involved i.e. for the management of the company in terms of its decision and the business plan that they will adopt for the commercialization of the new product or service.

Regarding the *(project) complexity*, this notion refers to the degree in which the various "elements" that will define the final outcome of the (research) product are interdependent, misaligned or depended on "outsiders" (i.e. spillovers from other entities or innovations) (Kostopoulos et al., 2015; Stock & Tatikonda, 2000). The "elements" that we refer to here, are the necessary building blocks or components of the product.

Both *project risk* and *complexity* are measured with Likert-type items tapping the degree to which the reference project was perceived, as compared to an "average" project. In other words, how far was the reference project from the firm's core area of technological expertise. The same type of measurement was used for (project) *complexity*. In this case questionnaire participants were asked to indicate the extent to which they perceived the focal project as being scientifically, technically and managerially complex and long-term (as opposed to short-term).

Regarding the *innovation potential* of the (reference) project we defined it to mean the degree to which the nature of the project rendered itself likely to result in results that can be attractive and usable enough for commercial exploitation. Basic research, for example, does not render itself for such results and thus their projects have low "innovation potential". On the contrary technological research projects which aim at developing new technologies or technological elements, are more likely to produce results that will be exploited commercially. Again, this *potential* was measured by a Likert-type scale.

c) <u>Control Variables</u>

As regards the control variables, such variables were also employed at the firm and "reference" project levels of analysis.

On the firm level of analysis, the control variables employed related to the *age* and *size* of the Organisation, its *R&D department size*, the *previous experience* it has with relevant Transport R&D projects and the *level of familiarity* it has with the other "reference" project participants. The age and size of the Organisation were measured by asking respondents to indicate the number of employees working for the Organisation, and how many years ago the Organisation was established. In order to gauge the size of the Organisation's R&D department, respondents were asked to indicate the number of employees working in the R&D department

of the Organisation. Furthermore, previous experience with Transport R&D projects was measured by asking respondents to indicate on Likert-type scales a) the extent to which they believe that their Organisation has a broad experience in such research projects and b) the approximate number of Transport-related collaborative R&D projects that the Organisation has participated in during the last ten years. Lastly, familiarity with other project participants was measured by asking respondents to indicate the extent to which they have collaborated in the past with partners involved in the project.

On the "reference" project level of analysis control variables utilized referred to the *size* and *duration* of the "reference" project as well as the Transport *sector* to which the project primarily belonged to. According to previous research, the size, as well as the duration of a research project, can have a significant effect on its implementation outcome (Hoang & Rothaermel, 2005). The size of the "reference" project was measured by asking respondents to indicate the number of partners involved in the project, while project duration was measured in months. In addition, participants were asked to indicate which Transport sector the project focused on and to indicate the primary focus of the project's work (i.e., whether it was technology, process, policy, service development, etc.).

4.3.2 The Revised Research Model

Our preliminary research model was revised after the first set of in-depth interviews conducted in the exploratory phase of our methodology, in order to include the relevant information and knowledge gained from the discussions with experts from the Transport sector. Through the analysis of the 1st round of interviews a new factor category was identified namely "Research-context" and included in our research model as shown in Figure 4.3.

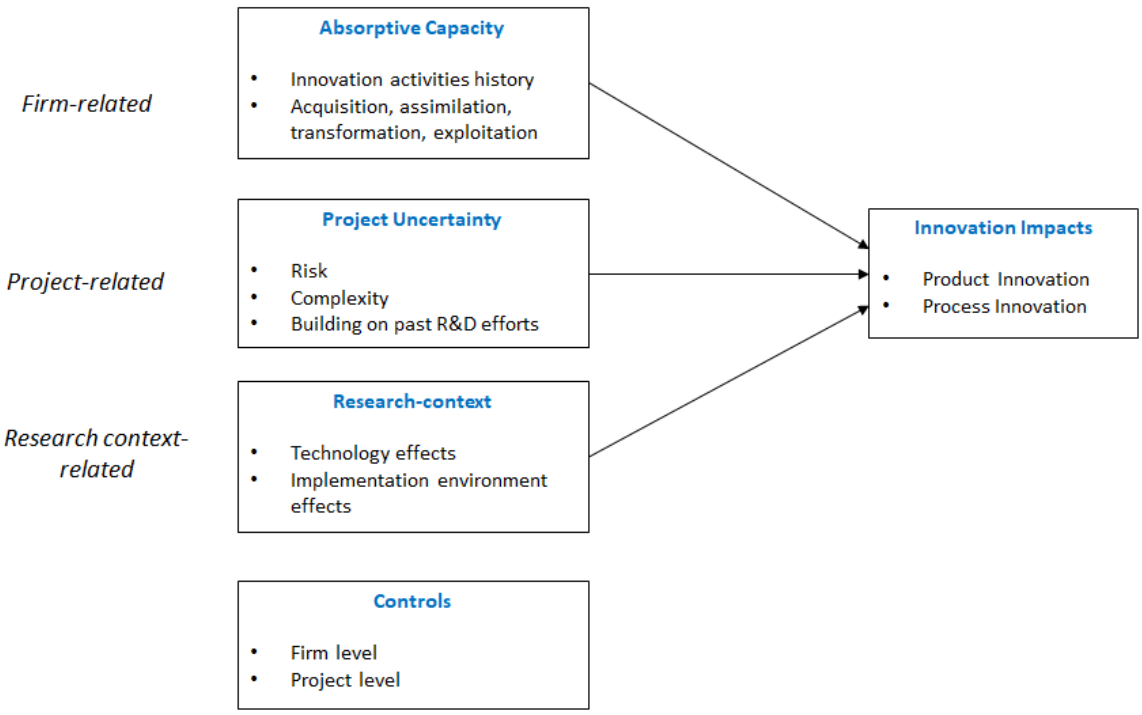


Figure 4.3: The revised research model of the study.

Research context-related factors

Within the "research-context" level of consideration, we identified for in-depth investigation and validation through our questionnaire survey, two distinct factor categories: *technology*-related factors and *implementation environment* related factors.

A. *Technology related factors.* In this category of factors, we included the following four types of factors:

1. *Technology/system maturity & relevance.* The meaning of "maturity" is related to the degree in which the technologies being investigated throughout a project are fully developed in the sense of technical completeness, accuracy, user-friendliness, etc. This was measured in the context of the "reference" project by asking the questionnaire respondents to indicate the extent to which the technology/system was: a) significantly developed, b) fully demonstrated within the life of the project, c) successfully deployed in the intended operational environment and finally d) successfully applied to all sites as it was initially planned. We also measured using Likert-type items the relevance of

the technology/system, i.e. the extent to which the research artifact meets end-user expectations and fulfills specific needs and requirements.

2. *Adoption cost.* There is a multitude of cost items related to the adoption of an innovative solution such as license costs, hardware costs (purchasing, installing and maintaining), personnel training, operational costs, etc. (Mora-Valentin, Montoro-Sanchez, & Guerras-Martin, 2004). We measured this with Likert-type items, asking respondents to indicate the degree to which the cost items mentioned above were important in the context of the "reference" project.
3. *Standardization.* Before any technical solution is adopted by the industry, on a large scale, it must be harmonized to existing standardization or cause a new standard to be developed. This will facilitate the further development of applications based on this technology and its full proliferation in the market. We used Likert-type questions to gauge the importance of standardization by asking whether: a) the technical elements for which an existing or applied for, standard existed, b) pending applications for new standards relevant to the technology/system and c) there were missing standardization protocols that were relevant to the technology/system.
4. *Privacy requirements/issues.* The degree to which privacy protection issues are involved will affect the degree to which implementation and innovation production relative to this new product or service will be affected. We measured the effect of privacy issues on innovation impacts by asking respondents to indicate the degree to which the new technology/system, raised issues related to privacy that had to be considered and the degree to which the core functions and elements of the technology/system required a dedicated "privacy certification".

B. Implementation environment related factors. In this category, four further types of factors were identified:

1. *Personnel requirements.* The adoption of innovation when the new "product" is a technology or system that is installed in an Organisation, may cause important implications for its workforce. New expertise may be required while other skills acquired in previous years may become obsolete. We assessed the effects of implications of personnel requirements with Likert-type items asking respondents to indicate the degree to which: skilled personnel was required for either the initial implementation or operation of the technology/system. Furthermore, respondents also

indicated the degree to which they believe that skilled personnel had to undergo special training in order to implement/operate the new technology/system.

2. *Data availability and quality.* This factor refers to the existence of necessary data for the application of the new system and the ease with which such data can be found in relation to their quality and reliability. Respondents were asked to indicate whether data relevant to the implementation & operation of the technology/system was readily available in the target implementation environment, whether this data was reliable (i.e., in terms of structure, format, content, etc.) and significantly costly to collect.
3. *Stakeholder cooperation agreement.* To secure the cooperation of all stakeholders involved in promoting and implementing innovation, a dedicated governance system and framework is necessary. Such system would primarily include a sound and tested stakeholder cooperation framework preferably strengthened through statutory measures. We used Likert-type items to measure the degree to which respondents consider a statutory "stakeholder cooperation framework" to be crucial for the implementation and operation of the technology/system. In addition, we also asked respondents whether they believe that the involvement of all relevant stakeholders was a requirement throughout the different stages of the implementation and operation lifecycle.
4. *Customization requirements.* This factor refers to the ease with which a research product can be deployed, i.e. the customization effort that is necessary (in terms of human resources, funding and time). A main element expressing the transferability of a solution is the degree of customization needed before its application (Haines, 2009). We measured the degree of customization, by asking the questionnaire respondents whether a) additional effort outside the project was required by the different stakeholders involved, b) specially qualified personnel was essential during the customization period and finally c) considerable data input was required.

5 The Quantitative Empirical Study

5.1 Description of Questionnaire and the Data Collection Process

The questionnaire survey consisted of six sections and respondents were asked to complete them while "referring" to a "reference research project" related to the Transport sector from their recent (within the last three years) project portfolio.

The **first** section of the questionnaire survey was introductory and included general guidelines for the respondents that helped them with completing the questionnaire survey. In this part, potential confidentiality issues were also addressed, so that respondents were well-aware of how the information they provide will be utilized throughout the research.

The **second** section of the questionnaire survey focused on gathering information about the main dependent variable of the research namely "Innovation Impacts". In order to do so, respondents were asked to assess different aspects of the exploitation of the "reference" project's results by their Organisation. For example, during this part of the questionnaire survey, information was gathered regarding the timeframe of the exploitation, as well as the impact it had on the Organisation.

The **third** section that followed, aimed at collecting data relevant to the characteristics of the "reference" project, such as the level of uncertainty found in different aspects of the project (managerial, commercial and technical uncertainty) and the inherent characteristics of the research context that is the main focus of the "reference" project.

The **fourth** section of the questionnaire survey asked respondents to provide information regarding the innovation profile and history of their Organisation. For example, respondents were asked to provide information related to the existence or not of certain resources and capabilities within their Organisation and innovation activities which the Organisation has undertaken in the (recent) past.

Lastly, the **last two** sections of the questionnaire survey focused mainly on obtaining demographic information for both the Organisation (size, age, etc.) and the "reference" project (duration, consortium size, etc.).

The questionnaire survey was administered in English, at a pan-European scale, through e-mail to a sample of approximately 700 individuals (i.e., RTD project managers, junior and

senior researchers, etc.) that are actively involved with European collaborative Transport R&D projects. The population from which the sample was drawn was identified at random through the authors business contacts which were asked to provide potential candidates for the completion of the questionnaire survey. The data collection process lasted for two months, more specifically from September to October 2017. With a thorough and persistent data collection effort, a 20% response rate was achieved, which translated to receiving back a total of 130 usable survey answers. The questionnaire survey approach was chosen, due to the availability of a large sample of individuals and Organisations that could provide the required information and more importantly, because it allowed for a thorough empirical analysis of the relationships and effects identified in the research model. The complete questionnaire survey is provided in the Appendix "Questionnaire".

5.2 Descriptive Statistics of the Sample

5.2.1 Firm Profile

In terms of the profile of the Organisations that participated in our survey, our sample comprised of both newly founded and established Organisations as well as all sizes companies, in terms of the number of employees (Figure 5.1). However, as expected the Organisations were mainly medium to large size.

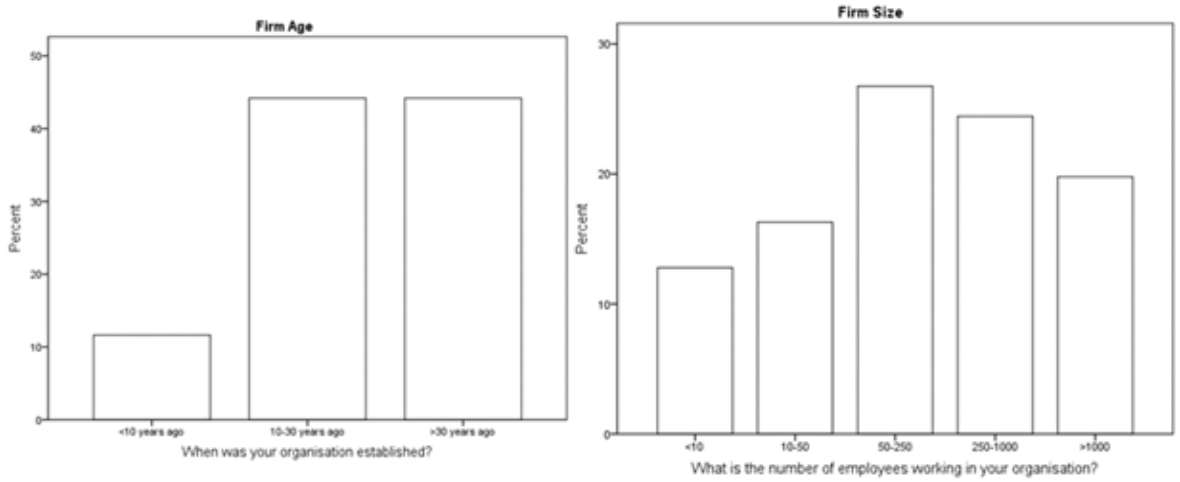


Figure 5.1: Age and size of Organisations in the study.

Furthermore, our sample included Organisations that had a large R&D department (as well as no R&D department at all), that focused mainly on research on the combined Transport and road sub-sectors (Figure 5.2).

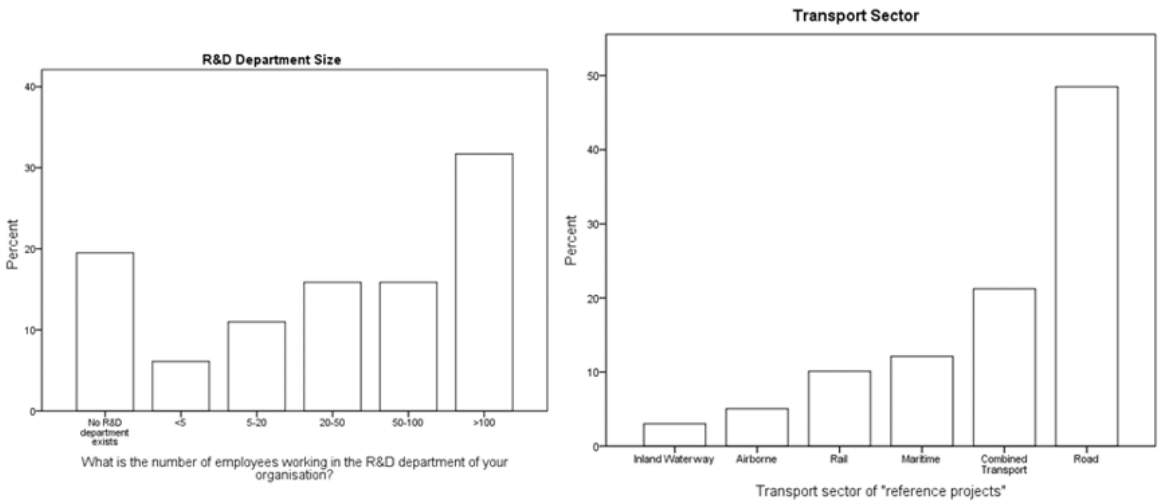


Figure 5.2: Size of R&D department and Transport sector focus.

In terms of the previous experience with R&D projects that the respondents in our sample had, this included Organisations that were highly experienced with Transport R&D projects, with most of them having participated in more than ten such projects (Figure 5.3).

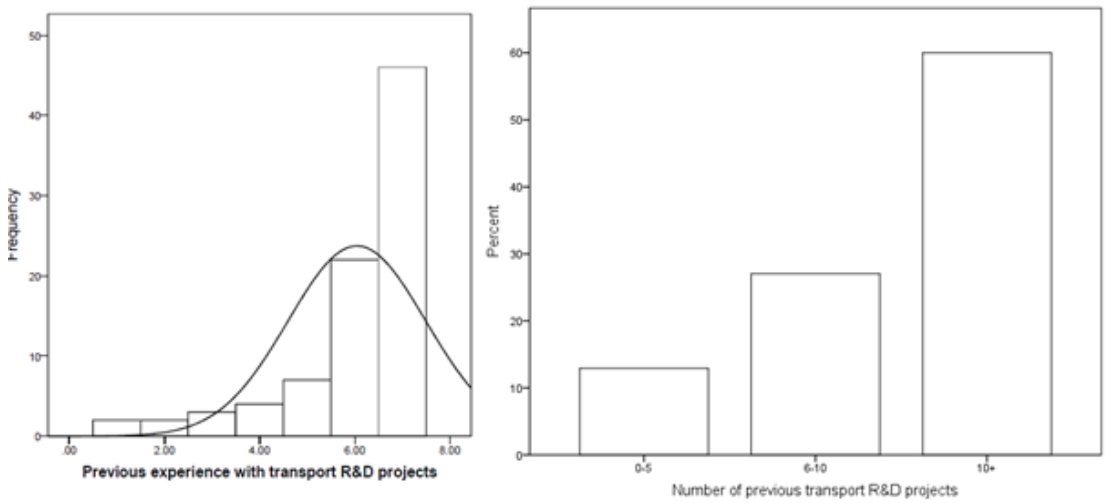


Figure 5.3: Previous Transport R&D experience of Organisations in our study.

With regards to the innovation history and performance of the Organisations in our sample, respondents indicated that their Organisations were focused on engaging in both in-house and external R&D (Figure 5.4).

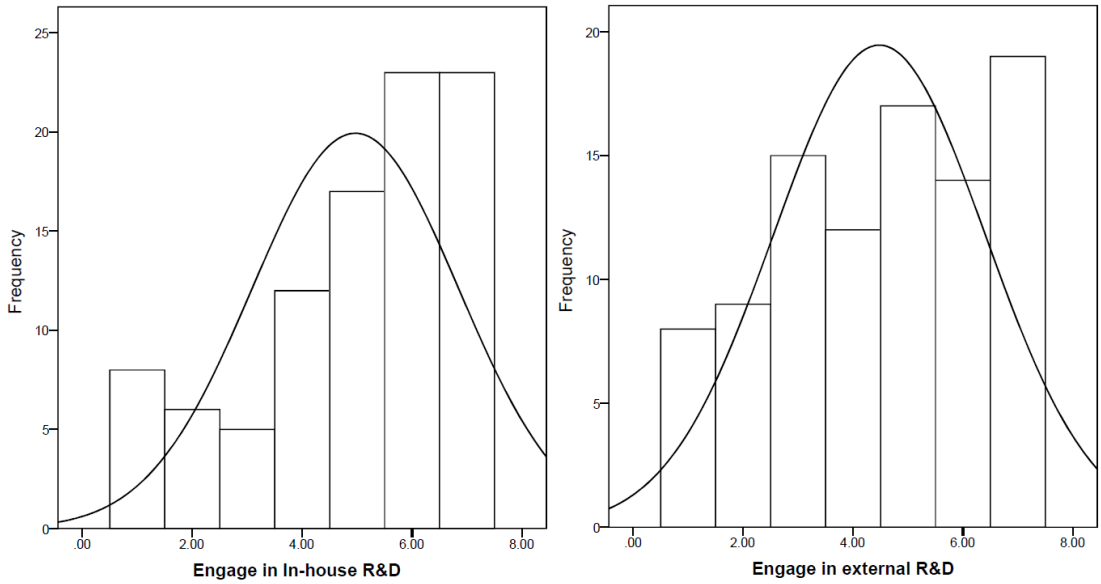


Figure 5.4: Innovation history and performance (1/2).

The innovations introduced by the Organisations were considered both new to the Organisation and new to the market (Figure 5.5).

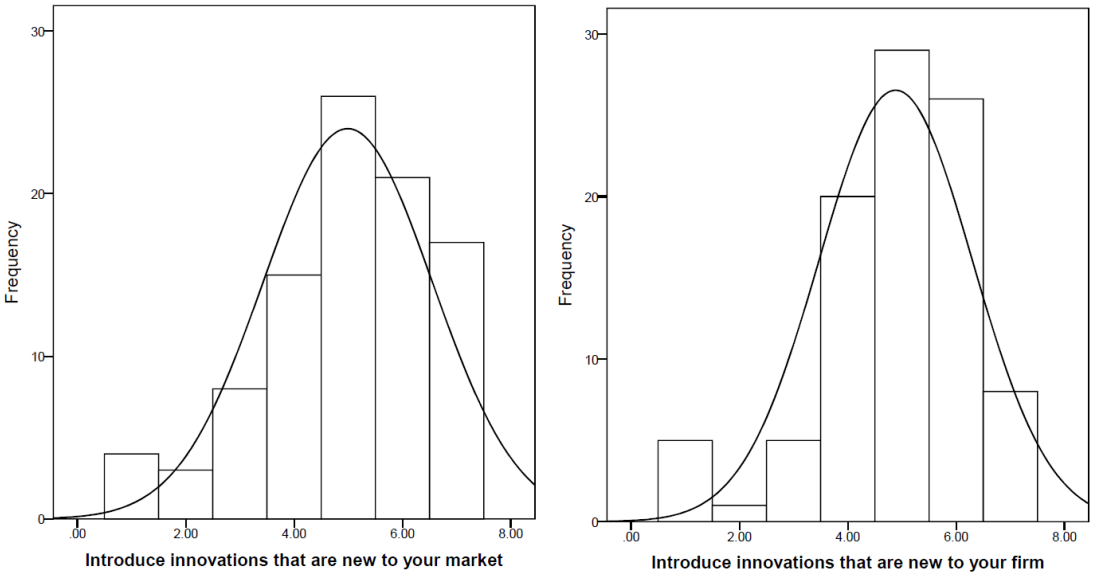


Figure 5.5: Innovation history and performance (2/2).

Additional descriptive statistics regarding the Organisations that participated in our survey can be found in the Appendix "Descriptive Statistics".

5.2.2 The "Reference" Project

With regards to the profile of the "reference project" that respondents had in mind when completing the questionnaire, answers were mostly based on medium & large-sized projects (in terms of the number of partners involved), that had been completed fairly recently (Figure 5.6).

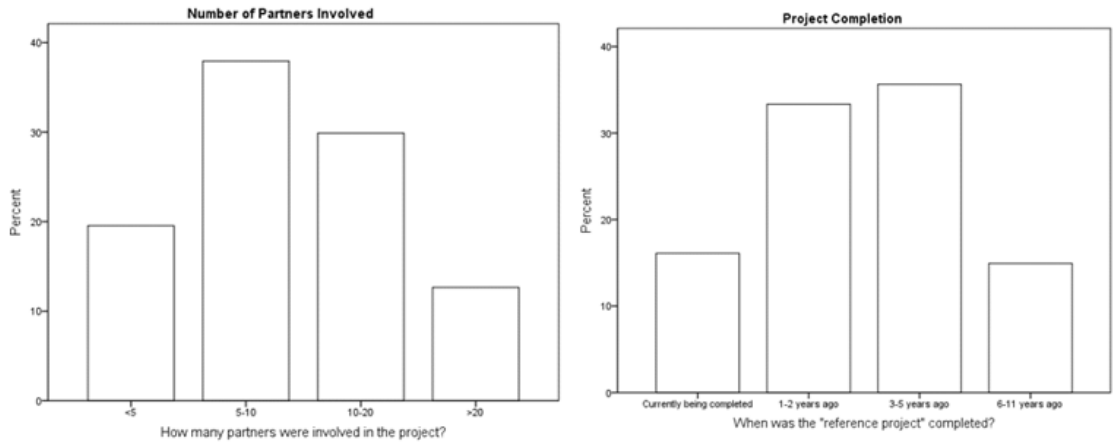


Figure 5.6: Size and completion time of projects in our study.

Furthermore, the "reference projects" in our sample focused mainly on developing technologies and services with funding originating mainly from EU programmes and national/government funds (Figure 5.7).

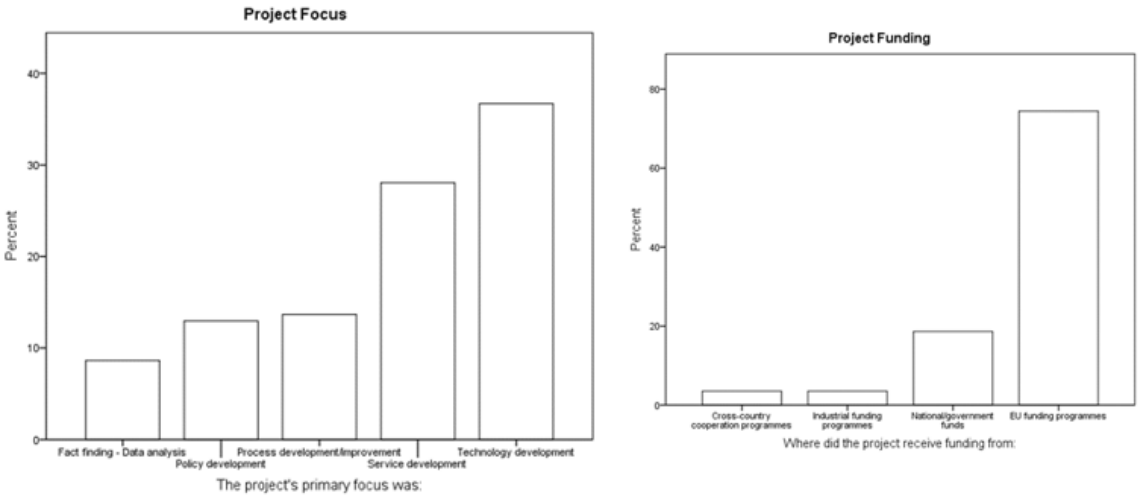


Figure 5.7: Focus of projects and origin of funding.

In the context of the "reference project", respondents indicated that their Organisations were responsible for initiating the proposal in 50% of the cases and heavily invested in the project by committing a large amount of resources (in terms of person-months) throughout its duration (Figure 5.8). This is important to note since it implies that our sample comprises of Organisations that could be considered as key stakeholders in the project, that played a significant role in the outcomes and research products that the project ultimately yielded and thus were more committed in the overall exploitation of research results.

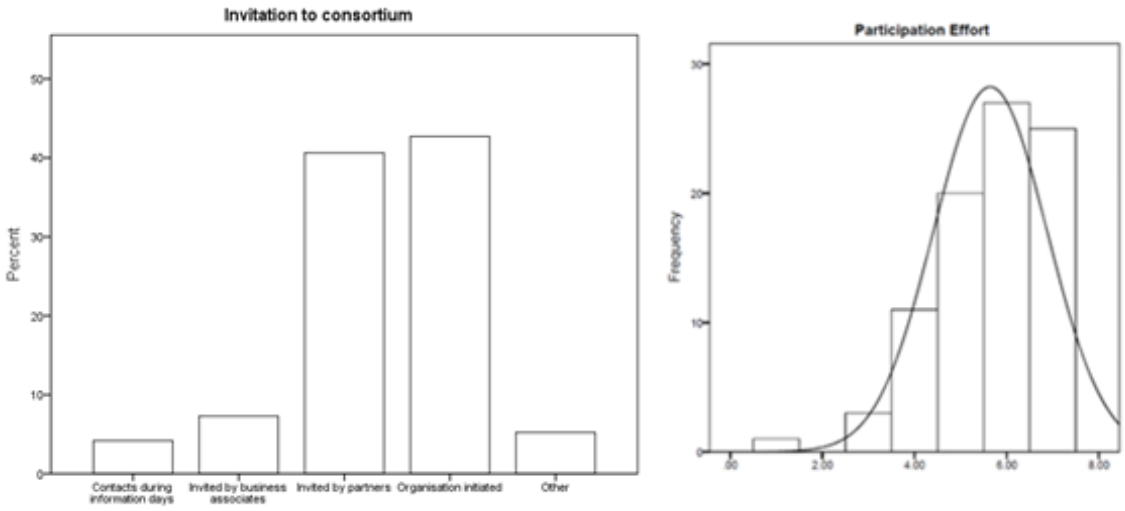


Figure 5.8: Partner invitation to consortium and participation effort.

Additional descriptive statistics regarding the "reference projects" that were selected by respondents to complete our questionnaire can be found in the Appendix "Descriptive Statistics".

5.2.3 The Research Context

Regarding the maturity of the technologies/systems being investigated throughout the research projects selected by our respondents, our sample mostly included projects that significantly developed and fully demonstrated most aspects of the technology/system within the life-cycle of the project (Figure 5.9).

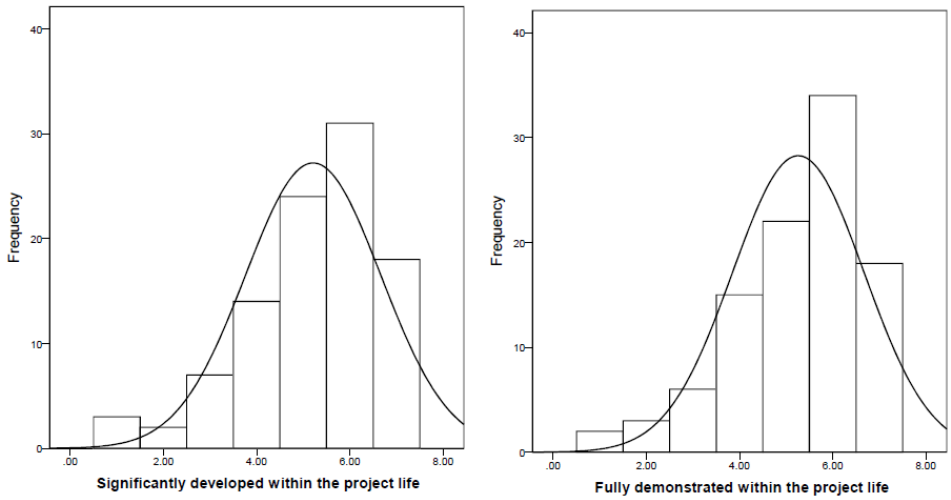


Figure 5.9: Maturity of the technologies/systems being investigated in the research projects of our study (1/2).

Furthermore, in most projects, the technology/system was also deployed in its intended operational environment and successfully applied to all initially planned test-sites (Figure 5.10).

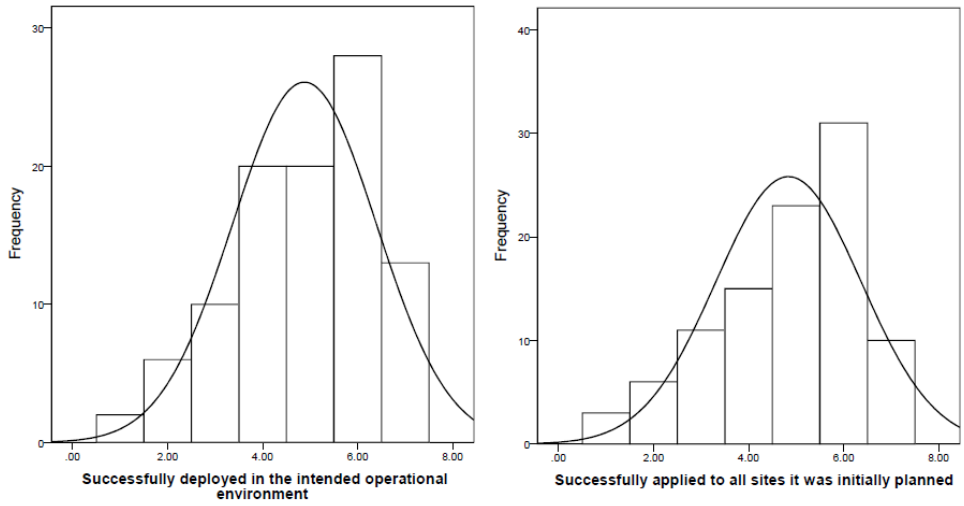


Figure 5.10: Maturity of the technologies/systems being investigated in the research projects of our study (2/2).

In the context of the relevance (i.e. the extent to which the research artifact meets end-user expectations and fulfills specific needs and requirements) of the technologies/systems under investigation, our sample included projects that according to our respondents covered most of the elements of the problem they were designed to address and produced results that met in most cases the expectations of end-users (Figure 5.11).

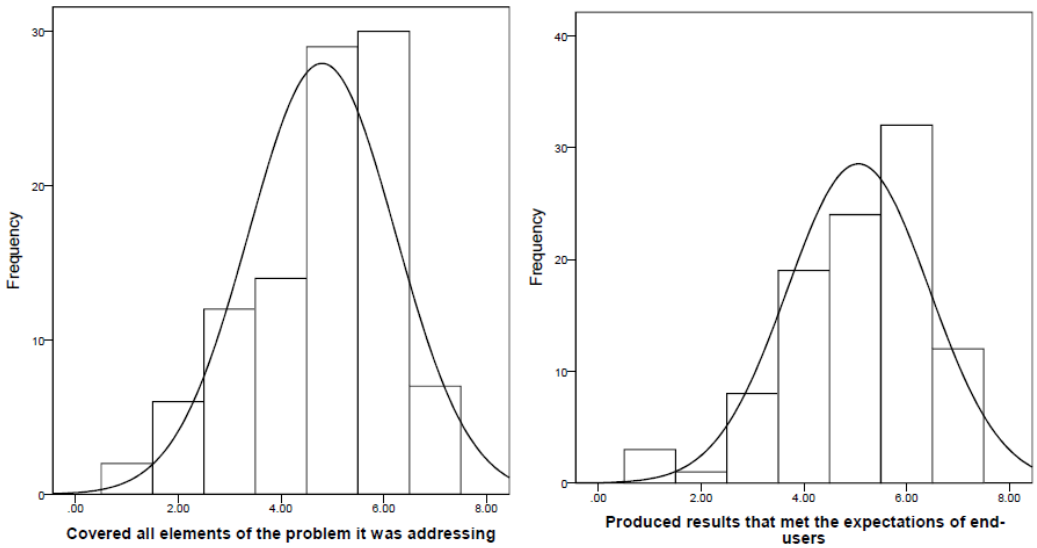


Figure 5.11: Relevance of the technologies/systems being investigated in the research projects of our study.

Regarding the ease with which the research product of the "reference project" could be deployed, i.e. the required customization effort, our sample indicated that (Figure 5.12) in most cases a) additional effort was required by the Organisation undertaking the research for the adoption of the technology/system, b) specially qualified personnel were required to customize the technology/system and finally c) a considerable amount of data input was required for the initialization and customization periods.

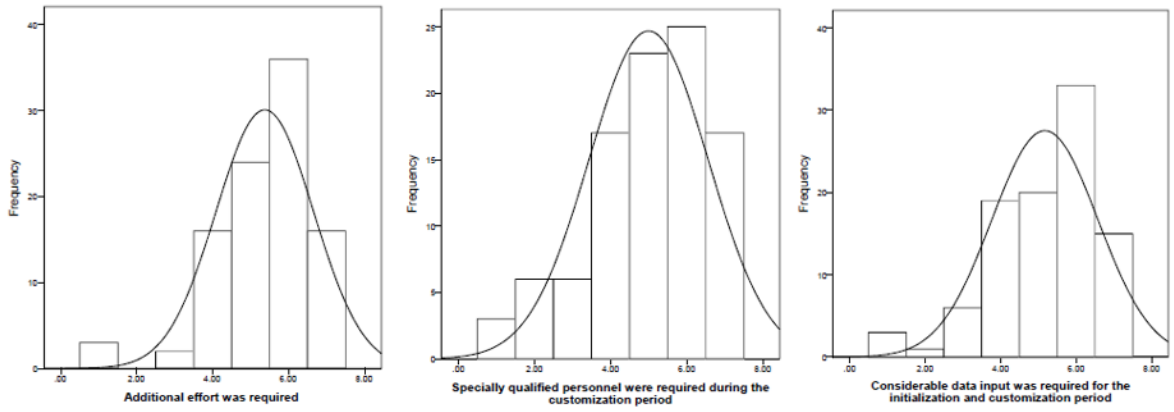


Figure 5.12: Ease with which the research product of the "reference project" could be deployed.

Turning to the effects of implication of personnel requirements for the successful adoption of the technology/system investigated within the "reference project", our sample

indicated that there was a very high requirement for skilled personnel both for the initial implementation and operation of the technology/system in the Organisation and most times specialized training was considered a pre-requisite for the successful operation of the technology/system (Figure 5.13).

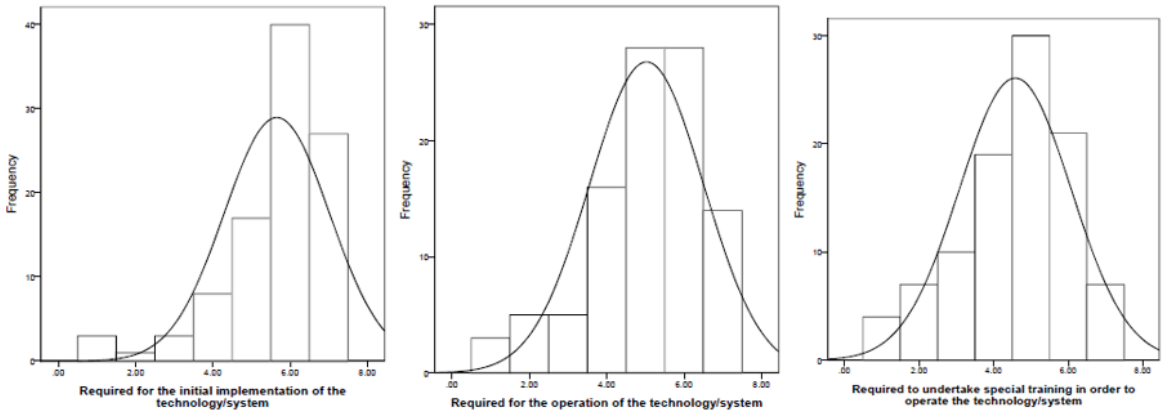


Figure 5.13: Effects of implication of personnel requirements for the successful adoption of the technology/system.

With regards to the existence of the necessary data for the application and operation of the technology/system and the ease with which such data could be found (Figure 5.14), our sample indicated that data were often available (with exceptions though) and reliable but in many cases the costs associated with the collection of such data were rather high.

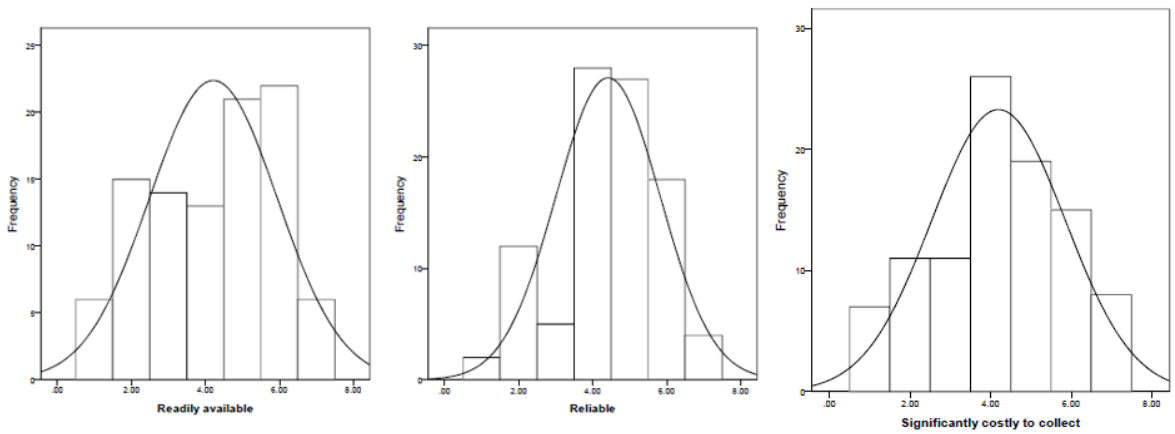


Figure 5.14: Existence of the necessary data for the application and operation of the technology/system.

In terms of securing the cooperation of all stakeholders involved in promoting and implementing the innovative research outcome, our sample indicated (Figure 5.15) that a) the actual involvement of all different types of stakeholders was highly required for the research

outcome to be implemented and b) a statutory “stakeholder cooperation agreement" was in most cases crucial in order to ensure the fruitful cooperation between stakeholders.

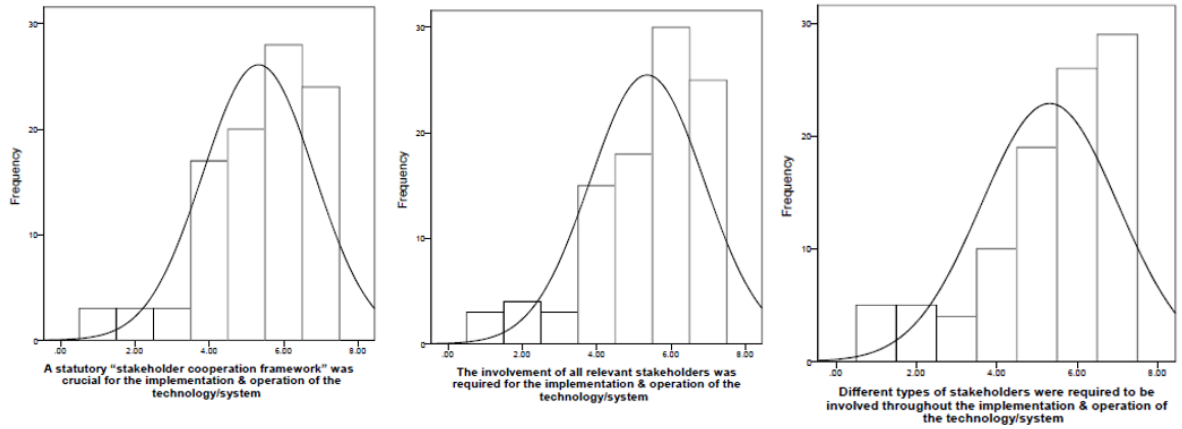


Figure 5.15: Stakeholder involvement in promoting and implementing the innovative research outcome.

5.2.4 The Innovation Impact

Most respondents indicated that the exploitation of the project’s results was successful and provided considerable value for their Organisation (Figure 5.16).

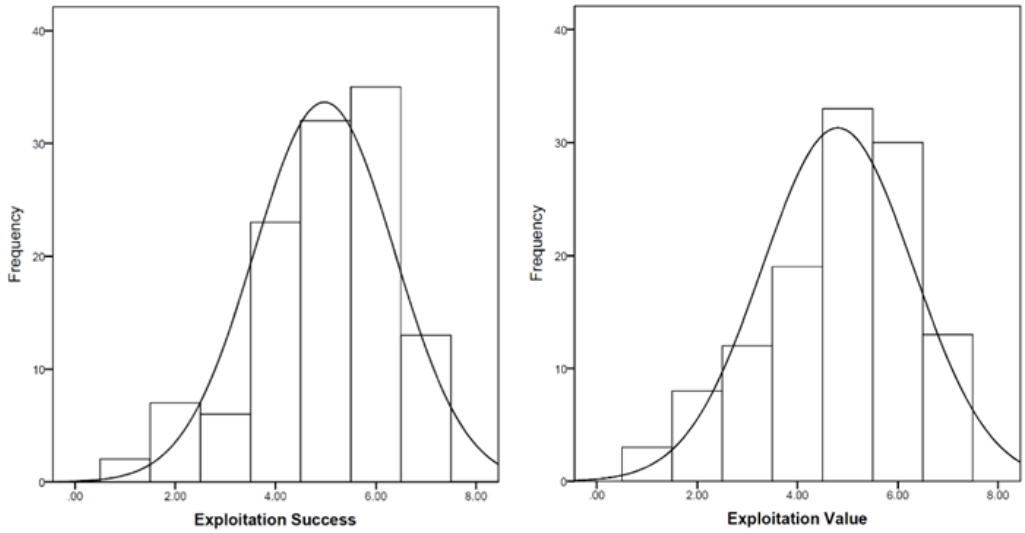


Figure 5.16: Success and value of the exploitation.

Our sample mostly viewed the exploitation process as highly beneficial and important for their Organisations (Figure 5.17).

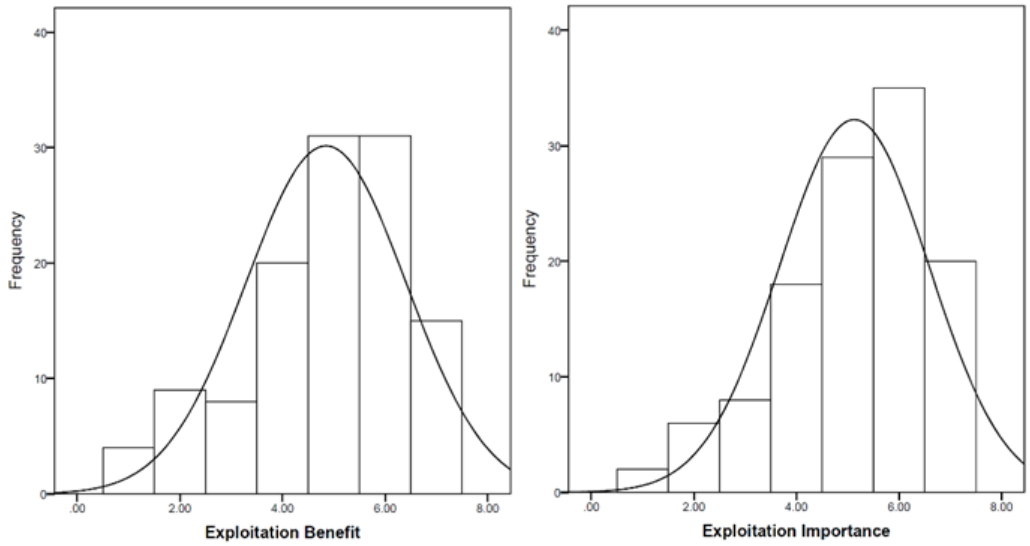


Figure 5.17: Benefit and importance of the exploitation.

Furthermore, project results were mostly exploited shortly after the end of the project and in most cases in combination with other project results (Figure 5.18).

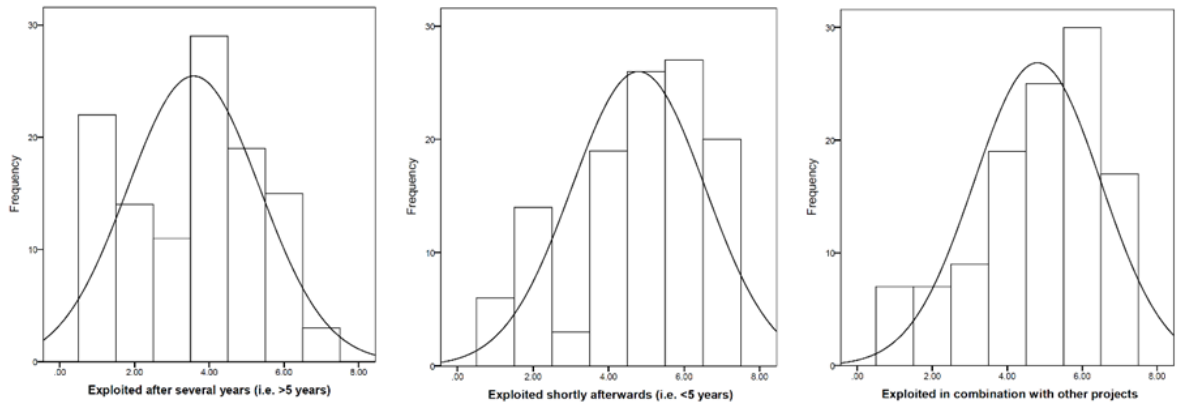


Figure 5.18: Timing of the exploitation effort.

Our sample also indicated that respondents selected "reference projects" to complete the questionnaire that were above average in terms of their significance, benefit for the Organisation and innovativeness of results (Figure 5.19).

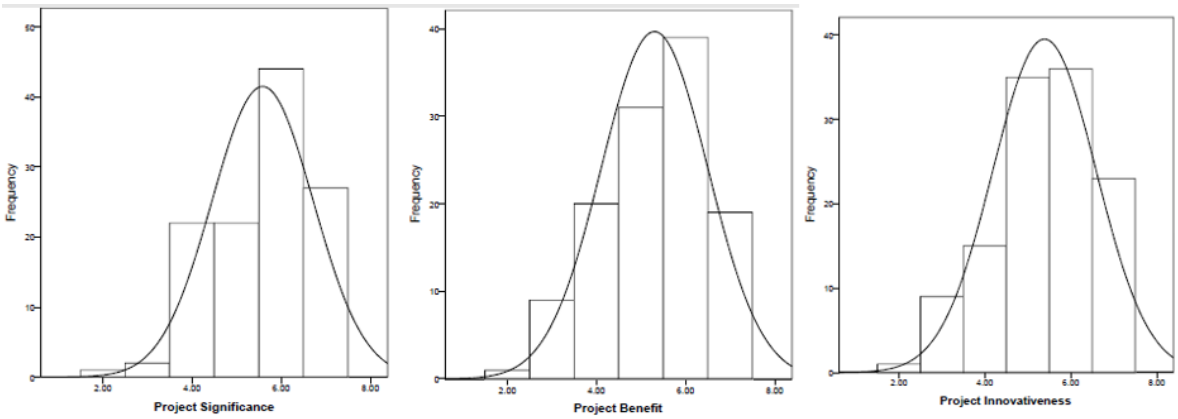


Figure 5.19: Significance, benefit and innovativeness of project results.

In addition, our sample also showed that selected "reference projects" had in general clear objectives and the work undertaken was characterized as highly ambitious, and potentially highly innovative (Figure 5.20). Taken collectively these characteristics of the potential innovation impact of a project show that our sample generally included projects that could be considered as highly impactful and valuable for the Organisations undertaking the work.

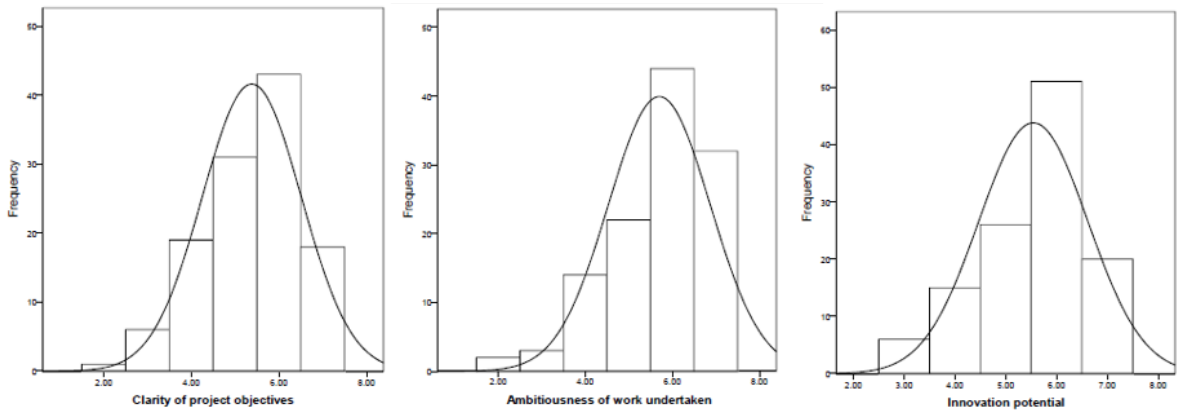


Figure 5.20: Clarity of objectives, ambitiousness of work undertaken and innovation potential of selected "reference projects".

5.3 Statistical Analysis

The research model shown in Figure 4.3 was empirically validated by using the SmartPLS3 (Partial Least Squares structural equation) modeling tool (version 3.2.7) (SmartPLS GmbH 2017). This tool can deliver empirical measures of the relationships between the indicators and the constructs (measurement models), as well as between the constructs

(structural model). The empirical measures enable us to compare the theoretically established measurement and structural models with reality, as represented by the questionnaire survey data (Hair, Hult, Ringle, & Sarstedt, 2016). Furthermore, it enables the simultaneous analysis of up to 200 indicator variables and the examination of extensive interactions among moderator and latent predictor variable indicators.

5.3.1 The Measurement Model

Initially, model assessment focuses on the measurement model[32] (Figure 5.21). Examination of PLS-SEM (Partial Least Squares-structural equation modeling) estimates enables us to evaluate the reliability[33] and validity[34] of the construct measures (Hair et al., 2016).

[32] The measurement model of the constructs presents the relationships between constructs and the indicator variables (rectangles) (Sarstedt, Ringle, & Hair, 2017).
[33] Reliability refers to the consistency of a measure.
[34] Validity is the extent to which the scores from a measure represent the variable they are intended to.

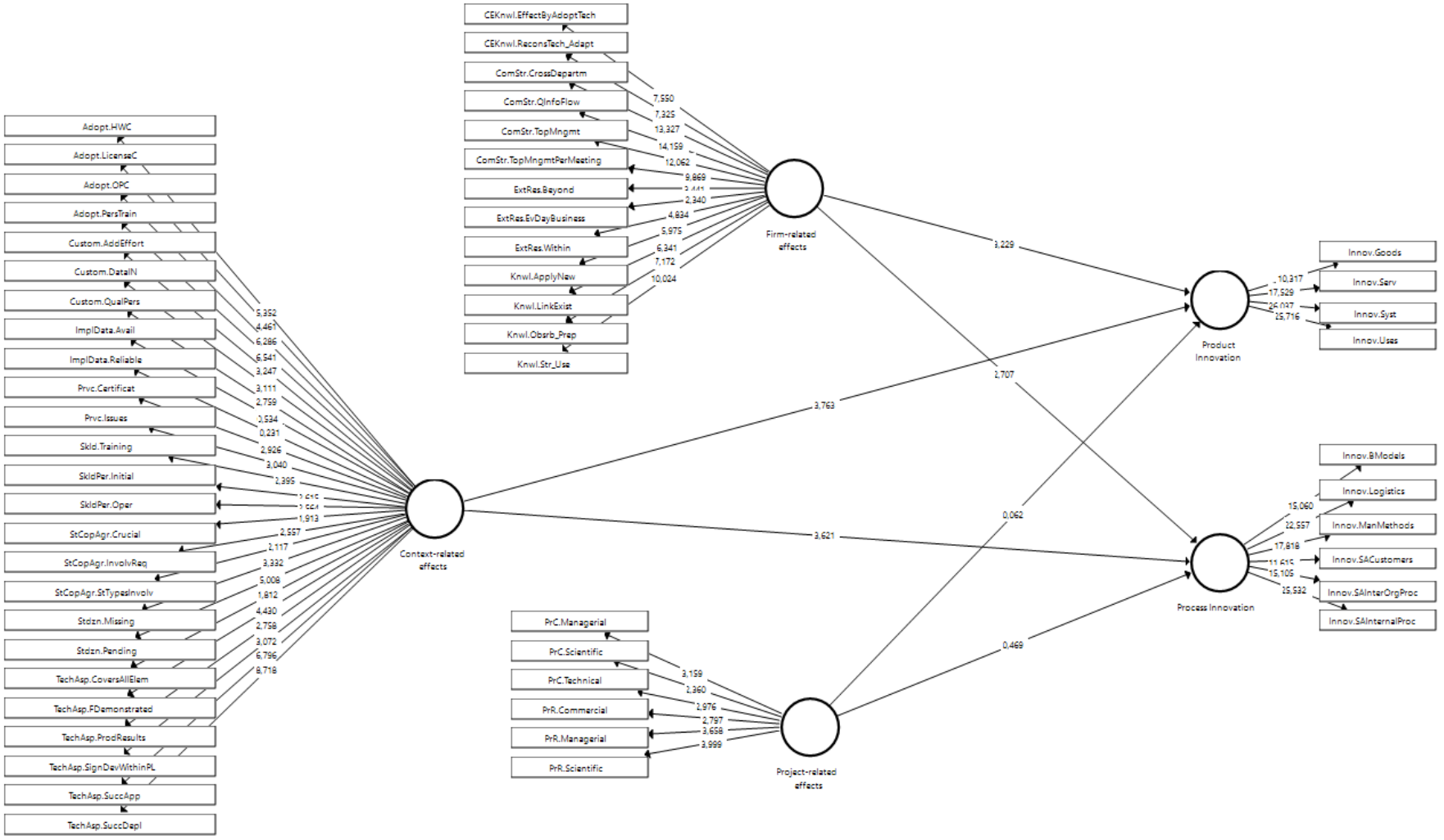


Figure 5.21: Measurement model results.

Reliability results are provided in Table 5.1. The data indicate that the measures of the factors considered are robust in terms of their internal consistency reliability[35] as indexed by the composite reliability measure.

The composite reliabilities[36] of the different measures range from 0.89 to 1.04, which exceed the recommended threshold value of 0.70 (Pallant, 2013). In addition, the average variance extracted (AVE)[37] for each measure exceeded 0.50 which is consistent with the guidelines given in (Fornell & Larcker, 1981).

Table 5.1: Assessment of the Measurement Model.

Variable constructs	**Cronbach's Alpha**	**rho_A**	**Composite Reliability**	**Average Variance Extracted (AVE)**
Innovation Impacts				
Product Innovation	0.83	0.84	0.90	0.68
Process Innovation	0.89	0.89	0.92	0.67
Firm-related effects				
Knowledge Acquisition	0.81	0.84	0.97	0.91
Knowledge Assimilation	0.88	0.89	0.98	0.91
Knowledge Transformation	0.91	1.04	0.99	0.95
Knowledge Exploitation	0.86	0.89	1.04	1.08
Project-related effects				
Project Risk	0.78	0.83	0.91	0.78
Project Complexity	0.77	0.79	0.92	0.80
Research-context effects				
Adoption cost	0.79	0.85	0.91	0.73
Customization requirements	0.84	0.90	0.96	0.90
Implementation data requirements	0.85	0.91	1.03	1.05
Personnel requirements	0.82	0.91	0.94	0.84
Privacy requirements	0.86	0.86	1.02	1.05

[35] Internal consistency reliability is a measure of how well the items on a test measure the same construct or idea (Hair et al., 2016).
[36] A means to assess the internal consistency reliability.
[37] Average variance extracted (AVE) is a measure of the amount of variance that is captured by a construct in relation to the amount of variance due to measurement error (Fornell & Larcker, 1981).

Process innovation	0.89	0.89	0.92	0.66
Product innovation	0.83	0.85	0.89	0.68
Stakeholder cooperation requirements	0.86	0.89	0.98	0.94
Standardization requirements	0.71	0.74	0.97	0.94
Technology/system maturity	0.81	0.89	0.93	0.82
Technology/system relevance	0.79	0.81	0.93	0.82

Table 5.2, Table 5.3 and Table 5.4 report the results of testing the discriminant validity[38] of the measurement scales. The elements in the matrix diagonals, representing the square roots of the AVEs, are greater in all cases than the off-diagonal elements in their corresponding row and column, supporting the discriminant validity of our scales.

Table 5.2: Discriminant Validity of Variable Constructs for Firm-related Effects.

Latent variables	Knowledge Acquisition	Knowledge Assimilation	Knowledge Exploitation	Knowledge Transformation	Process Innovation	Product Innovation
Knowledge Acquisition	**0.96**					
Knowledge Assimilation	0.33	**0.95**				
Knowledge Exploitation	0.28	0.44	**1.04**			
Knowledge Transformation	0.34	0.55	0.59	**0.97**		
Process Innovation	0.20	0.41	0.27	0.18	**0.81**	
Product Innovation	0.26	0.35	0.32	0.26	0.74	**0.82**

Table 5.3: Discriminant Validity of Variable Constructs for Project-related Effects.

Latent variables	Process Innovation	Product Innovation	Project Complexity	Project Risk
Process Innovation	**0.81**			
Product Innovation	0.71	**0.82**		

[38] Discriminant validity is the extent to which a construct is truly distinct from other constructs by empirical measures (Hair et al., 2016).

Project Complexity	0.04	0.11	**0.90**	
Project Risk	0.16	0.22	0.61	**0.88**

Table 5.4: Discriminant Validity of Variable Constructs for Research-context Effects.

Latent variables	1	2	3	4	5	6	7	8	9	10	11
1. Adoption post	**0.85**										
2. Customization req.	0.59	**0.95**									
3. Implementation data req.	-0.05	-0.06	**1.03**								
4. Personnel req.	0.38	0.52	0.00	**0.91**							
5. Privacy req.	0.38	0.41	-0.14	0.33	**1.02**						
6. Process innovation	0.40	0.06	-0.01	0.06	0.05	**0.81**					
7. Product innovation	0.35	0.19	-0.07	0.13	0.16	0.74	**0.82**				
8. Stakeholder cooperation	0.22	0.31	0.13	0.15	0.08	0.12	0.10	**0.97**			
9. Standardization req.	0.28	0.21	0.00	0.19	0.34	0.28	0.23	0.11	**0.97**		
10. Tech./system maturity	0.35	0.25	0.15	0.28	0.27	0.23	0.34	0.20	0.15	**0.91**	
11. Tech. /system relevance	0.18	0.08	0.27	0.09	-0.01	0.29	0.29	0.16	0.15	0.64	**0.91**

Convergent validity[39] was tested by extracting the factor and cross-loadings of all indicator items to their respective latent constructs. These results (Table 5.5, Table 5.6, and Table 5.7) indicate that all items loaded a) on their respective construct from a lower bound of 0.66 to an upper bound of 1.06; and b) more highly on their respective construct than on any other. The respective constructs' items' loadings and cross-loadings presented in Table 5.5, Table 5.6, and Table 5.7 confirm the convergent validity of these indicators as representing distinct latent constructs.

[39] Convergent validity is the extent to which a measure correlates positively with alternative measures of the same construct (Hair et al., 2016).

Table 5.5: Factor Loadings (bold) and Cross Loadings for Firm-related Effects.

	Knowledge Acquisition	Knowledge Assimilation	Knowledge Transform.	Knowledge Exploitation	Process Innovation	Product Innovation
Kn. Acq.1	**0.97**	0.30	0.32	0.19	0.20	0.27
Kn. Acq.2	**0.92**	0.14	0.28	0.20	0.09	0.20
Kn. Acq.3	**0.98**	0.43	0.37	0.40	0.24	0.26
Kn. Assim.1	0.37	**0.92**	0.59	0.48	0.29	0.36
Kn. Assim.2	0.28	**0.99**	0.59	0.45	0.42	0.37
Kn. Assim.3	0.35	**0.97**	0.58	0.39	0.35	0.27
Kn. Assim.4	0.27	**0.94**	0.38	0.35	0.49	0.33
Kn. Transf.1	0.24	0.45	**0.89**	0.59	0.07	0.20
Kn. Transf.2	0.28	0.51	**0.95**	0.61	0.09	0.15
Kn. Transf.3	0.36	0.52	**1.04**	0.61	0.16	0.22
Kn. Transf.4	0.39	0.62	**1.01**	0.55	0.28	0.33
Kn. Expl.1	0.29	0.47	0.59	**1.06**	0.31	0.36
Kn. Expl.2	0.30	0.44	0.64	**1.02**	0.23	0.30
Pro.Inn.1	0.21	0.38	0.13	0.22	**0.79**	0.63
Pro.Inn.2	0.13	0.31	0.06	0.16	**0.86**	0.60
Pro.Inn.3	0.12	0.38	0.18	0.32	**0.83**	0.62
Pro.Inn.4	0.15	0.20	0.11	0.07	**0.75**	0.58
Pro.Inn.5	0.18	0.35	0.23	0.27	**0.76**	0.57
Pro.Inn.6	0.16	0.29	0.16	0.16	**0.84**	0.57
Prd.Inn.1	0.13	0.33	0.14	0.27	0.63	**0.75**
Prd.Inn.2	0.30	0.27	0.29	0.30	0.50	**0.82**
Prd.Inn.3	0.18	0.22	0.21	0.25	0.63	**0.84**
Prd.Inn.4	0.23	0.31	0.19	0.23	0.68	**0.86**

Table 5.6: Factor Loadings (bold) and Cross Loadings for Project-related Effects.

	Project Complexity	Project Risk	Process Innovation	Product Innovation
Pr. Complexity 1	**0.91**	0.55	0.11	0.10
Pr. Complexity 2	**0.83**	0.51	0.01	0.09
Pr. Complexity 3	**0.95**	0.59	-0.02	0.11
Pr. Risk 1	0.45	**0.72**	0.09	0.00
Pr. Risk 2	0.57	**0.96**	0.19	0.22
Pr. Risk 3	0.60	**0.95**	0.13	0.23
Pro.Inn.1	0.06	0.16	**0.81**	0.63
Pro.Inn.2	0.01	0.11	**0.88**	0.59
Pro.Inn.3	0.05	0.18	**0.86**	0.59
Pro.Inn.4	-0.04	0.05	**0.75**	0.59
Pro.Inn.5	0.04	0.06	**0.69**	0.55
Pro.Inn.6	0.06	0.14	**0.85**	0.56
Prd.Inn.1	-0.02	0.08	0.63	**0.66**
Prd.Inn.2	0.14	0.24	0.50	**0.88**
Prd.Inn.3	0.07	0.15	0.61	**0.85**
Prd.Inn.4	0.12	0.20	0.69	**0.88**

Table 5.7: Factor Loadings (bold) and Cross Loadings for Research-context Effects.

	1	2	3	4	5	6	7	8	9	10	11
Ad. Cost 1	**0.81**	0.42	-0.08	0.20	0.14	0.32	0.26	0.21	0.27	0.16	0.29
Ad. Cost 2	**0.72**	0.36	-0.08	0.28	0.21	0.19	0.25	0.20	0.15	0.15	0.20
Ad. Cost 3	**0.95**	0.54	0.00	0.44	0.37	0.40	0.32	0.16	0.30	0.13	0.34
Ad. Cost 4	**0.92**	0.62	-0.05	0.38	0.38	0.36	0.44	0.21	0.24	0.20	0.34
Custom.1	0.57	**1**	-0.15	0.08	0.22	0.47	0.50	0.36	0.23	0.04	0.31
Custom.2	0.51	**0.94**	0.04	0.06	0.17	0.36	0.48	0.21	0.16	0.12	0.26
Custom.3	0.62	**0.90**	-0.01	0.01	0.13	0.31	0.52	0.31	0.20	0.06	0.10
Data Req.1	0.03	-0.03	**1**	0.01	-0.07	-0.11	0.01	0.15	0.07	0.23	0.10
Data Req.2	-0.11	-0.08	**1.05**	-0.02	-0.08	-0.17	-0.01	0.12	-0.06	0.31	0.19
Privacy 1	0.43	0.35	-0.16	0.09	0.15	**1.02**	0.32	0.04	0.38	-0.06	0.25
Privacy 2	0.36	0.49	-0.13	0.02	0.17	**1.03**	0.35	0.12	0.30	0.04	0.31
Pers. Req.1	0.37	0.51	0.10	0.08	0.10	0.25	**0.89**	0.12	0.23	0.11	0.16
Pers. Req.2	0.32	0.47	-0.07	0.06	0.16	0.33	**0.97**	0.15	0.15	0.08	0.34
Pers. Req.3	0.46	0.48	-0.01	0.02	0.04	0.40	**0.87**	0.14	0.14	0.06	0.22

Stakeholder1	0.16	0.25	0.28	0.12	0.08	0.03	0.04	**0.95**	0.11	0.19	0.18
Stakeholder2	0.27	0.33	0.17	0.09	0.07	0.06	0.21	**0.97**	0.05	0.21	0.28
Stakeholder3	0.22	0.32	-0.03	0.12	0.13	0.12	0.18	**0.98**	0.15	0.08	0.15
Standrard.1	0.24	0.13	-0.10	0.24	0.19	0.24	0.12	0.14	**0.94**	0.05	0.11
Standrard.2	0.30	0.26	0.07	0.30	0.24	0.39	0.23	0.09	**1**	0.22	0.18
Reliability1	0.01	-0.16	0.25	0.23	0.17	-0.26	-0.10	0.10	0.06	**0.87**	0.46
Reliability2	0.11	0.04	0.28	0.28	0.31	-0.13	0.01	0.08	0.08	**0.98**	0.53
Reliability3	0.34	0.26	0.21	0.29	0.28	0.30	0.29	0.24	0.25	**0.87**	0.71
Maturity1	0.30	0.19	0.08	0.22	0.32	0.17	0.16	0.15	0.06	0.57	**0.96**
Maturity2	0.25	0.08	0.04	0.08	0.15	0.08	0.17	0.01	-0.05	0.40	**0.81**
Maturity3	0.37	0.33	0.23	0.27	0.39	0.38	0.37	0.27	0.28	0.67	**0.95**
Pro.Inn.1	0.35	0.11	-0.13	**0.78**	0.64	0.09	0.01	0.04	0.24	0.25	0.22
Pro.Inn.2	0.37	0.07	-0.07	**0.89**	0.61	0.00	0.04	0.06	0.28	0.27	0.15
Pro.Inn.3	0.34	-0.02	0.12	**0.81**	0.62	0.09	0.10	0.09	0.25	0.21	0.22
Pro.Inn.4	0.26	0.05	-0.07	**0.78**	0.58	0.02	0.03	0.12	0.17	0.16	0.07
Pro.Inn.5	0.26	-0.03	0.09	**0.75**	0.58	0.01	0.06	0.16	0.18	0.28	0.23
Pro.Inn.6	0.37	0.09	0.02	**0.86**	0.58	0.04	0.08	0.11	0.22	0.26	0.23
Prd.Inn.1	0.15	-0.02	-0.01	0.62	**0.72**	0.06	0.04	0.04	0.27	0.29	0.20
Prd.Inn.2	0.30	0.26	-0.07	0.51	**0.81**	0.22	0.14	0.09	0.12	0.19	0.29
Prd.Inn.3	0.31	0.21	-0.04	0.63	**0.87**	0.14	0.14	0.11	0.19	0.22	0.35
Prd.Inn.4	0.36	0.16	-0.10	0.67	**0.88**	0.10	0.10	0.08	0.18	0.26	0.28

5.3.2 The Structural Model

After establishing reliability and validity for the items of our measurement model, the primary evaluation criteria for PLS-SEM results are the coefficients of determination (R^2)[40] and the level and significance of the path coefficients (Hair et al., 2016). The structural model of our analysis (i.e., the model containing all constructs together with their relationships-paths) and the total variance explained for each of our dependent variables is shown in Figure 5.22.

[40] The coefficients of determination (R^2) represent the amount of explained variance of the constructs in the structural model (Hair et al., 2016).

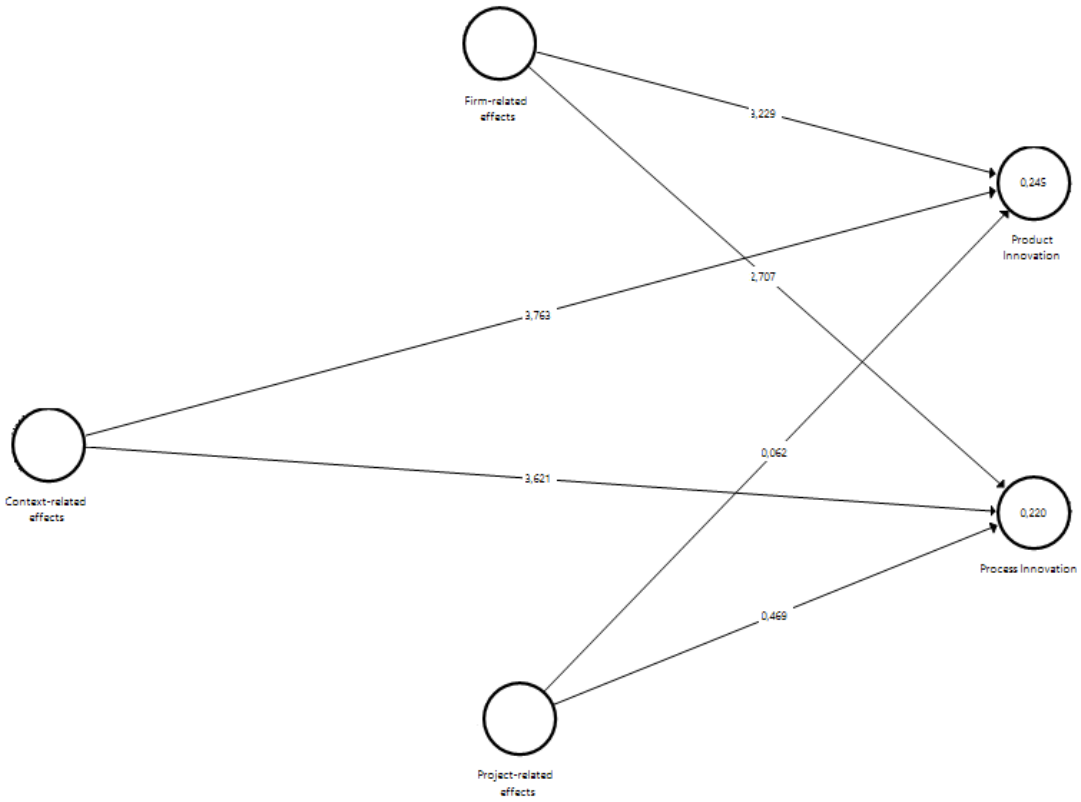


Figure 5.22: Structural model results.

All beta path coefficients are in the expected direction and statistically significant (at $p < 0.10$). For purposes of clarity, the beta values of all path coefficients are also shown.

<u>*Firm-related effects*</u> had an overall statistically significant positive effect on both product (beta = 3.22, $p < .00$) and process (beta = 2.70, $p < .00$) innovation. More specifically, for what concerns "firm-related" effects, knowledge *acquisition* had a non-significant influence on both product (beta = 1.14) and process (beta = 0.71) innovation. Knowledge *assimilation* had a statistically significant effect on both product (beta = 1.81, $p < .07$) and process (beta = 3.39, $p < .00$) innovation. Knowledge *exploitation* had a statistically significant influence on product innovation (beta = 1.96, $p < .05$) and a non-significant influence on process innovation (beta = 1.59). Finally, knowledge *transformation* had non-significant influence on both product (beta = 0.37) and process (beta = 1.33) innovation.

<u>*Project-related effects*</u> overall had non-significant effect on both product (beta = 0.06) and process (beta = 0.47) innovation. More specifically, project *complexity* had a non-

significant influence on both product (beta = 0.26) and process (beta = 0.55) innovation, while project *risk* had a non-significant influence on product (beta = 1.62) and process (beta = 1.55) innovation.

Research-context related effects overall had a statistically significant positive effect on both product (beta = 3.76, $p < .00$) and process (beta = 3.62, $p < .00$) innovation. In terms of technology-related effects, *maturity* had a non-significant influence on both product (beta = 1.51) and process (beta = 0.01) innovation. *Relevance* had a non-significant influence (beta = 1.09) on product innovation but a statistically significant positive influence (beta = 1.83, $p < .10$) on process innovation. *Adoption cost* had a positive influence on both product (beta = 2.06, $p < .05$) and process (beta = 4.39, $p < .01$) innovation. *Standardization requirements* had a non-significant influence (beta = 1.11) on product innovation and a significant positive influence (beta = 2.32, $p < .05$) on process innovation. *Privacy requirements* had a non-significant influence on both product (beta = 0.28) and process (beta = 0.98) innovation. Turning to implementation environment-related effects, *customization requirements* had a statistically significant influence (beta = 1.89, $p < .10$) on process innovation and a non-significant influence (beta = 0.13) on product innovation. *Personnel requirements* had a non-significant influence on both product (beta = 0.25) and process (beta = 0.16) innovation. *Data requirements* had a non-significant influence on both product (beta = 1.39) and process (beta = 0.86) innovation. *Stakeholder cooperation requirements* had a non-significant influence on both product (beta = 0.00) and process (beta = 0.58) innovation.

The model explains 24% of the variance in product innovation and 22% of the variance in process innovation. Taken separately, these R^2 values are considered of "weak" strength of effect (Chin, 1998; Höck & Ringle, 2006), but if considered as an individual dependent variable (i.e., product and process innovation) then our model explains 46% of the variance reported.

Following the above analysis, we also performed a PLS multigroup analysis (MGA)[41], to determine whether our model significantly differs between different groups formed by our firm and "reference" project control variables. PLS-MGA is a non-parametric significance test that finds a difference to be significant if the p-value is smaller than 0.05 or larger than 0.95 for the difference of group-specific path coefficients. This method (see Henseler, Ringle, &

[41] The multi-group analysis allows to test if pre-defined data groups have significant differences in their group-specific parameter estimates (e.g., outer weights, outer loadings and path coefficients) (Hair et al., 2016).

Sinkovics, 2009) is an extension of the original nonparametric Henseler's MGA method and is the most commonly used test.

a) Firm-level

In terms of the size of the Organisation (i.e., the number of employees), our PLS-MGA analysis indicated that there is a statistically significant difference between SMEs and larger Organisations in our sample (Table 5.8), particularly for what concerns the effect that "project-related" factors have on product innovation (p-value = 0.966).

Table 5.8: PLS-MGA analysis for SME's vs large Organisations.

	Path Coefficients-diff (| Large Organisations - SMEs |)	p-Value (Large Organisations vs SMEs)
Context-related effects -> Process Innovation	0,208	0,181
Context-related effects -> Product Innovation	0,258	0,137
Firm-related effects -> Process Innovation	0,112	0,698
Firm-related effects -> Product Innovation	0,132	0,736
Project-related effects -> Process Innovation	0,498	0,966
Project-related effects -> Product Innovation	0,265	0,889

Regarding the age of the Organisation, our PLS-MGA results indicated that there were no statistically significant differences in our PLS model between newly founded and established Organisations (Table 5.9).

Table 5.9: PLS-MGA analysis for newly established vs established Organisations.

	Path Coefficients-diff (| Firm Age_<10-20 years - Firm Age_>20-30 years |)	p-Value (Firm Age_<10-20 years vs Firm Age_>20-30 years)
Context-related effects -> Process Innovation	0,145	0,752
Context-related effects -> Product Innovation	0,060	0,619
Firm-related effects -> Process Innovation	0,034	0,582
Firm-related effects -> Product Innovation	0,064	0,649
Project-related effects -> Process Innovation	0,171	0,236

Project-related effects -> Product Innovation	0,023	0,477

In terms of the size of the R&D department of the Organisation, our PLS-MGA results indicated that were statistically significant differences between Organisations that have small and large R&D departments (Table 5.10), particularly for what concerns the effect that "project-related" factors have on process innovation (p-value = 0.962).

Table 5.10: PLS-MGA analysis for small vs large R&D department size.

	Path Coefficients-diff (| Large R&D department - Small R&D department |)	p-Value (Large R&D department vs Small R&D department)
Context-related effects -> Process Innovation	0,098	0,428
Context-related effects -> Product Innovation	0,147	0,783
Firm-related effects -> Process Innovation	0,047	0,554
Firm-related effects -> Product Innovation	0,141	0,277
Project-related effects -> Process Innovation	0,498	0,962
Project-related effects -> Product Innovation	0,043	0,564

Turning our focus on the previous experience Organisations had with Transport R&D projects, our results indicated that there were no statistically significant differences between Organisations that had limited experience and Organisations that were more familiar and experienced with such projects (Table 5.11).

Table 5.11: PLS-MGA analysis for previous experience with Transport R&D projects.

	Path Coefficients-diff (| Large previous R&D experience - Small previous R&D experience |)	p-Value (Large previous R&D experience vs Small previous R&D experience)
Context-related effects -> Process Innovation	0,091	0,686
Context-related effects -> Product Innovation	0,053	0,611
Firm-related effects -> Process Innovation	0,049	0,605

Firm-related effects -> Product Innovation	0,042	0,616
Project-related effects -> Process Innovation	0,124	0,705
Project-related effects -> Product Innovation	0,066	0,621

In terms of the degree to which the Organisation was primarily involved with intramural (in-house) or extramural (relevant activities that have been contracted to other parties) R&D activities, our analysis found no statistically significant different effects in our PLS model, as per our PLS-MGA analysis (Table 5.12).

Table 5.12: PLS-MGA analysis for the Organisations innovation record (intramural/extramural R&D).

	Path Coefficients-diff (| Extramural R&D - Intramural R&D |)	p-Value (Extramural R&D vs Intramural R&D)
Context-related effects -> Process Innovation	0,007	0,482
Context-related effects -> Product Innovation	0,075	0,322
Firm-related effects -> Process Innovation	0,013	0,499
Firm-related effects -> Product Innovation	0,005	0,504
Project-related effects -> Process Innovation	0,130	0,710
Project-related effects -> Product Innovation	0,168	0,791

Furthermore, the extent to which the Organisation has been mainly focusing on introducing innovations that are new to the market or new to the firm was also found to have no statistically significant difference in our PLS model (Table 5.13).

Table 5.13: PLS-MGA analysis for the Organisations innovation record (innovations new to firm/market).

	Path Coefficients-diff (| New to firm - New to market |)	p-Value (New to firm vs New to market)
Context-related effects -> Process Innovation	0,078	0,326

Context-related effects -> Product Innovation	0,023	0,560
Firm-related effects -> Process Innovation	0,029	0,620
Firm-related effects -> Product Innovation	0,055	0,400
Project-related effects -> Process Innovation	0,072	0,637
Project-related effects -> Product Innovation	0,017	0,469

Finally, for the firm-level of analysis, we examined the familiarity that Organisations had with other "reference" project participants (Table 5.14). Research "context-related" effects on product innovation were found to be significantly different between Organisations that were highly familiar with other partners of the "reference" project and Organisations that had very limited previous collaborations with project partners (p-value = 0.046).

Table 5.14: PLS-MGA analysis for the familiarity with other "reference" project participants.

	Path Coefficients-diff (| Previous collab. with 5-10 partners - Previous collab. with 10-20 partners |)	p-Value (Previous collab. with 5-10 partners vs Previous collab. with 10-20 partners)
Context-related effects -> Process Innovation	0,260	0,120
Context-related effects -> Product Innovation	0,346	0,046
Firm-related effects -> Process Innovation	0,193	0,865
Firm-related effects -> Product Innovation	0,278	0,938
Project-related effects -> Process Innovation	0,207	0,831
Project-related effects -> Product Innovation	0,121	0,667

b) Project-level

Turning our focus to the "reference" project-level of analysis, the results of the PLS-MGA analysis indicated that there is a statistically significant difference in terms of the size of

the project in our PLS model, particularly for what concerns the effects that research "context-related" factors have on product innovation (p-value = 0.049) (Table 5.15).

Table 5.15: PLS-MGA analysis for small vs large project size.

	Path Coefficients-diff (| Project Size_Small - Project Size_Large |)	p-Value (Project Size_Small vs Project Size_Large)
Context-related effects -> Process Innovation	0,260	0,122
Context-related effects -> Product Innovation	0,346	0,049
Firm-related effects -> Process Innovation	0,193	0,863
Firm-related effects -> Product Innovation	0,278	0,938
Project-related effects -> Process Innovation	0,207	0,839
Project-related effects -> Product Innovation	0,121	0,670

With regards to the Transport sector that the "reference" project primarily belonged to, the PLS-MGA analysis indicated that our PLS model does not differ significantly between different Transport sectors (Table 5.16).

Table 5.16: PLS-MGA analysis for the Transport sector of the project.

	Path Coefficients-diff (| Transport Sector_Combined - Transport Sector_Road |)	p-Value (Transport Sector_Combined vs Transport Sector_Road)
Context-related effects -> Process Innovation	0,167	0,751
Context-related effects -> Product Innovation	0,025	0,546
Firm-related effects -> Process Innovation	0,198	0,218
Firm-related effects -> Product Innovation	0,054	0,394
Project-related effects -> Process Innovation	0,007	0,527
Project-related effects -> Product Innovation	0,003	0,506

Lastly, for what concerns the project-level of analysis we examined the extent to which the "reference" project was building on previous R&D efforts. Our results indicated that there

was no statistically significant difference between projects that were not related to any previous R&D efforts and projects that were based on previous research efforts (Table 5.17).

Table 5.17: PLS-MGA analysis with regards to whether the project is building on past R&D efforts.

	Path Coefficients-diff (| Project builds on past R&D effort - Project doesn't build on past R&D effort |)	p-Value (Project builds on past R&D effort vs Project doesn't build on past R&D effort)
Context-related effects -> Process Innovation	0,021	0,350
Context-related effects -> Product Innovation	0,006	0,380
Firm-related effects -> Process Innovation	0,011	0,463
Firm-related effects -> Product Innovation	0,037	0,413
Project-related effects -> Process Innovation	0,070	0,351
Project-related effects -> Product Innovation	0,393	0,076

5.4 Analysis of the Results

a) Firm-level

Our findings show that firm-level characteristics of the exploiting Organisation to a certain extent play an important role in determining a) the ability of the Organisation to exploit research results from a project and b) the type of innovation that will most likely result by the exploitation (Table 5.18).

Table 5.18: Results of "Firm-related" effects.

	Product Innovation	Process Innovation
Independent Variables		
Past innovation record		
Intramural R&D	-	-
Extramural R&D	-	-
New-to-market product innovations	-	-
New-to-firm product innovations	-	-
New-to-firm process innovations	-	-
Absorptive Capacity		
Knowledge acquisition	-	-
Knowledge assimilation	+ (beta = 1.81, p < .07)	+ (beta = 3.39, p < .00)
Knowledge exploitation	+ (beta = 1.96, p < .05)	-
Knowledge transformation	-	-
Control Variables		
Size	+ Project-related factors (p-value = 0.966)	-
Age	-	-
Experience with collaborative R&D projects	-	-
Past collaboration/familiarity with partners	+ Research-context effects (p-value = 0.046)	-

More specifically, our findings in relation to specific "firm-related" characteristics are the following:

Age and size of the Organisation

In terms of the age and size of the Organisation undertaking the exploitation, on the one hand, one would expect that large and established Organisations will be more successful with their exploitation efforts, since they will have more capacity and greater experience to successfully implement research results and put them quicker and more efficiently in the market. On the other hand, as our qualitative and quantitative results suggest, this is not always

the case, since large and more established Organisations are often faced with a plethora of issues that inhibit their ability to transform research results into concrete innovations successfully. Large and established Organisations are often very "rigid" with multiple different departments that can result in the creation of bottlenecks for many seemingly obvious and simple tasks. For example, inherent bureaucracy that is in many cases a required characteristic for the efficient operation of large Organisations can in many ways hinder the process of exploitation.

Furthermore, as was highly noted by our interviewees, large Organisations are more prone to create "*research silos*" that make it harder to "*get the research out and into the rest of the Organisation"*. On the contrary, small and newly founded Organisations are not always set in their ways and can more easily respond and react to a wider variety of exploitation opportunities. Turning to the results of our qualitative analysis, interviewees on the subject noted that often small and newly founded Organisations can have more "*transparency and greater communication*" between the activities of their different departments.

Previous experience with Transport R&D projects and familiarity with project partners

Regarding the effect that previous experience with Transport R&D projects has on an Organisations potential to exploit research, our results indicated that prior experience does not seem to play a determining role for the successful exploitation of research results. Although earlier research has found different results on this topic (Anand & Khanna, 2000), one should consider when viewing our results, the fact that Organisations in our sample mostly reported that they were highly experienced and involved with Transport R&D projects (Chapter 5; Figure 5.3). This could help explain why our statistical analysis did not find any significant relationships between previous Transport R&D experience and innovation impacts since our sample did not represent Organisations that were highly inexperienced and new to Transport R&D projects. Despite the above, results from the qualitative research suggested that previous experience and more specifically, positive previous Transport R&D experience *"may facilitate the consecutive exploitation of research results by enabling individuals to be more creative and less afraid of the risks associated with the exploitation of research results".*

With regards to the level of familiarity between partners involved and the extent of previous collaborations with them, our results indicated that Organisations are more likely to successfully exploit research results when participating in projects whose consortia are

comprised of partners that are familiar with each other and have extensively collaborated in different projects in the past. Familiarity between partners of a consortium can lead to a more significant commitment by all participants to make the consortium work better and more efficiently to achieve its research objectives, ultimately yielding research results that are more valuable and worth exploiting for the Organisation. Furthermore, while keeping in mind that the duration of a collaborative R&D project is limited, an extensive collaboration past between partners of a consortium could enable them to work together more effectively quicker, since the process of establishing the necessary communication and collaboration dynamics between them will be easier and more efficiently done.

Past innovation record

In terms of the Organisation's record of innovation activities, the degree to which it has been primarily involved with intramural (in-house) or extramural (relevant activities that have been contracted to other parties) R&D activities does not seem to have an important bearing on the exploitation potential of the Organisation. Although our analysis did not find any significant links between the internal and external orientation (in terms of its R&D activities) of an Organisation, interviewees did note that both orientations could inhibit or enable an Organisation to successfully exploit and implement research results commercially. On the one hand, interviewees indicated that Organisations focusing primarily on intramural R&D activities could face difficulties trying to "*establish proper communication between the R&D department and the rest of the Organisation*". On the other hand, if there are individuals within the Organisation that are "*actively participating in the research and have a platform for the exploitation*" that they work with every day, they will be more successful with the exploitation of research results. In the case where the Organisation mostly focuses on extramural R&D activities, different problems could emerge with the communication of the two parties (i.e., the party carrying the research and the party exploiting it) as it is essentially as "*having two different Organisations trying to communicate with one another*". Both intramural and extramural R&D activities play an important role in managing to create an environment where research is more "*distributed within the Organisation*", providing a better opportunity for exploitation.

Absorptive Capacity

Lastly, for what concerns this category of factors, our findings showed that the capabilities of the Organisation to acquire, assimilate, transform and exploit knowledge gained from external sources also have an important role in determining the outcome of the exploitation effort. More specifically, the ability to assimilate and exploit external knowledge was found to have a significant impact on the ability of the Organisation to exploit research results and produce innovations. In the context of a collaborative R&D project, the participation of a number of partners with different backgrounds and expertise consistently produces knowledge spillovers which are crucial and relevant for a participating Organisation to analyze, interpret, and understand, in order to be in a better position to exploit the outcome of a collaborative effort. Having such capabilities allows for the Organisation to manage and control for the different aspects of the exploitation effort since it can facilitate more rapid and efficient dissemination of relevant knowledge within its product and process portfolio.

b) Project-level

The impact that project-level characteristics have on an Organisation's potential to exploit research results were found to influence to a certain extent the occurrence and the success of the exploitation effort (Table 5.19).

Table 5.19: Results of "Project-related" effects.

	Product Innovation	**Process Innovation**
Independent Variables		
Project risk	-	-
Project complexity	-	-
Control Variables		
Size	+ Research context-related factors (p-value = 0.049)	+
Transport sector	-	-
Project builds on past R&D effort	-	-

Project size, past R&D effort and the specific Transport sub-sector

In terms of the size of the project, our statistical analysis revealed that project size could be a significant determinant of the innovation potential of an Organisation, in terms of the impact it has on the relationship between research-context factors and product innovation. A large consortium – which is more likely to comprise of Organisations that have "*diverse knowledge stemming from different experiences*" (Spanos et al., 2015) – is better positioned and more likely to successfully address the exploitation issues and barriers that may arise from the intricate characteristics of the technology being investigated in the context of a Transport research project. A case in point of such issue are the costs related to the adoption of new innovative Transport solution. As mentioned earlier, a multitude of cost items could be related and have a significant impact to the outcome of the adoption of an innovative solution, such as license costs, hardware costs (purchasing, installing and maintaining), personnel training, operational costs, etc. Having a large consortium would enable for such costs to be more evenly and rationally distributed between partners of the consortium (i.e., different hardware manufacturing partners "sharing" hardware costs) thus reducing the overall costs associated with the implementation for the end consumer.

Our quantitative analysis also suggested that whether a project is building on past R&D efforts does not have a significant impact on the innovation impacts realized by Organisations. Contrary to this finding, our qualitative analysis suggested that indeed the likelihood of partners realizing innovation impacts is higher when the project they are involved in is building on R&D effort that was part of a previous R&D project or initiated internally by the Organisation. More specifically, when presented with this finding one of our interviewees noted that building on other R&D projects, results, and experience allows for knowledge about a specific research area to *"mature within the Organisation, reaching a point where it provides solid grounds for fruitful and effective exploitation".* Similarly, previous research findings (Kostopoulos et al., 2015) have noted that when a project is building on past R&D efforts, the "*accumulated learning and experience*" will allow partners to more effectively and efficiently address any issues (i.e., technological, managerial, etc.) that may arise from the project.

Furthermore, our quantitative analysis indicated that the Transport sub-sector that the research focuses on has no significant impact on whether the results of the research will be exploited commercially by participating Organisations. On the contrary, the analysis of our qualitative analysis revealed a different result. As multiple interviewees noted, the Transport sub-sector that the research project focuses on can have a significant impact on the actual implementation and exploitation of research results. This can be attributed to the fact that the

various Transport sub-sectors have inherent differences across a plethora of characteristics that dictate to a great extent the ease or difficulty with which research results can be exploited. For example, the origin of the research funding (which significantly varies between Transport sub-sectors) can play a crucial role in driving the adoption of research results and the creation of innovation. More specifically, while comparing different Transport sub-sectors one of our interviewees noted that: *"in the road sector you have a lot of private investment (currently though automation) which drives innovation in the sector. In the rail sector, it is typically very defensive with stakeholders being very focused on keeping the status quo since very small partners are involved, and any product the sector produces is extremely costly compared to any other sector. This is mainly due to the nature of innovation (incremental), the small number of players involved and the fact that at the EU level it is mostly an industrial policy and not a research policy in mind, since they are trying to keep the market closed from the Japanese and Chinese competitors who are considerably much cheaper".*

Furthermore, "*the stability (or instability) of a sector*" could also play an important role. Continuous change in a sectors' focus (i.e., from shared mobility to autonomous cars and shared Transport means in the road sector) affects the pace of research results exploitation by different stakeholders as well as their motivation to innovate by utilizing research, since they are not in many cases certain whether the innovative research results will have a market willing to buy the finished product. Another example of a factor that helps explain differences in the exploitation intensity between different Transport sectors is the rigidness of the structure of the sector (i.e., the airborne sector is highly structured in comparison to the road sector) which plays an important role in explaining the difference in exploitation between different sectors. The difference between our quantitative and qualitative results could be potentially attributed to the fact that "reference projects" selected by our questionnaire survey respondents were not "evenly" distributed between the various Transport sub-sectors (see Figure 5.2), and thus our statistical analysis was not able to "capture" these inherent differences between Transport sectors.

c) Research context-level

With regards to the characteristics of the "research-context" that affect the exploitation potential of participating Organisations, our results are shown in Table 5.20. As shown in this table, technology-related factors such as the adoption costs and the standardization

requirements associated with the technology were found to affect the Organisations exploitation effort significantly.

Table 5.20: Results of Research "context-related" effects.

Independent Variables	Product Innovation	Process Innovation
Technology-related		
Technology/system maturity	-	-
Technology/system relevance	-	+ (beta = 1.83, p < .10)
Technology adoption cost	+ (beta = 2.06, p < .05)	+ (beta = 4.39, p < .01)
Standardization requirements	-	+ (beta = 2.32, p < .05)
Privacy requirements	-	-
Implementation environment		
Personnel requirements	-	-
Implementation data requirements	-	-
Stakeholder cooperation	-	-
Customization requirements	-	+ (beta = 1.89, p < .10)

Organisations that are carefully considering the "adoption costs" associated with the exploitation of the results of an R&D project are more likely to realize innovation impacts. This is particularly true in the Transport sector where potential adopters are often very reluctant to invest in the produced results. Standardization requirements were also found to be important, but the surprising finding is that they are strongly associated with process innovations. Process innovations are in most cases related with improvements in internal operations of an Organisation and have often been considered as more complex than product innovations due to their tacit and systemic nature (Gopalakrishnan, Bierly, & Kessler, 1999). In such cases, multiple and diverse stakeholders are often required to be involved in the innovation implementation process, and this causes the Organisation to develop without an overall coherence (Francis & Bessant, 2005).

Regarding the factors that relate to the implementation environment of the technology under examination, our findings show that customization requirements are positively associated with innovation impacts especially, process innovation. Transport research products are rarely “one size fits all” but instead must undergo significantly costly transformations and customizations before they can be exploited commercially. This, coupled with the increased complexity of process innovation (in comparison to product innovation), would imply that an extensive customization effort from the exploiting Organisation will increase the likeliness of successful exploitation of project results and subsequent creation of process innovation.

A concise summary of the results can be found in Section 7.1.

6 The Qualitative Study Based on in-depth Interviews

6.1 1st Round of Interviews – Verifying the Research Model

The main objective of the semi-structured in-depth interviews conducted during the initial exploratory phase of this research (1st round of interviews) was to utilize the knowledge and experience of the Transport experts interviewed, in order to identify further contextual factors that potentially affect the exploitation of research results in the Transport sector. Furthermore, the potential explanatory power of our conceptual model was discussed during the interviews, in order to improve our understanding regarding the different relationships that may exist between factors and to determine the extent to which our model accurately reflects the Transport sector.

The nature and structure of the interview process as described in the Methodology Chapter (Chapter 4), allowed for the interviewees to address and elaborate on a plethora of factors that could potentially have an impact on the success of the implementation and exploitation of research results for an Organisation participating in publicly funded Transport R&D projects. Factor categories previously identified from the literature review and the preliminary research on the subject, such as factors relating to the characteristics of the firm undertaking the research, and the research project itself were addressed throughout the interviews but in addition, new categories of potentially impactful factors (i.e., the technology and implementation environment factor categories) also emerged and where discussed in further detail. A detailed description of the participants' professional and academic experience can be found in the Appendix "List of interview participants".

6.1.1 The Eight Interviews

Interview #1

Prof. Angel Aparicio

Professor at UPM (Universidad Politécnica de Madrid)

Prof Aparicio has experience from both the academic as well as the governance and administrative parts of research and innovation production. He has extensive experience with

EU funded research projects having participated in more than 30 of them for the last ten years. For many years, he was working as Director (and Director General) of the Spanish Research Center in Civil Engineering (CEDEX). This is a 50-year old public agency for technical studies and research of the Spanish Ministries of Transport and Environment, with some 750 people working in the domains of Transport planning, infrastructure development, coastal engineering, water policy, and management.

Following a short introduction on the research subject, the interview with Prof. Aparicio began with a general remark about the ***inherent difficulty*** found in the exploitation of research results and the implementation of innovation in the ***Transport sector***. As Prof. Aparicio commented, "*the framework in Transport makes innovation difficult because it is not designed to match and fulfill innovation and market requirements and needs directly*". The reason this happens according to Prof. Aparicio is because Transport strives to be "*a cheap commodity in general and thus it doesn't have a clear archetype for innovation*". Emphasizing the point made by other interviewers "*since there is no clear market for Transport innovation, key stakeholders in the sector simply don't care, because there is no demand from the market*". On the contrary, Prof. Aparicio noted that "*taking the health sector for example, it has always had continuous and enormous demands from society to exploit more research results faster and more efficiently*".

Questioning Prof. Aparicio about the reasons and the ways that exploitation and implementation of research and consequently innovation is driven within the Transport sector he commented that according to his view "*in many cases* ***innovation is driven by policy and regulations,*** *which dictate changes that have to be made which are not always based on efficiency. When policy and regulation are not the driving force behind innovation in the sector you have limited cases of some private Organisations that get an out of the box idea and then you have to try and balance the incumbents in the industry*". Illustrating this, is the example used by Prof. Aparicio about the announcement made by Google regarding the exploration of automated vehicles, that initially triggered the industry's interest but was quickly forgotten, since "*no one had intentions of moving to that direction, because there was not a demand from the market, and it was a highly risky move*".

The main problem highlighted by Prof. Aparicio is that in many projects "***the research market involved consists of small universities and research centers*** *in many different countries with a business model to produce research results but not to make anything out of*

the results. Directors of such institutes do not strive to promote the exploitation of research results but rather aim at the creation of more research jobs and simply move on once the research has finished." Generalizing this comment to include also private Organisations involved in such R&D projects, Prof. Aparicio noted that "*small players involved in big R&D projects don't have the required capacity to exploit research results in order to produce for example new products. More importantly, even if they have that capacity, they surely lack the capacity to challenge the socio-economic power of incumbents of the industry*".

Having said the above, Prof. Aparicio recalled the success of an R&D project that emphasized the importance of ***policy, regulation and political leadership*** *as the* ***driving forces behind the exploitation of research results and innovation***. The project, which was titled "European Railway Traffic Management System", was aiming at creating a new automatic system for train protection and voice/data communication between tracks and trains. The idea and need for the project were generated at a policy level since the EU Commission wanted a new system to replace the different legacy systems used by different countries throughout Europe. After several years of research, the system in terms of its concept and technology utilized was successfully implemented, but there was no interest from the industry to adopt the solution. As it was natural, "*big industry players such as Siemens and Alcatel at the time were very reluctant to comply with the changes in their customer's networks, and made steps forward as slowly as possible, trying to preserve some of their biggest and oldest products (in order to keep their profits high) and maintain their regional markets rather than opening them up*". To overcome this issue, the Commission approached countries that did not have much experience with such systems (e.g., Spain) and provided them with funds to cover a part of their expenses for adopting the new railway system. As a result, this immediately created a new market in these countries for the system which attracted the big incumbents of the industry which drove the uptake of the solution.

Another example of a successful exploitation of research mentioned by Mr. Aparicio, related to the area of pedestrian mobility (i.e., soft modes of Transport). As the Professor explained, "*in this area there is no technology necessarily involved, but research has been able to contribute significant results that have been implemented in different cases*". One such case was a research project titles MIRACLES (Multi-Initiative for Rationalized Accessibility and Clean Livable Environments – a subproject of the CIVITAS initiative) that took place in Rome, Italy. The project aimed to improve the sustainability and efficiency of urban Transport systems by reducing congestion, lowering emissions, and achieving a shift in the modal split towards

cleaner fuels and vehicles. The final user of the results of the research was, in this case, the city of Rome which at the time did not have the required resources to exploit the results of the research and put them into practice. Since this particular area presents a very concrete and niche market within the pedestrian services market, that doesn't require a significant amount of investment; it was perceived by smaller companies as an excellent environment to reap the benefits of the research and implement the results of the research project with a commercial product.

Continuing our discussion Prof. Aparicio focused on another important factor relating to the ***nature and pace that characterizes research in the Transport sector***. More specifically, he focused on the fact that "*the technological developments in the Transport sector are in most cases driven by incremental research*". Further explaining this comment, he noted that "*the logical position of an industry that has a strong power in the market (for example the industry of autonomous vehicles) will continuously try to make the most of their persistent positions of this incumbency. In essence, you are trying to maximize the profits you make out of innovations, while at the same time trying to anticipate the next steps while always making incremental steps in order not to overwrite all previous research and knowledge.*"

Interview #2

Prof. Phil Blythe

CEng, FIET, Professor of Intelligent Transport Systems, School of Civil Engineering, and Geoscience, Newcastle University and Chief Scientific Advisor, UK Department for Transport.

Professor Phil Blythe CEng, FIET is Professor of *Intelligent Transport Systems (ITS)* and has served as Director of the Transport Operations Research Group at Newcastle University for 13 years until June 2015. Currently, he is also serving as Chief Scientific Adviser for the UK Department of Transport (DfT). Prof. Blythe's research portfolio covers a wide range of areas where ITS has been applied to Transport (e.g., Road to vehicle communications, road user charging and toll systems, etc.). His primary research is forward-looking and attempts to bridge the technology-policy gap in terms of what technologies may evolve to meet future policy objectives or indeed influence future policy thinking.

Regarding the main topic of interest of this research, Prof. Blythe's first comment was focused on the overall approach that consortia adopt in terms of the exploitation of research

results. More specifically, he highlighted the fact that "*research* ***consortia are not concerned with the exploitation of their research results****; they are just bothered with getting the project and getting the money for the next project which is a real flaw and waste of money in the EU*". While attempting to clarify the above comment, Prof. Blythe explained that in reality "*many Organisations claim to be innovative and claim to support innovation, but they really don't understand what innovation is about. Also, many of them, don't have a sufficient "appetite" for risk, because with innovation comes risk, since not everything you try will be successful which is a fact you just have to accept*". He also added that ***Organisations often prefer producing proven solutions rather than anything more transformative***, which according to his view is the real challenge that has to be addressed.

Focusing on the Transport sector and particularly on the differences of the sector when compared to others, Prof. Blythe highlighted how particularly "bad" the sector has been in the past 20 years, at understanding what end-users want and how this fact has had a profound impact on the exploitability and adoption of research and innovation in the sector. "*The sector was primarily based on a technology push rather than a market and user pull that meant a lot of things that weren't designed well*". According to his view, the "***misalignment" with end-users' needs*** has been partially addressed over the years, since "*many aspects of the work done currently in the Transport sector are also done in other fields, making innovative Transport products much more embedded and natural to use*". Prof. Blythe illustrated the point above, through an example, regarding what is now happening with the automotive industry and autonomous driving. His example was based on the fact that "*many CEO's of car companies on automation are driving down the automation path and see great unique selling points for their products, but they can't answer questions regarding who wants these products or how they are going to be used in the future*".

Our discussion then moved closer to the Organisational level and the characteristics that a company should strive to adopt, to exploit more innovation for its products and processes. Prof. Blythe pointed out that, in order to "*react more effectively to innovation and work out whether it could evolve to help achieve what the company wants (high-level aspirations/strategic goals), a certain level of* ***agility and risk appetite is required***". Elaborating this point, he went on to explain that this "*level of agility and risk appetite"* ***should be embedded within the company "innovation ecosystem"*** that supports the evolution of innovations by "*fostering them and connecting the innovators into the company, so they understand the context in which the innovation has to be exploited and adopted*". This is

because "*innovation is not a simple process like turning a handle and almost every need in innovation is slightly different, so companies need to be adaptable"*.

Lastly, our discussion focused on what is meant by innovation, in order to provide more insight regarding what Organisations should potentially strive to exploit through R&D projects. Prof. Blythe agreed with the view that innovation is not always relevant to research and technology, giving the example of the early iPhone, whereas he explained: "*the camera was rubbish, it had really poor data rate for communication, but it looked great, and it turned around the whole expectation for smartphones*". On the contrary, he emphasized the fact that ***innovation is also, about "how you do things differently in terms of the processes, delivering objectives, delivering more to end-users, saving costs and doing things quicker***".

More specifically, for the Transport sector, he noted that a lot of the innovation in the sector is not technology related, but it is about "*doing things better for the users or for the Transport system itself*". He also pointed out the importance of "*softer social benefits*" of many innovations like "*making life better for people*" which often are neglected since they are very hard to quantify from different perspectives (the operator, the end-user, the government).

Interview #3

Mrs. Barbara T. Harder

CEO B. T. Harder, Inc.

Ms. Harder specializes in strategic management of Transportation research, technology and innovation implementation, and technology transfer; policy development and analysis; and best practices identification/assessment. She is the principal of B. T. Harder, Inc., a consulting firm focusing on Transportation research management, technology implementation, Transportation policy development and analysis, and program and performance assessment. She assisted FHWA in examining issues of quality, performance, and relevance of research activities. In addition, she is part of a team creating an innovation infrastructure for the Pennsylvania Department of Transportation to enable products of research and other innovations to be systematically deployed and institutionalized as standard practice throughout the department. Ms. Harder is an-ex chairperson of the Standing Committee on the Conduct of Research of the US Transportation Research Board (US/TRB).

Our discussion with Ms. Harder began with clarifying that the Transport sector is distinct in relation to other sectors in terms of the exploitation of the research results and the adoption and implementation of innovation. ***One of the unique distinctions identified by Mrs. Harder relates to "the differences between the goals/aspirations/strategies of developers (private sector) and adopters (public sector) of solutions***", which creates different views as to what "is to be expected" by the developer and the adopter. To illustrate this point, Ms. Harder explained that in the US, in the public sector the word "exploitation" of research or innovation is not something that is commonly used. It has "too much of a negative connotation attached to it" since it is seen as "something closely related to profit" and for that reason, the public sector prefers better to "deploy" or "use" instead.

Another distinction relates to the timeframes the public and private sectors follow when deciding to invest in the exploitation of research results and innovation. For example, "*there is a similarity in what you do (between the two sectors), but the goals and processes differ. Certainly, in the private sector, if you have a technology that takes you two years to put in practice, you most probably are never going to get it used since other technologies will have it superseded by that time.*" On the contrary, regarding the public sector, she commented, "*in the public sector, it might take the same amount of time but for a completely different reason (risk aversion)*". Summarizing this point Mr. Harder went on to comment that "***both public and private sectors might even be using the same techniques in some cases, but it's a different timeframe for each one, with different methodologies, structures, culture, etc.".***

Lastly, the final distinction identified by Ms. Harder relates to the ***nature and purpose of funding between the public and private sectors***. As she explained, *"an item/technology developed with public money, can't always be used for profit by private companies, since it comes from the taxpayer's money"*. This sheds light to the difficult issues that entrepreneurs/innovators face when approaching public Transport authorities to propose the exploitation of an innovative solution and in most cases, the public authority will decline since "*it is not able to procure it, because they don't have any competitors to gauge whether this is an appropriate product for them*".

Ms. Harder expressed an opinion that resulted from her experience working in both the public sector (as a program coordinator/officer) and the private sector (as a consultant). According to her, *"the single most important factor that enables every stakeholder, to reap more benefits from the exploitation of research done throughout the Transport sector, is the*

impact created by building an innovation culture within the sector and a complete ecosystem for the exploitation and implementation of research results*"*. According to Mrs. Harder, the way of fostering this culture and creating a healthy ecosystem is by "*having people in the Transport sector, that are open to change and are true proponents of research and innovation, able to influence key stakeholders. This will ultimately lead to the pull of technological and other relevant innovations within the sector*". Unfortunately, the simplest example of why this is not always the case is the fact that "*agencies can't hire the people needed to bridge the gaps since they are under constant pressure to keep their Organisations small and maybe the talent, experience and necessary skills are not there either*".

Several factors were also identified as relevant and worthy of further research by Ms. Harder throughout the interview but were not examined in further detail. One of these factors was related to the "***senior leadership***" of the Organisation and particularly to the influence and consistency that the senior leadership has when it comes to promoting changes and overcoming stagnation within the Organisation. In addition, another factor that was related to the ***exploitation likeliness of research results within an Organisational context*** was *regarding* the **level of *risk aversion*** that characterized a firm. Since risk is inherent to both the exploitation and implementation of research, Organisations must have "an appetite for risk and embrace both the successes and failures" that are linked with it. Lastly, another significant factor mentioned was that of ***Organisational dynamics***. Continuously strengthening the relevant human resources and enhancing employee performance allows Organisations to "manage and promote Organisational learning and better business practices" which are key success factors for the exploitation of available knowledge within the Organisation.

Interview #4

Prof. Jorge A Prozzi

Ph.D., Associate Professor and Fellow Clyde Lee Endowed Professorship in Transportation Engineering, the University of Texas.

Dr. Prozzi is researching testing and behavior of road building materials, design and rehabilitation of pavements; asphalt technology; mechanistic and empirical design; accelerated pavement testing; applications of probability and statistics to pavement engineering problems; reliability and pavement management systems. He has also conducted analytical research on

the application of quantitative methods by applying advanced econometrics for the development of performance models for the optimum management of the pavement infrastructure.

The interview with Dr. Prozzi began with a discussion about the **clear distinction that exists between the nature of research that takes place in Europe and research that is done in the US**. Dr. Prozzi noted that in Europe, "*big ideas come from the top and start filtering down to smaller players, with the R&D projects being funded primarily to address the higher-level topic*". In contrast, in the US, "*ideas can originate from a single researcher after thorough processing, which can eventually end up being funded for his idea*". As Dr. Prozzi explained, "*the common ground between the two, is the fact that implementation is not planned adequately as part of the project*". Currently in the US as Dr. Prozzi mentioned, The Texas Department of Transportation has taken the initiative to implement two relevant guidelines regarding the **inclusion of exploitation and implementation as phases of the project from its conception**. Firstly, they are aiming at including the **value of research as part of the proposal phase**, by involving metrics and other variables, to quantify the value/success of the research and to characterize how valuable the results of the research will be. Secondly, they have decided to **bring the exploitation and implementation discussions earlier in the proposal stage**, because they believe that it is imperative to create a shared understanding between the different stakeholders involved in the project early on and as the project progresses revise and reformulate the generic ideas generated in the proposal stage in order to make them more specific and more actionable.

Interview #5

Mr. Sigfried Rupprecht

CEO RUPPRECHT CONSULT - Forschung & Beratung GmbH

Mr. Rupprecht is the founder and CEO of one of RUPPRECHT CONSULT one of the largest German consulting firms in the mobility and Transport sectors. The firm carries out research projects and studies in the field of Transport throughout Europe and implements projects based on the research products of the company.

An important consideration that emerged throughout my discussion with Mr. Rupprecht is the fact that according to his view, "*the Transport world is different from the IT world*".

Clarifying his statement, Mr. Rupprecht emphasized the fact that a Transport product innovation in the public world is a *"highly political thing*". By this expression, he meant that "Transport" is a more complex innovation when compared to other sectors, since non-experts play a determining part in the success or failure of the innovation (i.e., "*Everyone with a driver's license acts as a Transport expert/traffic engineer when for example a traffic application doesn't work as expected*").

Mr. Rupprecht also recognized the fact that certain unique aspects relate to innovation in the Transport sector, which might differ from other sectors. According to him, these unique aspects are focused on the **different suitability and marketability issues that Transport product innovations are related to.** Throughout our discussion, Mr. Rupprecht identified three of these unique aspects of product innovations particular to the Transport sector.

The first relates to "***the public function of innovation and the public recognition or lack of recognition of a Transport innovation product*"** putting a strong emphasis on the public perception and the critical role this perception has for the uptake and utilization of Transport innovations.

The second aspect relates to "***the heavily politicized decision-making process that takes place in the Transport world***", meaning that in many cases, it is only up to an elected person within an Organisation to have a strong vision and to push for the use and exploitation of truly innovative results and products.

The third aspect relates to the "***contextual needs and requirements that a Transport innovation attempts to fulfill***" and, put simply, it highlights how important it is in the specific sector to address needs and requirements that arise from the context, using relevant technologies, that are in line with the needs and requirements of the context. For example, "*building a metro service for a large city, might be suitable to address the needs and requirements of that city, but building a metro service for a medium-sized city in the Peloponnese might not be a suitable solution, since it is not in line with the context that it is being proposed.*"

While discussing the decision process that Organisations go through when deciding to exploit research results, Mr. Rupprecht commented that "***many decisions made are not based on facts, but rather on "gut feeling", different stakeholder's beliefs or even pressures***" (e.g., stylus vs finger for smartphone interactions). This is demonstrating that ***both internal and external, rational and non-rational factors can strongly affect exploitation decisions*** and

ultimately highlighting the fact that "*very often, the really important decisions are made outside the textbook content*".

Furthermore, another factor that Mr. Rupprecht identified as highly relevant and important for the exploitation of research results is the ***nature and breadth of the research project***. Referring to the breadth of the research project, Mr. Rupprecht made clear that it is crucial to "understand what kind of products go into the research, in order to understand the potential exploitable products that may come out of it". This points to the different relevant characteristics of a research project such as whether its focus is long-term or short-term, whether it requires a highly collaborative effort to accomplish its research goals etc.

For what concerns the nature of the research project, Mr. Rupprecht pointed out that it is very important to determine from the beginning, *how lightly the different stakeholders view the exploitability of the research product* since experience has shown that ***for highly exploitable products, funding is sometimes not even requested***. This is because since by the time funding is granted, "*the world has moved on*" (i.e., user requirements have changed; competitors have already reached the market with a product, etc.) Highlighting both the nature and the breadth of the research project, Mr. Rupprecht commented, "***to a certain degree, the nature and breadth (of the research project) determine the success rate of exploitation***".

Another factor brought forward by Mr. Rupprecht as very important and determining to the exploitation of research results is ***the role that the consortium has in terms of its communication and collaboration dynamics***. As he puts it, this factor raises important issues, since "*in European funding, the nature is mostly collaborative with several owners of a product, which becomes an important factor in terms of, for example, IPR structure of the products developed in EU projects*". Furthermore, he notes that *communication and collaboration dynamics built within consortia have enabled EU projects to develop products in a very advanced way, but on the expense of research exploitation, ultimately questioning whether this type of collaboration and communication adopted within EU research projects is supportive of research exploitation and adoption.*

For what concerns the "context-related" factors and specifically the factor of ***maturity***, Mr. Rupprecht commented that the concept must be carefully examined when considered, because "*one way or another we all use products that have not been perfected*". Further justifying his comment Mr. Rupprecht brought forth the example of Microsoft and the fact that it releases new versions of its OS almost every two years, which by no means does this indicate

that previous versions are mature when new releases come out. Also, he pointed out, that the factor heavily depends on the nature of the product being examined, highlighting the major differences between a Terminal Operating System and a mobile application. Lastly, he proposed that instead "User friendliness or relevance" might be more appropriate factors to examine.

Regarding the ***Reliability and Accuracy of research outcomes***, Mr. Rupprecht commented that they are both concepts that the end-user would not know about and thus he could not judge a product based on these two factors. Furthermore, who is judging whether a product is reliable and accurate is on many occasions an unknown in the sector of Transport. He mentioned, "Few people know that the market leader for traffic modelling is counting "half a car as equivalent to a bike". This is not correct because a car and a bike have completely different ways of behavior in a traffic situation". In his point of view, "***reliability and accuracy are part of a more complex question that relates to the quality of a product, and so it is the desired outcome but only as a relative word in comparison to other quality goods***".

Interview #6

Prof. Alex Skabardonis

UC Berkeley professor and California PATH program manager

Prof. Skabardonis began by pointing out that in terms of the technology used in the Transport sector, "*an important factor that must always be considered is the* ***uniqueness of the usage behavior of users*** *(driver-traveler behavior). The response and reaction of users for example to the release of a new travel service is unpredictable when compared to the release of a new iPhone where the functionality is expected, making the measure of success a rather challenging task*". Furthermore, staying in the topic of technology Prof. Skabardonis explained that "*in many cases, the technology involved in the sector requires expensive hardware/software, as well as dedicated personnel to achieve the desired functionality which makes potential adopters very reluctant to invest. Even when solutions to overcome such issues are found (i.e., cloud computing), stakeholders are still not comfortable enough because different issues especially critical for the sector emerge (privacy/security issues) which cannot be overlooked*".

Another factor highlighted by Prof. Skabardonis relates to the ***multitude of institutional constraints*** that originate from different state and local agencies for the exploitation and implementation of research results. The effect of these constraints can be understood when examining the example provided by the Professor about a fare pay system introduced in the San Francisco Bay Area in the late '90s. The project to introduce a universal fare payment card took almost five years since there were 37 agencies involved throughout the project. A multitude of issues had to be overcome, ranging from the proportion of the task at hand, the appropriate allocation of costs between involved agencies that differed in size and the issue of re-allocating employees such as fare collectors. Even though a private company was involved and offered to split the profits from the system in favor of the agencies and although the system was an apparent technological and social innovation, it was not implemented at the end due to the other plethora of institutional constraints that could not be solved.

Furthermore, another factor, which is highly relevant according to Prof. Skabardonis with the exploitation of research results, is the ***maturity of the solution offered***. Particularly for the US, Prof. Skabardonis noted that "*for a provided solution to be adopted, the solution must work otherwise people don't even want to be bothered with it.*" A strong case demonstrating this fact was the solution of automatic incident detection systems, which was adopted early on by many stakeholders (i.e. highway administrations) but turned out to be a rather complex solution ("*dispatching a tow truck for an incident that isn't there is a big problem*") which introduced many setbacks to the normal operation of these agencies. Following the "*immediate disuse of the solution*" came the "*discouragement from investing in such solutions, even after the technologies used had matured and become more effective and optimized*". According to Mr. Skabardonis, *maturity plays a very important role* because "*it also leads to other implications relating to a range of issues that may lead to stopping the research and exploitation of particular research. Even at this current state, there are maturity relate by-issues such as ethical and legal issues present with the use of automated vehicles*".

Pointing to the importance of user expectations, Prof. Skabardonis emphasized the important role they play, since "*users often expect miracles and thus their expectations need to be managed, because even if the technology works, it may not fulfill the expectations of the end users/stakeholders*". The Professor went on to explain that "*in the Transport sector, every negative thing has a much larger delay than what you would normally expect since it involves many more stakeholders. This is mandatory, and if you are to be successful in exploiting results, you have to translate what you are planning to achieve, so each involved stakeholder*

understands and aligns his expectations". Mr. Skabardonis strong opinion is that "*for the exploitation of research results to be successful, the project should strive to be focused, comprising of a small, specific and local consortium which tries to solve a single, very particular problem each time*".

Interview #7

Robert (Bob) E. Skinner Jr

Immediate past Executive Director of US - TRB

Mr. Skinner was for the past 20 years the highest chief administrative officer of the US Transportation Research Board (US/TRB), the largest Transport research Organisation in the world. He has vast experience in research governance and management issues including the promotion of their implementation. His experience covers not only the US Federal research and innovation production system but also a more international perspective since he was responsible for all international cooperation and exchanges activities of the US/TRB.

The interview with Mr. Skinner began by looking at what is precisely meant by the term "research results" and in which cases and to what extent the stakeholders in the Transport industry exploit these. First, Mr. Skinner pointed out that there is an inherent variety of results that must be examined, because "*some of the research carried out in the field is* ***research of an advanced or fundamental character, that no one expects the results to be implemented immediately****. In many of these cases, more research will have to be carried out before the actual outcome can be exploited*". This, in turn, creates an inherent difficulty in terms of "*keeping the lineage clear*" as to which research projects contributed to the work that ultimately led to the exploitation.

Mr. Skinner highlighted the fact that research done on methods and processes shows up on the implementation side in different ways. He went on to illustrate how this is often overseen, by describing the example of how we think mostly of private sector firms which "*aim specifically on product development, sort of working in a closed system, under considerable pressure to produce another version of their product and push it to the market, thus being closer to applied engineering than blue sky research*". In addition, he mentioned the fact that "*some of these large financially successful firms that are heavily capitalized, have a latitude to*

experiment with research (while often still aiming for products) in areas where they don't even do anything".

The above example of the private sector is in complete contrast with publicly funded research, which according to Mr. Skinner consists mainly of two types. On the one hand, there exists a "***hybrid type of government funding*** (e.g., the US DARPA program) which aims at sponsoring in some respect the riskier research, with the idea that ultimately it is going to filter back to the sector". On the other hand, there is the type of ***publicly funded research that "relates specifically to government processes and responsibilities/activities*** which in most cases is the type of funding found in the field of Transport". In particular, Governments are funding research to "*help come up with better methods/processes/technologies for the Transport system and particularly for those systems that are managed by the public sector*".

Thus, in the words of Mr. Skinner, "*it is essential to understand the nature, purpose, and goal of funding, in order to better understand the types and exploitation potential of different results that are products of publicly funded R&D projects*". Emphasizing on the characteristics of funding, Mr. Skinner explained one of the ***fundamental differences between the private and public sector***, which further highlights the importance of the nature and purpose of the funding. The **private sector is** "***heavily product oriented*** *something that is embedded to their culture and its part of their DNA since they depend on it to survive*". The ***public sector*** (e.g., highway agencies) ***is tasked to maintain a certain infrastructure*** (often a mature technology) which is not necessarily expected to have a breakthrough every year but mostly depends on incremental improvement".

This goes to show that although both worlds are "constrained by economics", in the private sector, product improvements, allow for price increases. In the public sector, "*money is always in short supply, and it mainly consists of what we are willing to tax ourselves since there is no market out there to go and raise money to maintain the infrastructure. This means that research that saves money has an advantage over research that delivers customers with a better product*".

Another important factor that Mr. Skinner pointed out during our discussion was related to *the role that the institutional context* plays for what concerns the exploitation of research results. Highlighting the challenges of exploiting innovative research results in a public Transport agency, Mr. Skinner used the example of "***method vs. format specifications***" often utilized by public agencies in the procuring process. As explained, ***method specifications offer***

no incentives to innovate with respect to the product delivered, whereas ***format specifications offer a lot more incentives to utilize research***, innovate and deliver a better product or use innovative methods to deliver products faster and more efficiently. Building on that, Mr. Skinner explained that in the "*slow-paced and conservative environment of the public sector, where people are involved mostly with mature technologies and where there is no clear market in the conventional sense, the specification methods selected don't encourage innovation from the private sector, since public agencies tend to be risk averse*". For these cases, Mr. Skinner suggested, "***it is a gamble of building a culture of innovation that will help stakeholders in both public and private sectors recognize that there is value in pursuing research and even more so focusing on its exploitation***".

Lastly, to emphasize the diversity of the context in the exploitation of research results and the implementation challenges faced in some instances, Mr. Skinner used the example of autonomous vehicles. He pointed out that in some cases the challenges might arise from the idea/product development and introduction process (e.g., Tesla, Google, UBER being forced to make their solutions flawless since in this context "being accurate 99.999% of the time" is simply not enough). In other environments (i.e., a highway system), we simply know that it is difficult to innovate (in relation to autonomous vehicles) because "*there are simply not enough incentives to do so*".

Interview #8

Mr. Bret Johnson

Associate Director, Northwestern University Transportation Center

Director, Center for the Commercialization of Innovative Transportation Technology

Northwestern University

Mr. Johnson is the head of the special agency that the Northwestern University has set up to promote and induce research implementation in its Transportation Center, the Northwestern University Transportation Center (NUTC) which was launched in 1956, i.e. has a life of more than half century. This Agency is the Center for the Commercialization of Innovative Transportation Technology or CCITT. The NUTC has been connected with the industry from the beginning. At first, it established relations with individual industries in the Transport sector such as Atchison, Topeka & Santa Fe Railroad, United Airlines, Standard Oil, Lockheed Aircraft Corporation but later is established a special Business Advisory Council

(BAC). The BAC today consists of 90+ Senior Transportation Executives representing all modes of transportation and has as leadership (chair, vice chair, and executive council) some very prominent names in the industry.

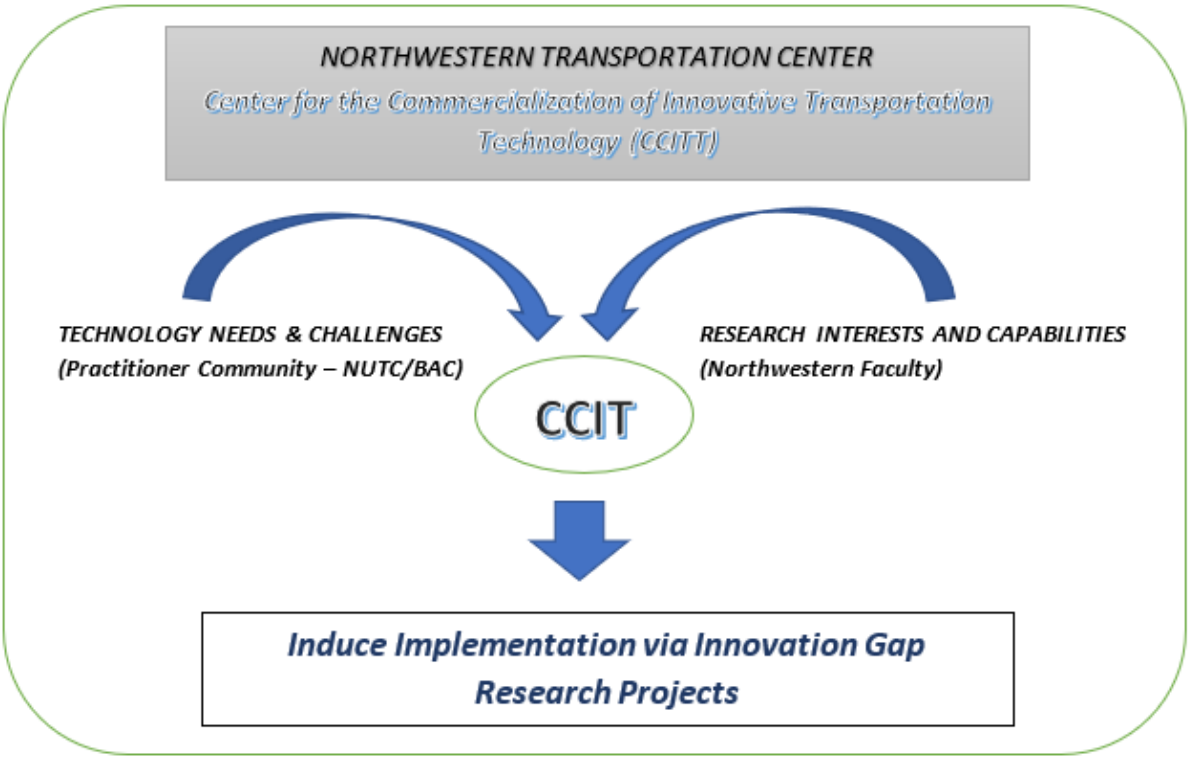


Figure 6.1: The process via which the special body for the implementation of research results at Northwestern University – the CCITT – supports projects to overcome the "innovation gap".
(Source: Presentation by Mr. Bret Johnson at the 98th TRB Conference, Washington DC, Jan 2019)

The CCITT funds translational research to address the "Innovation Gap". The process with which the CCITT caries its mission is shown in Figure 6.1. It collects input from the practitioner community (i.e., industry, commerce, manufacturing, users, society) as to the technology needs and challenges that exist. This is done mainly through the Business Advisory Council (BAC) or directly from the practitioner community. The CCITT also receives input from the Northwestern University's faculty as to its interests and capabilities and then it selects the specific research projects that apply to it for support to implementation focusing on funding the activities that will enable them to overcome the so-called innovation gap(s).

The key factors that the CCITT takes into consideration in selecting the projects to support in this way are:

- ✓ Does the research project have a strong likelihood to solve an important problem that will impact the transportation industry, either the commercial sector or the government sector?
- ✓ Is the potential impact on the practitioner community significant?
- ✓ Is the project, method and/or outcome original, unique or novel?
- ✓ Does the project develop, employ or produce novel concepts, approaches, methodologies, tools or technologies to the problem?
- ✓ Is there a strategy to transfer outcomes to a transportation practitioner?
- ✓ Is an external implementation partner involved and committed?
- ✓ Does the research project demonstrate an opportunity to impact the transportation sector within 12 months of its completion?

As of today, the reported project outcomes (for the projects supported by the Commercialization of Innovative Transportation Technology office, or CCITT), are shown in Figure 6.2 below:

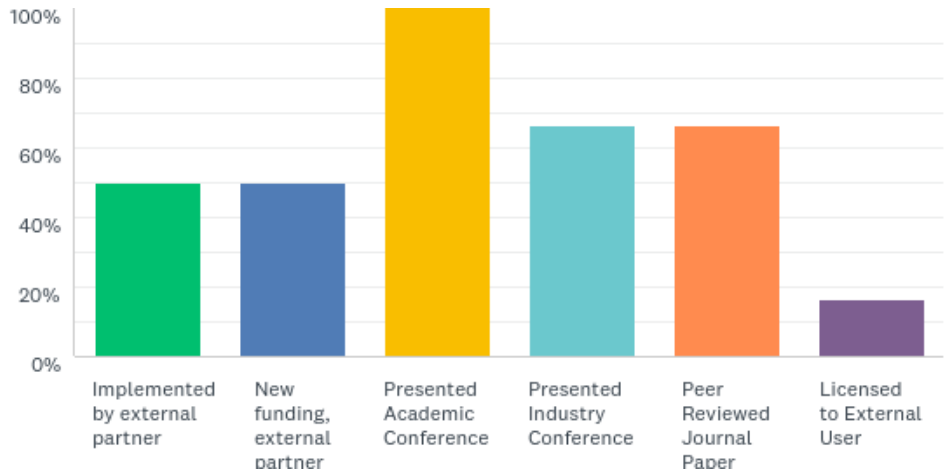


Figure 6.2: Northwestern' University's CCITT reported project outcomes.
(Source: Presentation by Mr. Bret Johnson at the 98th TRB Conference, Washington DC, Jan 2019)

According to the experience of Mr. Johnson, the inducements that help drive commercialization/implementation of research results for University-based research, are the following:

1. Good collaborators who work together in a sustained collaboration;
2. Funding to do the implementation right;
3. Agency interest to learn and adapt their processes to take advantage of the tools' capabilities;
4. Researchers' interest in real-world impact and desire to see the practical results of their research.
5. Commercial relevance. Challenge is that the commercial relevance of new technology is not always obvious beyond the University. In this case, it requires the "irrational" exuberance on the part of the students and faculty to create a startup and drive implementation.
6. Address the on-the-ground need of the industry / or specific company. (Interest for the basic implementation of an existing research product or PhD dissertation).

For *industry-based research* the key inducements according to Mr. Johnson, are:

1. Addressing a real challenge or providing a learning opportunity;
2. Existence of a "champion" at the source of funding i.e. someone who will drive implementation on-site after the research is completed and not resist new ideas.
3. Routine meetings/teleconferences between the research team and the "customer". These build confidence.
4. Include a final phase (with funding) to support implementation tasks.
5. Stay on point –don't deviate from the mission of the project.

According to Mr. Johnson's experience, there are several very important "lessons" to be learned as regards the implementation of research results – especially for what he calls "Industry Research Projects", i.e., what we would call "strongly applied" research. These include:

a) Technology looking for solutions is generally a recipe for implementation failure;
b) Need investigators motivated by real-world challenges;
c) Need to balance the University mission of education (in his words: Graduate Research Assistants are not consultants);
d) Need engaged "customer" who will champion the research outcomes;

e) Need to build-in a (funded) implementation/integration stage into the project with clear expectations of roles and responsibilities for investigators and users.

6.1.2 Summary of Findings

Table 6.1 presents the main outcomes/findings of these 1st round exploratory in-depth interviews. To summarize, this round of interviews allowed us to utilize the knowledge and experience of the Transport experts interviewed, in order to identify further contextual factors that potentially affect the exploitation of research results in the Transport sector.

From these interviews, we managed to obtain further contextual insights regarding the previously identified "firm" and "project-related" factors, as well as identify a new category of "research-context related" factors that affect the implementation of research results. More specially, the "research-context related" factors identified, related to two distinct categories; the t*echnology* and the *implementation environment*-related factors. The "technology-related" factors included characteristics of the technology/system under investigation in a project that according to our interviewees could potentially have significant impacts in determining the subsequent exploitation of the projects research results. Factors identified were the technology/system *maturity* and *relevance,* the associated *adoption costs* and the requirements for *standardization* and *privacy*. The "implementation environment" factors included characteristics that were relevant to the environment where the technology/system was to be potentially deployed. In this category, factors identified by our interviewees related to the *requirements for personnel*, the *availability,* and *quality* of data, the *stakeholder involvement* and the requirements for further *customization*.

Table 6.1: Summary of findings from the 1st round of interviews.

	Interviewee 1	*Interviewee 2*	*Interviewee 3*	*Interviewee 4*	*Interviewee 5*	*Interviewee 6*	*Interviewee 7*	*Interviewee 8*
Firm related	*"…the research market involved consists of small universities and research center…with a business model to produce research results but not to make anything out of the results".* *"…small players involved in big R&D projects don't have the required capacity to exploit research results".*	*"…don't have a sufficient "appetite" for risk, because with innovation comes risk, since not everything you try will be successful".* *"…react more effectively to innovation … a certain level of agility and risk appetite is required".* *"…level of agility and risk appetite" should be embedded within the company "innovation ecosystem".* *"…connecting the innovators into the company, so they understand the context…".*	*"…agencies can't hire the people needed to bridge the gaps, since they are under constant pressure to keep their Organisations small and maybe the talent, experience and necessary skills are not there either…".* *"senior leadership" of the Organisation and particularly the influence and consistency that the senior leadership has when it comes to promoting changes and overcoming stagnation within the Organisation".* *"level of risk aversity" that characterizes a firm".* *"…manage and promote Organisational learning and better business practices…".*		*"…many decisions made are not based on actual facts, but rather on "gut feeling", different stakeholder's beliefs or even pressures…".* *"…both internal and external, rational and non-rational factors can strongly affect exploitation decisions…"*	*"…success depends on the knowledge about the industry and the experience and expertise of the Organisation doing the exploitation…".*	*"…large financially successful firms that are heavily capitalized, have a latitude to experiment with research (while often still aiming for products) in areas where they don't even do anything".*	*"Need for engaged "customer" who will champion the research outcomes".*

		"…almost every need in innovation is slightly different so companies need to be adaptable".						
Project related	*"…the technological developments in the Transport sector are in most cases driven by incremental research…".* *"…always making incremental steps in order not to overwrite all previous research and knowledge".*	*"…research consortia are not concerned with exploitation of their research results; they are just bothered with getting the project and getting the money for the next project…".*	*"…an item/technology developed with public money, can't always be used for profit by private companies, since it comes from the taxpayer's money".*	*"…implementation is not planned adequately as part of the project".* *"Involving metrics and other parameters to quantify the value/success and characterize how valuable the results of the research will be".* *"…bring the exploitation and implementation discussions earlier on the proposal stage…".* *"…research results often can't be commercialized by nature, but instead are used to benefit the public or the underrepresented communities, so*	*"…understand what kind of products go into the research, in order to understand the potential exploitable products that may come out of it…".* *"…how lightly the different stakeholders view the exploitability of the research results, since experience has shown that for highly exploitable products, funding is sometimes not even requested…".* *"…to a certain degree, the nature and breadth (of the research project) determines the*	*"…for the exploitation of research results to be successful, the project should strive to be focused, comprising of a small, specific and local consortium which tries to solve a single, very particular problem each time…".*	*"…research of an advanced or fundamental character, that no one expects the results to be implemented immediately".* *"…publicly funded research that relates specifically to government processes and responsibilities / activities…".* *"…it is essential to understand the nature, purpose and goal of funding, in order to better understand the types and exploitation potential of different results that are*	*"Existence of a "champion" at the source of funding i.e. someone who will drive implementation on-site after the research is completed and not resist new ideas".* *"Routine meetings / teleconferences between the research team and the "customer"".* *"Include a final phase (with funding) to support implementation tasks".* *"Stay on point –don't deviate from the*

				the social value of research is also very important…".	*success rate of exploitation…"* *"…communication and collaboration dynamics have enabled EU projects to develop products in a very advanced way, but on the expense of research exploitation…"*		*products of publicly funded R&D projects…".* *"…research that saves money has an advantage over research that delivers customers with a better product…".*	*mission of the project".*
Tech. related		*"The sector was primarily based on a technology push rather than a market and user pull that meant a lot of things that weren't designed well".* *"…misalignment with end-user's needs…"* *"many aspects of the work done currently in the Transport sector are also done in other fields, making innovative Transport products much*	*"…the differences between goals/aspirations/strategies of developers (private sector) and adopters (public sector) of solutions".*		*"…the public function of innovation and the public recognition or lack of recognition of a Transport innovation product…".* *"User friendliness or relevance might be appropriate factors to examine"* *"…reliability and accuracy are part of a more complex question that relates to the quality of a product, and so it is the desired outcome but as a*	*"…uniqueness of the usage behavior of users (driver-traveler behavior)".* *"…in many cases the technology involved makes potential adopters very reluctant to invest".* *"…different issues especially critical for the sector emerge (privacy / security issues) which cannot be overlooked".*	*"…it is a gamble of building a culture of innovation that will help stakeholders in both public and private sectors recognize that there is value in pursuing research and even more so focusing on its exploitation…".*	*"Technology looking for solutions is generally a recipe for implementation failure".* *"Addressing a real challenge or providing a learning opportunity".*

		more embedded and natural to use". *"…innovation is also, about "how you do things differently in terms of the processes, delivering objectives, delivering more to end-users, saving costs and doing things quicker".*			*relative word in comparison to other quality goods…"* *"TCO (Total Cost of Ownership) offers an efficient way to measure whether a Transport product can be adopted, while minimizing unnecessary and inefficient expenses".*	*"…for a provided solution to be adopted, the solution must work otherwise people don't want to be bothered".* *"…immaturity may lead to stopping the research and exploitation of a particular research".* *"…user expectations need to be managed…"*		

6.2 2nd Round of Interviews - Validation of Preliminary Quantitative Research

For what regards the second round of interviews, which were conducted during the explanatory phase of our methodology, the aim was to present and discuss with Transport experts some of the preliminary findings obtained from the questionnaire survey. The main objective with this round of interviews was to create a more objective and authoritative evaluation of our initial results and to validate and interpret them in the context of the operational and business environment of the Transport sector and in the light of the experts' experience.

6.2.1 The Four in-depth Interviews

Interview #1

Prof. Angel Aparicio

Professor at UPM (Universidad Politécnica de Madrid)

1) The effects of exploitation timing on exploitation usefulness and success

Following a short presentation of the results from the survey, our discussion with Prof. Aparicio quickly focused on the role that the timing of the exploitation has on the success or failure of exploitation. Prof. Aparicio commented on the importance of short-term focused exploitation by emphasizing that often *"in many European projects the particular people that are involved in the actual implementation of the project are the ones that are gaining the experience, expertise and the network and many Organisations are not very good at keeping that know-how at the Organisational level. So, people change places, and the knowledge created through the results of the project is lost with them".*

2) The moderating effects of absorptive capacity on exploitation timing

Furthermore, Prof. Aparicio strongly agreed that the absorptive capacity of an Organisation can also play a crucial role in managing and controlling for the effects of the exploitation timing effort of an Organisation since "*it can facilitate a more rapid and efficient dissemination of knowledge within the Organisation"* minimizing the effects of the *"rotation*

of people moving from place to place and project to project" that is often observed in Organisations participating in R&D project in the specific sector.

3) Project research team seniority and influence as a barrier to exploitation

Pointing out another important factor that is related to the involvement of junior researchers working in European projects and the success or failure of the exploitation efforts, Prof. Aparicio noted that *"…it can be sort of difficult to get results actually implemented in the Organisation because these researchers are not too influential at the administrative level".* This is mainly because from his experience in many cases he has observed that senior people from the Organisations are involved in the initial stages of the proposal and then little by little they *"change/withdraw from actively being involved with the project, with junior researchers taking over the implementation of the project".* Consequently, the above, coupled with the fact that the EU Commission does not require any precise reporting on the actual changes in the research team causes a strong barrier for the exploitation of research results by Organisations.

4) Age and size of the Organisation as determinants of market strategy

Shifting the focus of the discussion on the characteristics of the Organisation Prof. Aparicio noted in relation to the results of the survey on the subject that *"on the one hand you would expect that big/older Organisations have more capacity to actually implement research results and put them quicker and more efficiently in the market but the truth is big Organisations are mostly interested in not losing existing market share (being defensive) rather than getting innovation actually done if it is not necessary".* Further explaining his point Prof. Aparicio commented that larger Organisation see no actual reason to dedicate resources to create a new product to get money out of the market when they can continue creating profits from older technologies/products. This mindset though differs in smaller/newer Organisations whose goal is to gain and increase their relative smaller market share by *"…disrupting the current market status quo, thus becoming more prone to adopt and utilize research results and innovations in order to achieve their goal".*

5) Market strategy of incumbents affecting the nature and pace of research in the Transport sector

Continuing our discussion, Prof. Aparicio focused on another important factor relating to the nature and pace that characterizes research in the Transport sector. More specifically, he focused on the fact that "*the technological developments in the Transport sector are in most cases driven by incremental research*". Further explaining this comment, he noted that "*the logical position of an industry that has a strong power in the market (for example the industry of autonomous vehicles) will continuously try to make the most of their persistent positions of this incumbency. In essence, you are trying to maximize the profits you make out of innovations, while at the same time trying to anticipate the next steps while always making incremental steps in order not to overwrite all previous research and knowledge*".

6) Factors explaining variance in exploitation potential between different Transport sub-sectors

Focusing on the differences between Transport sectors in terms of their exploitation breadth and intensity Prof. Aparicio commented that the origin of the research funding could play a crucial role in driving the adoption of research results and the creation of innovation and thus explaining some of the variability noticed. More specifically, while comparing different Transport sectors, he noted that *"in the road sector, you have a lot of private investment (currently though automation) which drives innovation in the sector. In the rail sector it is typically very defensive with stakeholders being very focused on keeping the status quo since very small partners are involved and any product the sector produces is extremely costly compared to any other sector. This is mainly due to the nature of innovation (incremental), the small number of players involved and the fact that at the EU level it is mostly an industrial policy and not a research policy in mind since they are trying to keep the market closed from the Japanese and Chinese competitors which are considerably much cheaper".*

Interview #2

Mrs. Barbara T. Harder

CEO B. T. Harder, Inc.

1) Exploiting in combination with other projects as a requirement for the creation of exploitation capacity within the Organisation

Our discussion with Ms. Harder began with presenting to her the results from the clustering analysis. After the presentation of the results, Ms. Harder was quick to note that the factor of exploiting results in combination with other research projects is a rather interesting one since *"it provides a lot of insight as to how Organisations think about the exploitation of their results"*. This is because building on other R&D projects, results, and experience, allows for knowledge about a specific research area to *"mature within the Organisation, reaching a point where it provides solid grounds for fruitful and effective exploitation".* Giving an example of the above-mentioned maturing process, Ms. Harder mentioned a case where an Organisation builds dedicated implementation staff over several projects and thus creates the capacity for successful future exploitation. Quoting Ms. Harder *"when you have experience in exploiting, the next time it comes around you can more easily recognize it and take advantage of it".* On the same topic, Ms. Harder also pointed out that *"an experienced exploitation/implementation team can also speed up the process of exploitation since they are in a better position to easily recognize and implement research results in the Organisation"* and in addition, *"their previous experience and involvement in projects can serve as a platform for exploiting whatever (product/process) a new research project might offer in terms of exploitable results"*.

2) Similarities between exploitation timing and rate of adoption (Diffusion of Innovations Theory)

Continuing our discussion, Ms. Harder emphasized that *"timing unequivocally plays an important role that must be thoroughly considered when examining the exploitation of research results"*. This is because *"timing is a factor that heavily depends on the innovations introduced and how the Organisation goes about utilizing them in its current portfolio"*. Referencing Everett Roger's exploitation/dissemination curve, Ms. Harder found similarities with the timing variable of our study and she noted that *"usually you have some initial Organisations that are going to pick up and adopt an innovation almost immediately, but you are not going to get the full implementation and full deployment of an innovation until a certain period of time, when it finally becomes self-sustaining (reaching the required critical mass) that it definitely has changed something and people follow that new innovative procedure/process".*

3) Factors explaining differences in the timing of exploitation

On the same topic of exploitation timing, Ms. Harder also pointed out that Organisational and financial aspects (funding requirements) can prolong or shorten the time within which the exploitation occurs. More specifically she noted that *"exploitation timing is evidence of when and how that implementation is happening, but there are also things that are happening that make that time shorter or longer, for example, if you lost a champion it might take a little while longer for the remaining people to get up to speed or influence the Organisation in such a way that the results will be put into practice"*.

4) How characteristics of the Organisation affect risk-taking and absorptive capacity

Our discussion continued with the effects that the size and age of an Organisation have on the intensity of exploitation undertaken. On this topic Ms. Harder noted that the impact of senior personnel within an Organisation in influencing an innovative kind of management might be more readily transferred throughout the Organisation if it is smaller in size, since that might affect junior people to take the risk of adopting an innovation more efficiently and effectively as it will be easier for them to respond to the influence of senior personnel. Ms. Harder explained that this happens because *"smaller companies have a better vision all the way through the company on doing the implementation and being more exploitative. Larger Organisations are more prone to create research silos that make it harder to get the research out and into the rest of the Organisation".* Furthermore, she noted that for a plethora of reasons "*larger Organisations also often struggle to seamlessly communicate knowledge* (absorptive capacity related to the size of the Organisation) *within their ranks"* whereas smaller Organisations can tackle this issue more efficiently due their reduced size.

5) Negative impact of in-house R&D and the distribution of research within the Organisation

Moving our discussion to another outcome (the difference in innovation impacts between Organisations that have an in-house R&D department and those who don't), Ms. Harder noted that Organisations who have in-house R&D departments in many cases find themselves in the position of continuously trying to establish proper communication between the R&D department and the rest of the Organisation. More specifically she mentioned that *"…it is almost as if you are having two different Organisations which are having difficulties*

communicating with one another. It is difficult for researchers to communicate with practitioners.

6) Creating a positive exploitation experience through previous experience with R&D projects

On the factor of previous experience with R&D projects, Ms. Harder pointed out that similar to the factor of exploiting in combination with other R&D projects, having a solid positive R&D experience from previous projects *"may facilitate the consecutive exploitation of research results by enabling individuals to be more creative and less afraid of the risks associated with the exploitation of research results".* Furthermore, she emphasized that *"exploiting any kind of innovation, results to change and people often avoid change so if you've had a good experience and know the processes you feel more confident in carrying the innovation all the way through and it will not be as disruptive as you've been through the process before".*

7) Factors explaining variance in exploitation potential between different Transport sub-sectors

Lastly, examining differences in the exploitation potential between Transport sectors, Ms. Harder noted that funding within each sector might explain some of the variations observed. More specifically she pointed out that (in the context of a specific R&D project) *"if the goal of an Organisation is to promote its profits then most likely it will have more incentives for exploitation".* In addition, she also noted that *"differences in the origin of the funding might also explain variation in the consequent magnitude of the exploitation",* i.e., research on the road sector might be funded mostly by public funds whereas research in the rail sector might be funded mostly by private funds *"leading to differences in the outcome of the research and its consequent exploitability".* On the same topic, Ms. Harder also commented on the overlap that can be observed in terms of the factors that affect the exploitation inside a single Organisation and a whole sector. She noted that *"innovation history and performance of the sector play an important role to determine how a sector reacts to the introduction of innovations and whether or not these are quickly and efficiently adopted".*

Interview #3

Prof. Jorge A Prozzi

Ph.D., Associate Professor and Fellow Clyde Lee Endowed Professorship in Transportation Engineering, the University of Texas.

1) Differences in the exploitation timeframe between private and public sectors

The interview with Prof. Prozzi began with a discussion about the different timeframes the public and private sectors follow when deciding to invest in the exploitation of research results and innovation. As he mentioned, "*there is a similarity in what you do (between the two sectors), but the goals and processes differ. Certainly, in the private sector, if you have a technology that takes you two years to put in practice, you most probably are never going to get it used since other technologies will have it superseded by that time*". On the contrary, regarding the public sector, he commented, "*in the public sector, it might take the same amount of time but for a completely different reason (risk aversion)*". Summarizing this point Prof. Prozzi went on to comment that "*both public and private sectors might even be using the same techniques in some cases, but it's a different timeframe for each one, with different methodologies, structures, culture, etc.".*

2) Nature of research results as a constraining factor for exploitation

Another topic discussed with Prof. Prozzi pertains to the purpose and value of research done in both the EU and the US. As he highlighted, "*research emphasizes on the business side, because it is funded by the EU and very often there exist strong partnerships with the industry. Having said that, you must keep in mind that research results often can't be commercialized by nature, but instead are used to benefit the public or the underrepresented communities, so the social value of research is also very important*". As heard from other interviewers as well, Prof. Prozzi mentioned that "*public authorities aim to serve society and are not driven by profits. The public sector thus, should not be involved with the technology side of research and exploitation, since the private sector will continue providing innovations in that side (as long as there is money to be made from technology)*". Further emphasizing his point, regarding the nature and purpose of funding between the public and private sectors Prof. Prozzi explained that *"an item/technology developed with public money, can't always be used for profit by private companies since it comes from the taxpayer's money"*. This sheds light to the difficult

issues that entrepreneurs/innovators face when approaching public Transport authorities to propose the exploitation of an innovative solution and in most cases, the public authority will decline since "*it is not able to procure it, because they don't have any competitors to gauge whether this is an appropriate product for them*".

3) Factors explaining variance in exploitation potential between different Transport sub-sectors

Lastly, in relation to the size age of the Organisation as factors that cause variations in the exploitation success or failure, Prof. Prozzi mentioned that the success of the exploitation of results heavily depends "*on the knowledge about the industry and the experience and expertise of the Organisation doing the exploitation*". Emphasizing this fact, Prof. Prozzi recalled a successful exploitation case, originating from a public innovation grant aiming to optimize sensors for traffic measurement. A partner within the project, which was involved with the communication industry, saw the opportunity in exploiting the results and re-invented the sensor solution based on the results of the project. "*Knowing the particular business and having the background and experience of the industry instilled within the people of the Organisation, allowed for a successful transition from research to exploitation and finally to implementation*".

Interview #4

Prof. Alex Skabardonis

UC Berkeley professor and California PATH program manager

1) Exploitation timing and "proof of value" of the research as determinants of exploitation effort and success

Our discussion with Prof. Skabardonis began by examining the concept of exploitation timing and how it plays an important factor in the overall outcome of the exploitation effort. From his experience, Prof. Skabardonis pointed out that in most projects he has participated in "*the research results where exploited immediately after the end of the project or not exploited at all"*. He also noted that in some cases, on top of keeping the exploitation effort in the short-term, "*research must prove in a relatively small timeframe that it has the potential to bring*

strong financial gains; otherwise it is usually forgotten, and additional effort into exploiting the results will in most cases not be invested by stakeholders".

2) Difficulty of tracing exploitation success back to its origin

On the other hand, Prof. Skabardonis pointed out that there are many exploitation cases where promising results and consequent start-ups that have been formed to exploit these results were bought by larger Organisations, speeding up and increasing the success rate of the exploitation but at the same time making it rather difficult to truly understand which factors played a contributing role that led to a successful exploitation.

3) Factors explaining variance in exploitation potential between different Transport sub-sectors

Lastly, for what regards the role of the Transport sector in the exploitation of research results, Prof. Skabardonis noted that *"the stability in a sector plays an important role"*. Another relevant factor that plays an important role in explaining differences in the exploitation intensity between different Transport sectors is *"the rigidness of the structure of the sector"* (i.e., the airborne sector is highly structured in comparison to the road sector) which plays an important role in explaining the difference in exploitation between different sectors. Lastly, Prof. Skabardonis pointed out that also *"the level of regulation in a sector can also play a crucial part"* in explaining differences in the exploitation of research.

6.2.2 Summary of Findings

A summary of the findings from the 2nd round of interviews can be found in the table below (Table 6.2).

Table 6.2: Summary of findings from the 2nd round of interviews.

	Interviewee 1	*Interviewee 2*	*Interviewee 3*	*Interviewee 4*
Exploitation timing	• Importance of **short-term focused exploitation** "*… people that are involved in the actual implementation of the project are the ones that are gaining the experience, expertise and the network… people change places and the knowledge created through the results of the project is lost with them".*	• **Rate of adoption, critical mass** *"…you are not going to get the full implementation and full deployment of an innovation until a certain period of time, when it finally becomes self-sustaining (reaching the required critical mass)".* • **Differentiating factors** in the exploitation timing "*…there are also things that are happening that make that (exploitation) time shorter or longer, for example if you lost a champion it might take a little while longer for the remaining people to get up to speed or influence the Organisation in such a way that the results will be put into practice".*	• Differences between **public and private sector** *"…in the private sector, if you have a technology that takes you two years to put in practice, you most probably are never going to get it used, since other technologies will have it superseded by that time".* "*…in the public sector, it might take the same amount of time but for a completely different reason (risk aversity)*".	• **"Proof of value"** of research *"Research must prove in a relatively small timeframe that it has the potential to bring strong financial gains, otherwise it is usually forgotten and additional effort into exploiting the results will in most cases not be invested by stakeholders".*
Characteristics of the Organisation	• **Moderating effects** of absorptive capacity "*…it can facilitate a more rapid and efficient dissemination of knowledge within the Organisation"* minimizing the effects of the "*rotation of people*	• Effects on **risk-taking** and **absorptive capacity** *"…smaller companies have a better vision all the way through the company on doing the implementation and being more exploitative. Larger Organisations are more prone to create research silos that make it harder to get the*		

	moving from place to place and project to project". • **Age** and **size** as determinants *"…the truth is big Organisations are mostly interested in not losing existing market share (being defensive) rather than getting innovation actually done if it is not necessary".* Smaller/newer Organisations whose goal is to gain and increase their relative smaller market share by *"…disrupting the current market status quo, thus becoming more prone to adopt and utilize research results and innovations in order to achieve their goal".* • **Research team** seniority Senior people from the Organisations *"change/withdraw from actively being involved with the project, with junior researchers taking over the implementation of the project…"* *"…difficulty to get results actually implemented in the Organisation because these researchers are not too*	*research out and into the rest of the Organisation".* "*…larger Organisations also often struggle to seamlessly communicate knowledge within their ranks".* • **In-house R&D** and the **distribution of research** in the Organisation *"…it is almost as if you are having two different Organisations which are having difficulties communicating with one another. It is difficult for researchers to communicate with practitioners".* *"If you have people within the Organisation that are participating in the research and have a platform for the exploitation … they will be more successful with the exploitation of research results. The research will be much more distributed within the Organisation and they will have a better opportunity for exploitation because they are closer to solving real life problems".* • Creation of **exploitation capacity** *"…when you have experience in exploiting, the next time it comes around you can more easily recognize it and take advantage of it…"* *"an experienced exploitation/implementation team can also speed up the process of exploitation since they are in a better position to easily recognize and implement research results…".*		

	influential at the administrative level".	• Positive **exploitation experience** *"…exploiting any kind of innovation, results to change and people often avoid change so if you've had a good experience and know the processes you feel more confident in carrying the innovation all the way through and it will not be as disruptive as you've been through the process before".*		
Differences between Transport sub-sectors	• **Nature** and **pace** of research "*…the technological developments in the Transport sector are in most cases driven by incremental research*". *"…you are trying to maximize the profits you make out of innovations, while at the same time trying to anticipate the next steps while always making incremental steps in order not to overwrite all previous research and knowledge*". • **Funding** *"…in the road sector you have a lot of private investment (currently though automation) which drives innovation in the sector".* *"In the rail sector it is typically very defensive with stakeholders*	• **Funding** Research on the road sector might be funded mostly by public funds whereas research in the rail sector might be funded mostly by private funds *"leading to differences in the outcome of the research and its consequent exploitability".* • Sector **performance** *"…innovation history and performance of the sector play an important role to determine how a sector reacts to the introduction of innovations and whether or not these are quickly and efficiently adopted".*	• **Knowledge** about the industry "*Knowing the particular business and having the background and experience of the industry instilled within the people of the Organisation, allowed for a successful transition from research to exploitation and finally to implementation*".	• Sector **characteristics** *"The stability in a sector plays an important role".* *"The rigidness of the structure of the sector".* *"The level of regulation in a sector can also play a crucial part".*

	being very focused on keeping the status quo…". *"…at the EU level it is mostly an industrial policy and not a research policy in mind since they are trying to keep the market closed from the Japanese and Chinese competitors which are considerably much cheaper".*			

7 Conclusions and Further Research

7.1 Thesis Overview – Findings

The main findings of our questionnaire survey analysis are presented below. Factors categories examined were found to have both statistically significant and non-significant impacts on the innovation potential of Organisations examined. More specifically, statistically significant effects were found in terms of:

"Firm-related" effects:

- Knowledge *assimilation* and *exploitation* dimensions of the absorptive capacity of an Organisation have a statistically significant impact on product and process innovation.
- The *size* of the Organisation has a statistically significant impact on its ability to introduce product innovations from the exploitation of research results by moderating the effects of "project-related" factors.
- *Past collaborations/familiarity* of the Organisation with other consortium partners has a statistically significant impact on its ability to introduce product innovations from the exploitation of research results by moderating the effects of "research-context related" factors.

"Project-related" effects:

- The *size* of the project has a statistically significant impact on the ability of the Organisation to introduce product innovations from the exploitation of research results by moderating the effects of "research-context" related factors.

"Research -context" related effects:

- The *relevance* of the technology/system has a statistically significant impact on process innovation.
- The *costs* associated with the adoption of the technology/system have a statistically significant impact on both product and process innovation.

- The *standardization* requirements of the technology/system have a statistically significant impact on process innovation.
- The *customization* requirements of the technology/system have a statistically significant impact on process innovation.

Furthermore, our qualitative analysis (i.e., the second round of in-depth interviews with Transport experts) indicated that:

In terms of the *timing of exploitation*, Organisations should emphasize on the:

- Short-term focused exploitation
- Impact that different rates of adoption and critical mass accumulation can have on the exploitation of IT research results
- Various factors can affect the timing of the exploitation, such as the availability of personnel, etc.
- Differences between public and private sectors
- Importance of providing "Proof of value" of research for its subsequent exploitation

In terms of *"firm-related" factors*, Organisations should emphasize on the:

- The potential moderating effects that absorptive capacity can have on the exploitation
- The age and size of the Organisation as determinants of exploitation potential
- The importance of having a senior Research team involved in the research project
- The importance of having a balance between in-house R&D and the distribution of research within the Organisation
- The importance of creating a positive exploitation capacity within the Organisation

In terms of factors that explain differences in exploitation outcome *between Transport sub-sectors*, Organisations should consider:

- The importance of the nature and pace of research in the specific Transport sub-sector
- The availability and origin of funding
- The innovation history and performance of the particular Transport sub-sector

- The knowledge it has about the specific Transport sub-sector
- Other Transport sub-sector characteristics such as the stability and rigidness of the sub-sector and the level of regulation that exists

This research has focused on the first stages of the "innovation production" cycle i.e., those that follow immediately after the research execution phase. This is the stage in which the research producing entity will determine to pursue, or not, the exploitation of the results of its research which it conducted on its own or – most usually – within larger collaborative research consortia. It is also the stage in which the relevant decision makers within the research performing entity will decide the extent to which they will go with this exploitation, i.e., whether they will remain with the "knowledge created" which they can explore later, or they will proceed all the way to producing "innovation" in the sense of creating market induced commercial products or services which they will promote and sell in the marketplace. As we have specified in the introduction, the main objective of this PhD work was to investigate the factors and conditions that influence the decisions for the exploitation of research results in the context of collaborative IT-related research projects in the Transport sector. We concentrated on publicly funded research because it is there that most of the issues of exploitation apply since in privately funded research the funding entity is – almost always - doing so in order to get exploitable results in the form of commercial products.

In discussing the potential contributions of this PhD work to research result exploitation and innovation production, in fact the achievement of its objectives, we need to remember that the situation to date is characterized by a large number of research projects that are assigned to collaborating consortia of research performing entities under a contract. This contract specifies the terms and conditions for the execution of the (research) work and also defines several deliverables in the form of reports or demos or prototypes. The research assigning entities can be private or public sector entities, but we are mainly referring here to research funded by the public sector as it is there that the exploitation of research results is an issue. In most of the cases of publicly funded research Programmes, the research performing consortia conduct the research according to their research contract and when they finish and submit the prescribed (in the contract) deliverables the work stops. We are, therefore, at a situation in which there are research contracts worth billions of Euros on which the "return on investment" in terms of the value of implemented innovation is practically unknown.

Given the aims and the subject area of this PhD and the existing practice as delineated above, the appreciation of the contributions of this PhD research is tantamount to appreciating the degree to which the results of this PhD work facilitate the creation of "value for the money spent on research". If the research stage is the stage in which we are "converting money to knowledge" (i.e., research products) the research results exploitation stage is about "converting knowledge to money". The main contribution of this PhD research, therefore, can be stated as its contribution to the better understanding of the processes and the conditions and factors under which the level of funding spent on research will produce an equal or higher value of innovation products- preferably much higher! It is therefore very important that by finding the most influencing factors for research result exploitation - even if it is for the specific areas chosen for this present research study – we can influence the potential for "exploitation" of the research results and the final production of innovation.

The above issues are of great and ever-increasing interest in Europe and worldwide. It is characteristic, of this interest, that the relevant Directorate General (DG) for Research of the European Commission has been renamed, for the Horizon 2020 Programme, to *DG for Research Technology Development & Innovation (DG/R&D&I)* and in the new Framework Programme, the *Horizon Europe* Programme that will span the period 2021 - 2027, to simply *DG R&I* for *Research and Innovation*. Correspondingly, the initial expression for research and technological development, i.e., R&D, has become now *R&I* i.e., *Research and Innovation*. Furthermore, the emphasis put on innovation creation by the two leading world public administrations in the field of Transport, i.e. the *US Department of Transport* and the *EU's Directorate General of Research & Innovation / Transport division*, is shown by the fact that the first activity they decided to perform together under their cooperation Agreement of 1998 which started being implemented in 2012[42], was the Organisation of a 2-day workshop on *Transport research (results) implementation.* The report produced by this workshop is cited in the reference list of this PhD and has formed a valuable source of material not only for this PhD (in the initial planning stages) but for many other works on this subject.

The more specific contributions of this research work are examined in detail in the following sections, under the labels of:

[42] The *EU – US agreement for scientific and technological cooperation* was signed in 1998 and covered many areas of research (European Commission, 1998). For the Transport sector, the cooperation started in 2012 with the signing of the *Implementation Agreement for the Transport* sector.

A. *Research and Academic contributions*, i.e., the impacts that relate to potential academic applications of the results, a better understanding of the relevant issues and also the dissemination of the findings through papers and other dissemination channels of the research and academic world.
B. *Business / Policy contributions*, i.e., the impacts on the way that the various businesses (research performing or not) can handle the issues of exploitation of research results to produce innovations. Under the same title, we will also examine how the results of this PhD work can influence the formulation of the appropriate policies to facilitate and promote innovation, by the relevant policy formulating bodies.
C. (Transport) *sector contributions*. Finally, we will examine the potential impacts on the sector itself, i.e., the contributions that this research work may have, on the Transport systems of the future and the way that the Transport sector as a whole can benefit from a better and more pronounced exploitation of the research results in the areas under consideration.

7.2 Research/Academic Contributions

The contribution of the work performed here provides the potential for several academic / research impacts. These can be derived from the exploitation of the results achieved in this PhD study by the research and academic community for the further analysis, clarification, and investigation of the research result implementation environment, mainly in the research performing or research exploiting entities. A list of the results of this PhD work that would fit best this role and thus cause important relevant are the following:

1. Description and conceptualization of a *research model containing a set of determining factors for the successful implementation of research results* (Section 4.3.2). More specifically, our research model extends existing models by introducing a new set of factors (research-context related factors) that were derived from the experience of experts in the field of research implementation. The resulting *Technology* and *Implementation environment* related factors expand and enhance knowledge on aspects of the output of research that are highly relevant and impactful on the success of the implementation and exploitation of research.
2. Precise formulation and practical application of a methodology that describes in detail an approach on how to *combine quantitative and qualitative research methods* (Section

4.1). Utilizing qualitative research methods for the exploratory and explanatory phases of our research methodology, allowed us to more effectively leverage the specialized (and to a certain extent implicit) knowledge of our interview participants since it was employed for both the construction and validation of our research model.

3. Description and formulation of a *framework for analyzing the implementation of research for research projects focusing on Intelligent Transport Systems* (Section 4.3.2). We expand and add to the growing body of ITS literature, by providing a specialized framework for the analysis of determining factors for the implementation of research results, that can be utilized to understand and further examine in great detail different cases of ITS research implementation efforts.
4. Precise formulation and description of a *multi-disciplinary approach to analyse issues relevant to the implementation and exploitation of research results in the Transport Sector* (Chapter 2 & Section 4.2). By combining elements from different academic disciplines our research model examines a unique combination of factors which have not been thoroughly studied by the Transport academic community. A prime example of this is the introduction and use of the Dynamic Capabilities Frameworks (i.e., *absorptive capacity)* for the implementation of Transport research results.

All the above results are of research / academic interest in several ways. For the research producing entities and the individual researchers they can form a significant contribution by answering the question "What makes a research result suitable for implementation?" The answer (to be found in our questionnaire results on the factors affecting successful implementations) can guide the research performing entities or individual researchers to undertake the necessary actions according to the case at hand.

Of interest, finally, are the contributions of this PhD research to the academic / research stakeholders that are interested in the investigation of the *relationship* between research execution and research implementation. The key issue here, is the relationship and distinction between research, leading innovation and innovation, leading research. In other cases, the research itself is resulting to innovation (e.g., through new analytical methods, products, applications or new policies being formulated) while in others, the innovative product that is created produces an interest in a particular research topic, which spurs (further) research. That research then becomes the catalyst for further and broader implementation initiatives. The information that results from our questionnaire surveys and the interviews can be of use in investigating this relationship and this can help further clarify research implementation issues.

7.3 Business and Policy Contributions

On the level of the *business*, this PhD research can contribute benefits as well. It is important for a company to know the main factors that will facilitate and induce the exploitation of its research results and the eventual production of innovation. The functioning of innovation cycles in a company (or business) is risky by the very nature of innovation. Such company must act in a way that on the one hand does not aggravate risk and on the other maximizes opportunities and benefits. A wrong move can derail the course of innovation (and sometimes ruin the business of the whole company).

For this reason, in this PhD we have particularly focused attention to the issues and factors of success as relate to the functioning and objectives of a business (company, firm). They are the so-called "firm-related factors" in our questionnaires and subsequent analyses. They relate to the characteristics that are specific to a firm or business, that is undertaking the original research or comes in later for the exploitation of research results, and which enhance its potential for research result implementation. These factors characterize the internal environment and the ability of a firm to assimilate and further develop results from collaborative research.

Of considerable contribution can also be the "firm-related" factors influencing research result exploitation that we have extracted from our surveys and which relate to the exploitation of new technologies or results of a technological nature. The main finding here is the fact that even if a given research project successfully develops a new technology, its implementation usually requires it to be complemented with other relevant technologies or pieces of knowledge and know-how. These will have to be acquired by outside sources, and in such cases, the implementing entity can utilize "spillovers" from research results generated outside it. The ability to do so depends upon sufficient levels of pre-existing in-house innovative capabilities and accumulated knowledge from own research efforts (Roberts et al., 2012). All these characterize the so-called, *absorptive capacity* of the firm. The *absorptive capacity* is the ability to fully absorb, utilize and exploit the new knowledge generated within a research consortium by the individual company that participates in a research project consortium. We have researched and formulated specific factors that affect a firm's absorptive capacity to acquire, assimilate, transform and exploit the knowledge gained from a collaborative research effort. Such factors include a measure of the firm's ability to identify and absorb knowledge (by specifically asking our questionnaire respondents).

The relevant items of our questionnaire analysis were:

a. Whether searching for relevant information concerning the industry served by the company, is considered an every-day practice in the Organisation;
b. If the top management motivates employees to use information sources within the core industry; and
c. If top management expects that employees deal with information beyond the core industry.

Another business-related contribution is the definition and "measurement" of the *transformation capacity* of a company i.e., the ability of a firm to develop processes and routines to analyze, interpret, understand and finally assimilate externally acquired knowledge. This was measured by asking respondents to indicate the extent to which:

a. There is cross-departmental communication of ideas and concepts within the Organisation;
b. The top management gives emphasis on cross-departmental cooperation to solve problems;
c. The existence of quick information flows throughout the different business units of the company; and
d. The top management demands periodical cross-departmental meetings to interchange new developments, problems and achievements.

To "measure or gauge" the *transformation capacity* of the company we asked respondents to indicate - using Likert-type items in the questionnaire - the extent to which they believe that the employees working in the Organisation have the ability to:

a. structure and use accumulated knowledge;
b. Are used to absorb new knowledge as well as to prepare it for further processes and make it available;
c. Successfully link existing and newly acquired knowledge; and
d. Are able to apply new knowledge to their practical everyday work.

Exploitation denotes an Organisation's capacity to improve, expand, and use its existing routines, competencies, and technologies to create something new based on the ''transformed'' knowledge. The Organisation's *knowledge exploitation capacity* was measured by asking respondents to indicate the extent to which they believe that:

a. Their Organisation reconsiders technologies and adapts them according to newly acquired knowledge; and
b. Their Organisation has the ability to work more effectively by adopting new technologies.

The results from all the above inquiries and surveys, provide the contributions of this PhD research to enhancing a business' capability to innovate and implement the results of its own- or third-party research. They can, in summary, be described as providing input and information on the critical company-related innovation questions that were discussed in previous sections, i.e.:

1. What are the factors that affect a company's ability to implement research results?
2. How can the management of an interested company proceed in order to promote a specific result towards implementation?
3. How can the management of a company become interested in financing suitable research implementation actions; and
4. Who should be involved and to what extent?

On the level of innovation promoting *policies,* our work contributes several basic information and research results that could be utilized in formulating regulation and legislation that facilitates the innovation production process and mitigates "strategic risks". "Strategic" are the risks that are of a strategic nature and can endanger the whole innovation environment within a company, or even a country or region. These risks are present in almost every innovation producing activity and every stage of the process. Their avoidance presupposes vigilance, foresight, and prescience on the part of business managers but also on the part of the governments. Main areas in which specific "innovation promoting" regulation and legislation is needed, are:

- Providing a fair competition environment (focusing primarily on protecting start-ups and forgiving failures);
- Handling employment and personnel mobility issues[43];
- Regulating insurance and litigation risks (especially during tests and demos of new products); and

[43] Personnel mobility has been referred to as "mixed blessing" because on the one hand may derail the innovation capabilities of the company "loosing" competent personnel, but on the other it has been defined as an "opportunity" that can revive and enlighten the whole innovation producing process in the receiving company.

- Facilitating the production and manufacturing of prototypes and their relevant licensing and testing requirements.

Another major policy related contribution, which results from our several interviews and our extensive questionnaire survey is the data and information that relate to the policies for promoting *entrepreneurship*. Successful entrepreneurs/innovators are major "engines of innovation". Through their initiatives, ingenuity, foresight, judgement, and perseverance as well as the many roles that they undertake, they can make innovation systems successful and manage the process of innovation introduction and acceptance by potential users. There are two sets of challenges we found that are needed to be addressed by policymakers to maximize the entrepreneurial dynamism of a country or region (while at the same time mitigating the associated economic and societal risks).

- The first is to promote "openness" and fair play in the competition environment. This challenge includes setting the provisions for the free flow of data across sectors and Organisations and the related need to protect privacy and intellectual property.

- The second set of challenges relate to the policies that need to be formulated in order to activate the enablers of innovation in the sense of providing protective measures and provisions for innovator companies and entrepreneurs.

Also, perhaps most important, to strengthen the *sustainability* of innovation in a certain field or area by providing the supporting environment for companies to invest in innovation and by ensuring that innovation market places operate under "healthy" rules of competition and with an expanding base of consumers to supply. Actually, a most important set of innovation supporting policies are the ones that promote consumption through various types of tax incentives and standards-setting as these are shown to be important factors that will encourage a company to invest in innovation. As private companies are increasingly developing the capabilities to focus on research and post-research investment in order to promote the exploitation of research results, the role of government is switching from "investor of first resort" to a "guarantor of sustainability".

For the research governing and funding entities, these results can form the basic material for the issuance of guidelines for facilitating research implementation and innovation production. Most importantly, they can help these entities to investigate the most effective ways of formulating and inserting clauses in the research contracts that will induce or facilitate - right

from the beginning of the research or even at the proposal submission stage – the subsequent implementation of results. A characteristic event that shows the importance that public administrations attach to having this ability is the workshop organized by the Directorate General for Research and Innovation of the European Commission, Division H – Transport, on October 25th, 2013. This workshop was convened on the eve of the current 7-year research framework Program Horizon 2020 and lasted two days. A number of 30 experts from research conducting and other entities were invited to participate, and the convening question was: "What and at which stage of the research cycle, can we do to make better use of the results from research projects and to increase the impact of Transport research on innovation?" This convening question was answered in three rounds, focusing each on the pre-project, project, and post-project phases[44].

7.4 Transport Sector Contributions

There are also contributions of this PhD research to the Transport sector in general and these materialize mainly through the impacts on the companies and businesses that operate in the Intelligent Transport Systems areas. The subject matter of this PhD research relates to the so-called *fuzzy front end of innovation,* i.e., the early stages of the whole research and innovation (R&I) cycles. At this end, the large corporations in the Transport sector e.g., the large automobile manufacturing corporations or the large multinational logistics service providers, are quite capable to successfully produce and commercialize research results through their own funding and high-tech personnel - and they usually do so. However, to the large majority of Small and Medium-size Enterprises (SMEs), which are considered an indispensable source of innovation in the Transport sector, the results of this research can – as already discussed above - provide significant contributions/insights.

Through the results that relate to the firm-level factors of success mentioned earlier the operation of the Transport, and more specifically the ITS market can be influenced by the advent of relevant innovations. Through the specific *ITS action plans* that all European Union member countries are obliged to compile specific actions are foreseen for the advancement of the installation and implementation of ITS related R&D results. For such implementations,

[44] The answers were published in a special *Newsletter* issued by the DG after the workshop (European Commission, 2013).

there are strong political sensitivities and higher dedicated funding, especially for SME related research and development activities. To the extent that this PhD work enhances the opportunities for research result implementation in these SMEs, it can be of considerable value. This is strengthened by the emerging strong and institutionalized collaboration, in the form of the innovation triple helix, between Universities/research centers, ITS related SMEs and government-related entities.

The above realizations (on the importance and practical use of the triple helix innovation development model in the European ITS sector) are confirmed by a relatively recent study of innovation investment of European companies in the Transport sector which was performed by the EU's *Joint Research Center* (Wiesenthal et al., 2011). This analysis, which also included a survey of attitudes and data from several European manufacturers of Transport equipment, Transport service providers and constructors of Transport infrastructure was also published in (Wiesenthal et al., 2015).

We are in a period when the Transport sector is experiencing - through the advent of many innovations – changes on a catalytic scale. These changes occur in both the hard and the softer (i.e., Organisational or institutional) scale and are based on the creation of innovation by innovation-friendly businesses and management models as well as corresponding innovative funding arrangements. The findings of this PhD research study contribute to the further development of innovation in these areas and help the Transport sector stakeholders to find useful models to follow and develop knowledge from the research they perform or are involved in. This bottom-up approach compliments the top down one based on the European Commission's ITS action plans and other actions mentioned before.

Most of the impacts (of this PhD work) are also expected in other areas of the Transport sector especially those that are traditionally low innovators such as infrastructure construction and maintenance and – partially - Transport service provision. In such areas, legacy systems as well as cultural and regulatory impediments, prevent the establishment of rigorous and sustainable innovation ecosystems and thus innovation production remains at a relative disadvantage. It is there that this research study can have a greater impact especially in geographic areas of the European Union where there are great disparities as regards the amount of national research and development and the level of transformational innovations that are finally produced. The levels of these disparities vary also, depending on the subset of the Transportation sector considered. By contrast, in areas of the Transport sector such as car or

equipment manufacturing, there is little that we can see by way of contribution of this PhD because in these areas the involved companies are fiercely innovative, as well as competitive and their innovation producing activities are an integral part of their commercial and competitory practices. The European Transport sector, when it comes to vehicle and equipment manufacturing, evolves in a context of global competition and performance-related regulations that are highly innovative anyway (European Commission, 2016).

Another factor that may make the results of this PhD work, an attractive contribution to Transport sector stakeholders may be the current trend of accelerating growth in private sector investment in Transport related R&D and the slowing down of corresponding public investment. As the private sector small and medium-sized Transport related companies will have to rely more and more on their own financing for R&D, the results in this PhD study will become more attractive and interesting. The key turning point will be when medium-sized innovation-related firms, reach a level of market value that allows them to generate sufficient internal revenue[45] which they can then use to move forward on innovation producing activities on their own accord. In the field of Transport, we have seen several such companies to either invest in developing their own innovation or purchasing successful start-up companies with the intellectual property and expertise necessary to move forward in the fields of their interest[46].

The above trends do not apply in periods of economic downturn and application of austerity programmes. When the overall economic environment deteriorates (e.g., as in 2009 and on) several private sector Transport related firms are in need of government support[47]. In such cases, the policy related contributions of this research can become useful in formulating government interventions as necessary.

Finally, as our results indicate, research result exploitation (be it in the field of ITS, or other areas of Transport), is also depended on the ability of the sector to accommodate new business models oriented to more flexible and less formal structures that can accommodate joint ownership by inventors and investors while utilizing private or public funding. These

[45] E.g. from advertising and consumer product sales, as well as by the generation of investment capital through stock offerings and venture capital.

[46] For example, in the sector of artificial intelligence applications in Transport, as discussed in (Bughin, Hazan, Ramaswamy, Chui, & Allas, 2017).

[47] Even Tesla, literally owes its survival to US federal loans issued through the *Advanced Technology Vehicle Manufacturing Program* which was initiated in 2008 in response to the economic downturn. The loan, consisted of about $400 million in funding to finance an advanced manufacturing facility to make all-electric, zero emission cars (Overly, 2017).

"new business models" are invariably related to innovatory start-ups and the many relevant "loose" models of business development with a minimum initial investment by young scientists and entrepreneurs. For an engineering graduate of a high-level University, the prospect to create - or join - an "up and coming" such innovatory high-tech firm in an innovation system that also provides ownership through stock options and the like, is quite an attractive prospect and this is quite often the case in the Transport sector.

Overall the relevance and potential impact of this PhD study on Transport sector innovation is seen mainly through the facilitation of research results exploitation at company level and the consequent production of innovations that will influence the sector. Transport innovations go well beyond the development of new hardware or software systems. They include new ways of Organisation and trip making like *shared mobility* services and many other applications that will form the new *mobility as a service* landscape that will revolutionize mobility[48]. By facilitating the decision making and the initial funding of activities for the implementation/exploitation of research results by companies and other research providing entities, the findings, and recommendations of our surveys and interviews can impact on the Transport sector as a whole.

7.5 Limitations and Further Research

As regards the limitations of our analysis, we can first refer to the *measurement of our dependent variable*. Asking respondents to report on innovation impacts with regards to a specific "reference" project could be considered as a "limitation" since the *chosen project* might not be a very representative one. Furthermore, although asking respondents to refer to more than one "reference" project enhances the opportunity for more precise information to be gathered, it also potentially increases the time necessary to answer the questionnaire to prohibitive levels.

Another limitation that could be identified is *the number and type of dependent variables* used i.e., the product and process innovations that result from the exploitation of results of a research project. A different set of dependent variables might lead to more direct relationships and correlations with the independent variables (influencing factors) being

[48] For many writers, our current stage of development in these areas is paralleled to the stage of development of the internal combustion engine-based mobility at the beginning of the 20th century.

observed. However, this study aimed to examine the direct innovation impacts that Organisations realize from their participation in collaborative (Transport) R&D projects and these two dependent variables were the most likely to be better conceptualized and understood. Future research efforts on this issue could focus on examining additional dimensions of innovation impacts, that could potentially help capture more of the value/innovation that Organisations realize from the exploitation of research results.

Furthermore, limitations were also identified in relation to the profile of the Organisations participating in our study and the "reference" project that they selected to respond to our questionnaire survey. Organisations participating in our questionnaire survey *were mostly large in terms of their employee base and reported having extensive experience* and knowledge with regards to R&D projects. This indicates that Organisations in our sample were more likely to report successful exploitation initiatives when compared to inexperienced, smaller Organisations participating in such projects.

Lastly, the *"reference" projects* in our questionnaire survey were mostly considered as successful by respondents, and their funding originated mainly from European and national/governments funds. This prohibited us from observing potential differences between successful and unsuccessful projects and between different sources of funding. Future research could work on addressing these issues by a) examining in more detail less experienced Organisations, in order to further understand the impact R&D experience can have on the exploitation effort and innovation impact realized by Organisations and b) examine in more detail the potential role that the origin of the funding and the project success (or failure) has as an influencing factor.

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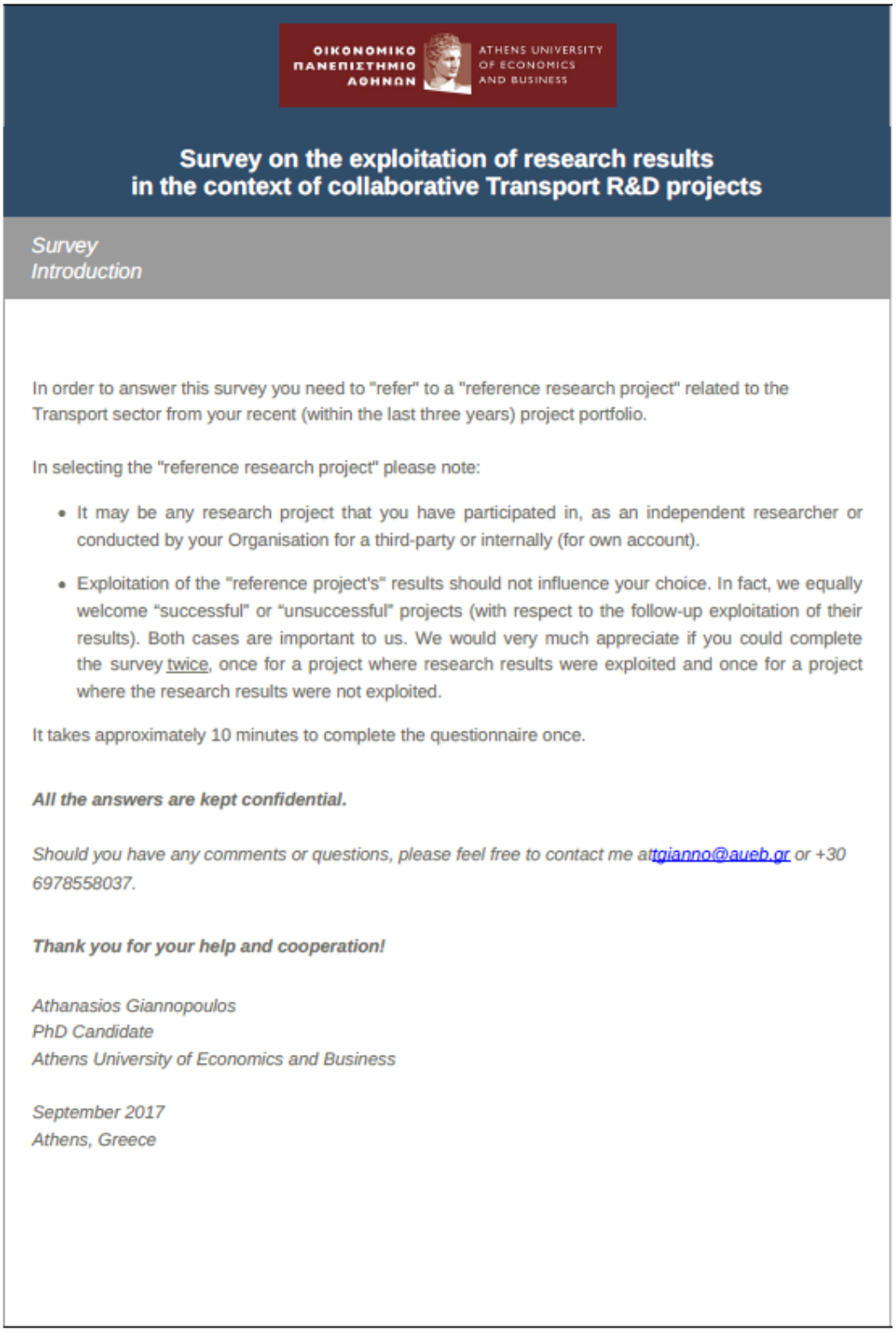
Appendices

Questionnaire



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Survey
Introduction

In order to answer this survey you need to "refer" to a "reference research project" related to the Transport sector from your recent (within the last three years) project portfolio.

In selecting the "reference research project" please note:

- It may be any research project that you have participated in, as an independent researcher or conducted by your Organisation for a third-party or internally (for own account).
- Exploitation of the "reference project's" results should not influence your choice. In fact, we equally welcome "successful" or "unsuccessful" projects (with respect to the follow-up exploitation of their results). Both cases are important to us. We would very much appreciate if you could complete the survey twice, once for a project where research results were exploited and once for a project where the research results were not exploited.

It takes approximately 10 minutes to complete the questionnaire once.

All the answers are kept confidential.

Should you have any comments or questions, please feel free to contact me at tgiannop@aueb.gr or +30 6978558037.

Thank you for your help and cooperation!

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September 2017
Athens, Greece

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A. Innovation Impact

The following questions relate to the innovation impact the "reference project" had on your organisation

The "reference project" refers to a specific research project that you or your organisation have been involved in.

1. How would you assess the exploitation of the project's results in your organisation in terms of its...

	Low			Medium			High
...success	○	○	○	○	○	○	○
...benefit	○	○	○	○	○	○	○
...value	○	○	○	○	○	○	○
...importance	○	○	○	○	○	○	○

To what extent do you agree with the following statements regarding the timing of the exploitation in your organisation:

2. The "reference project" research results were? ...

	Strongly Disagree			Neutral			Strongly Agree
...exploited by your organisation after several years (i.e. >5 years after the "reference project" had finished)	○	○	○	○	○	○	○
...exploited by your organisation <5 years after the completion of the project	○	○	○	○	○	○	○
...exploited in combination with research results of other projects	○	○	○	○	○	○	○
...not exploited at all by your organisation	○	○	○	○	○	○	○

3. How would you rank the "reference project" in relation to its...

	Low			Medium			High
Significance	○	○	○	○	○	○	○
Benefit	○	○	○	○	○	○	○
Innovativeness	○	○	○	○	○	○	○
Clarity of project objectives	○	○	○	○	○	○	○
Ambitiousness of work undertaken	○	○	○	○	○	○	○
Innovation potential	○	○	○	○	○	○	○
Coherence of work plan	○	○	○	○	○	○	○
Effectiveness of work plan	○	○	○	○	○	○	○
Efficiency of leadership	○	○	○	○	○	○	○
Effectiveness of leadership	○	○	○	○	○	○	○

4. During the 3 years after the project was completed and in relation to the "reference project", did your organisation introduce new or significantly improved...

	Not at all			Neutral			To a great extent
...goods	○	○	○	○	○	○	○
...services/systems for third parties	○	○	○	○	○	○	○
...information systems/applications for your organisation	○	○	○	○	○	○	○
...uses for existing goods or services	○	○	○	○	○	○	○
...business models to support new or existing goods or services	○	○	○	○	○	○	○
...methods of manufacturing or producing goods or services	○	○	○	○	○	○	○
...logistics, delivery or distribution methods for your inputs, goods or services	○	○	○	○	○	○	○
...supporting activities for your internal processes, such as maintenance systems or operations for purchasing etc.	○	○	○	○	○	○	○
...supporting activities for your inter-organisational processes for collaborating with business partners (i.e. suppliers, the public sector etc.)	○	○	○	○	○	○	○
...activities or services for supporting customers throughout their transportation/logistics activities	○	○	○	○	○	○	○

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B. Characteristics of the "reference project"

The following questions examine the inherent characteristics of the "reference project"

1. Compared to a "typical" R&D project of your organisation, the "reference project" was?...

	Not at all			Neutral			To a great extent
...scientifically risky	○	○	○	○	○	○	○
...commercially risky	○	○	○	○	○	○	○
...managerially risky	○	○	○	○	○	○	○
...distant from the organisation's core area of technological expertise	○	○	○	○	○	○	○
...scientifically complex	○	○	○	○	○	○	○
...technically complex	○	○	○	○	○	○	○
...managerially complex	○	○	○	○	○	○	○
...of a more long-term view as regards its time horizon and potential impacts	○	○	○	○	○	○	○
...building on past R&D efforts (either conducted in-house or within a national R&D programme or an international cooperative programme)	○	○	○	○	○	○	○

The following questions relate to different aspects of the research outcome of the "reference project"

To what extent do you agree with the following statements regarding the technological aspects of the research outcome:

2. The technology/system...

	Not at all			Neutral			To a great extent
...was significantly developed within the project life	○	○	○	○	○	○	○
...was fully demonstrated within the project life	○	○	○	○	○	○	○
...was successfully deployed in the intended operational environment	○	○	○	○	○	○	○
...was successfully applied to all sites it was initially planned	○	○	○	○	○	○	○
...covered all elements of the problem it was addressing	○	○	○	○	○	○	○
...produced results that met the expectations of end-users	○	○	○	○	○	○	○

3. For the adoption of the technology/system...

	Not at all			Neutral			To a great extent
...license costs were important	○	○	○	○	○	○	○
...hardware costs were important	○	○	○	○	○	○	○
...personnel training costs were important	○	○	○	○	○	○	○
...operational costs were important	○	○	○	○	○	○	○

4. For the customization of the technology/system...

	Not at all			Neutral			To a great extent
...additional effort was required	○	○	○	○	○	○	○
...specially qualified personnel were required during the customization period	○	○	○	○	○	○	○
...considerable data input was required for the initialization and customization period	○	○	○	○	○	○	○

5. Privacy issues

	Not at all			Neutral			To a great extent
The technology/system created privacy issues that had to be considered	○	○	○	○	○	○	○
The core functions and elements of the technology/system required a "privacy certification"	○	○	○	○	○	○	○

6. Standardization (or lack of)

	Not at all			Neutral			To a great extent
The technical elements of the technology / system were covered by an existing or applied for standard	○	○	○	○	○	○	○
There were pending applications for new standards that were relevant to the technology/system (including those initiated by the project team)	○	○	○	○	○	○	○
There were missing standardization protocols relevant to the technology/system	○	○	○	○	○	○	○

To what extent do you agree with the following statements regarding the implementation environment aspects of the research outcome?

7. Skilled personnel were...

	Not at all			Neutral			To a great extent
...required for the initial implementation of the technology/system	○	○	○	○	○	○	○
...required for the operation of the technology/system	○	○	○	○	○	○	○
...required to undertake special training in order to operate the technology/system	○	○	○	○	○	○	○
...made redundant due to the introduction of the technology/system	○	○	○	○	○	○	○

8. Data relevant to the implementation & operation of the system…

	Not at all			Neutral			To a great extent
…was readily available	○	○	○	○	○	○	○
…was reliable (in terms of structure, format, content etc.)	○	○	○	○	○	○	○
…was significantly costly to collect	○	○	○	○	○	○	○

9. Stakeholder cooperation framework

	Not at all			Neutral			To a great extent
A statutory "stakeholder cooperation framework" was crucial for the implementation & operation of the technology/system	○	○	○	○	○	○	○
The involvement of all relevant stakeholders was required for the implementation & operation of the technology/system	○	○	○	○	○	○	○
Different types of stakeholders were required to be involved throughout the implementation & operation of the technology/system	○	○	○	○	○	○	○

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D. (Your) Organisation's profile

The following questions relate to your organisation's profile, with regards to research exploitation and innovation creation

Please answer the following questions with regards to the current state of your organisation.

To what extent do you agree with the following statements regarding your organisation's...

1. ...use of external resources to obtain information

	Not at all			Neutral			To a great extent
The search for relevant information concerning your industry is every-day business in your organisation	○	○	○	○	○	○	○
Top management motivates employees to use information sources within the core industry	○	○	○	○	○	○	○
Top management expects that the employees deal with information beyond the core industry	○	○	○	○	○	○	○

2. ...communication structures

	Not at all			Neutral			To a great extent
In your organisation ideas and concepts are communicated cross-departmental	○	○	○	○	○	○	○
Top management emphasizes cross-departmental support to solve problems	○	○	○	○	○	○	○
In your organisation there is quick information flow, e.g. if a business unit obtains important information, it communicates it promptly to all other BU's or departments	○	○	○	○	○	○	○
Top management demands periodical cross-departmental meetings to interchange new developments, problems and achievements	○	○	○	○	○	○	○

3. ...knowledge processing

	Not at all			Neutral			To a great extent
Employees have the ability to structure and use collected knowledge	○	○	○	○	○	○	○
Employees are used to absorb new knowledge as well as to prepare it for further purposes and make it available	○	○	○	○	○	○	○
Employees successfully link existing knowledge with new insights	○	○	○	○	○	○	○
Employees are able to apply new knowledge to their practical work	○	○	○	○	○	○	○

4. ...commercial exploitation of new knowledge

	Not at all			Neutral			To a great extent
Your organisation regularly reconsiders technologies and adapts them according to new knowledge	○	○	○	○	○	○	○
Your organisation has the ability to work more effectively by adopting new technologies	○	○	○	○	○	○	○

5. To what extent does your organisation...

	Not at all			Neutral			To a great extent
...engage in In-house R&D (R&D activities that are undertaken in-house and on your expense)	○	○	○	○	○	○	○
...engage in external R&D (R&D activities that your organisation contracts out to other entities)	○	○	○	○	○	○	○
...introduce innovations that are new to your market	○	○	○	○	○	○	○
...introduce innovations that are new to your firm	○	○	○	○	○	○	○

6. To what extent do you believe the above profile for your organisation has changed in the last 5 years?

Not at all			Neutral			To a great extent
○	○	○	○	○	○	○

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C. Project-related info

With regards to the "reference project", please answer the following:

1. Name of the project (real or "reference" name)

2. When was the "reference project" completed?

- ○ Currently being completed/just completed
- ○ 1-2 years ago
- ○ 3-5 years ago
- ○ 6-8 years ago
- ○ 9-11 years ago
- ○ >11 years ago

3. The transport sector of the "reference project" was:

- ☐ Airborne
- ☐ Maritime
- ☐ Inland Waterway
- ☐ Rail
- ☐ Road
- ☐ Combined Transport
- ☐ Other (please specify)

4. The project's primary focus was:

- [ ] Technology development
- [ ] Service development (new or improved)
- [ ] Policy development
- [ ] Process development / improvement
- [ ] Fact finding - Data analysis
- [ ] Other (please specify)

5. How many partners were involved in the project

- ◯ <5
- ◯ 5-10
- ◯ 10-15
- ◯ 15-20
- ◯ >20

6. With how many of the partners involved in the project have you collaborated in the past?

None of them			Some of them			All of them
◯	◯	◯	◯	◯	◯	◯

7. Where did the project receive funding from?

- [ ] EU funding programmes
- [ ] Cross-country cooperation programmes
- [ ] National/government funds
- [ ] Industry funding programmes
- [ ] Other (please specify)

8. The idea for the project originated from:

- [ ] Industrial (manufacturing) organisation
- [ ] ICT provider
- [ ] Transport operator
- [ ] Logistics operator
- [ ] Other service provider
- [ ] Consultant
- [ ] Academic / research institution
- [ ] Other (please specify)

9. How did your organisation join the consortium of the project?

- [ ] My organisation initiated it
- [ ] Invited by partners of previous projects
- [ ] Invited by other business associates
- [ ] Contacts during information days
- [ ] Other (please specify)

10. How would you rate your participation in the project in terms of effort?

(your organisation's person-months compared to the total person-months of the project)

Low			Medium			High
○	○	○	○	○	○	○

ΟΙΚΟΝΟΜΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
ATHENS UNIVERSITY OF ECONOMICS AND BUSINESS

Survey on the exploitation of research results in the context of collaborative Transport R&D projects

E. Firm-related info

1. What is the number of employees working in your organisation?

- ◯ <10
- ◯ 10-50
- ◯ 50-250
- ◯ 250-500
- ◯ 500-1000
- ◯ >1000

2. When was your organisation established?

- ◯ <5 years ago
- ◯ 5-10 years ago
- ◯ 10-20 years ago
- ◯ 20-30 years ago
- ◯ >30 years ago

3. To which business sector / industry does your organisation (primarily) belong?

- ◯ Industrial (manufacturing) organisation
- ◯ ICT provider
- ◯ Transport operator
- ◯ Logistics operator
- ◯ Other service provider
- ◯ Consultant
- ◯ Other (please specify)

4. If your organisation has an R&D department, what is the number of employees working in this department?

- ◯ No R&D department exists
- ◯ <5
- ◯ 5-10
- ◯ 10-20
- ◯ 20-50
- ◯ 50-100
- ◯ >100

5. Does your organisation have experience with transport-related collaborative R&D projects?

Not at all						To a great extent
◯	◯	◯	◯	◯	◯	◯

6. In how many transport-related collaborative R&D projects has your organisation participated in during the last 10 years (approximately)?

0					5					10+
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Thank you!!

Descriptive Statistics

Firm Profile

Furthermore, in our sample, most respondents indicated that the capacity of their Organisation to use external resources to obtain new information is high, since their Organisation strives to research industry relevant information on a daily basis and top management keeps employees motivated to use information sources from both within and outside the core industry (Figure 0.1).

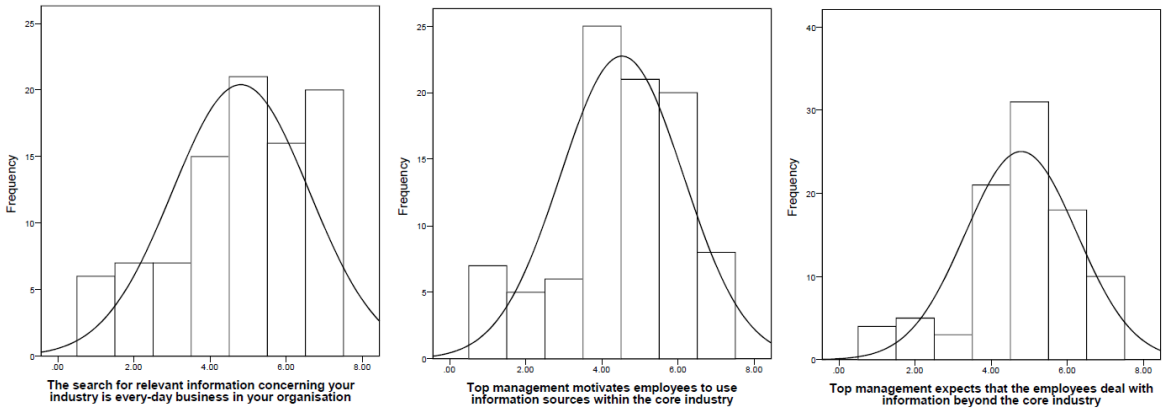

Figure 0.1: Use of external resources to obtain new information.

Regarding the communication structures of the Organisations in our sample, respondents indicated that newly acquired and existing information within their Organisations most often flows quickly, and emphasis is given by top management for cross-departmental communication of ideas and concepts to support the solution of potential problems (Figure 0.2).

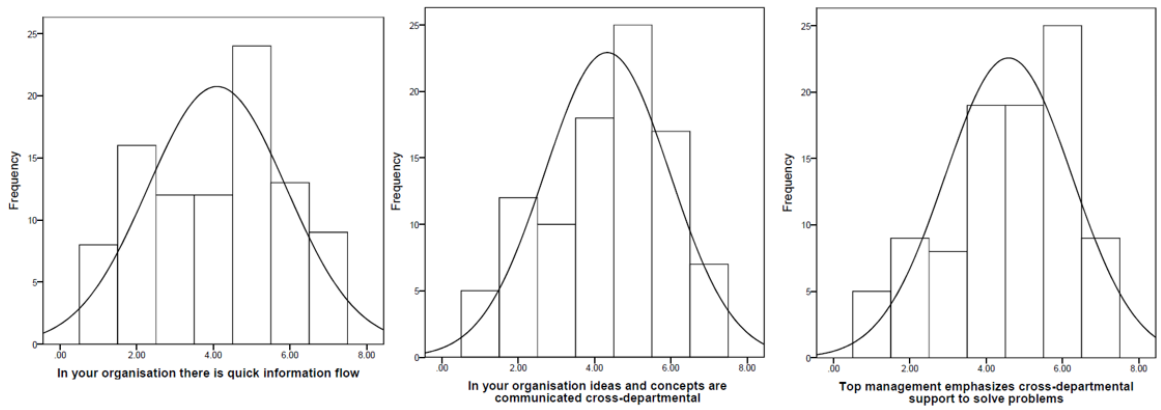

Figure 0.2: Communication structures of the Organisations in our sample.

Respondents in our sample indicated that the ability to structure and use collected knowledge is of high importance and in addition, the ability to get accustomed to absorbing collected knowledge and making it readily available for further purposes is of very high importance (Figure 0.3). Taken collectively, this indicates that our sample includes Organisations that highly regard the combination of existing knowledge with newly acquired and assimilated knowledge.

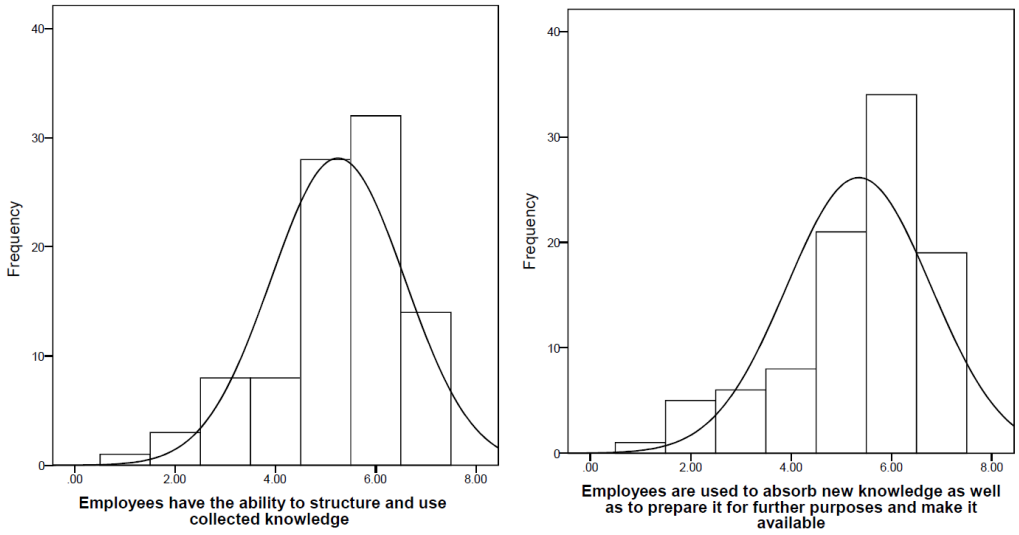

Figure 0.3: Ability to structure and use collected knowledge.

Organisations in our sample also indicated that a very important ability they strive to maintain is the capacity of their employees to link existing knowledge with new insights successfully and even more so to apply any new knowledge acquired to their practical day-to-day work (Figure 0.4).

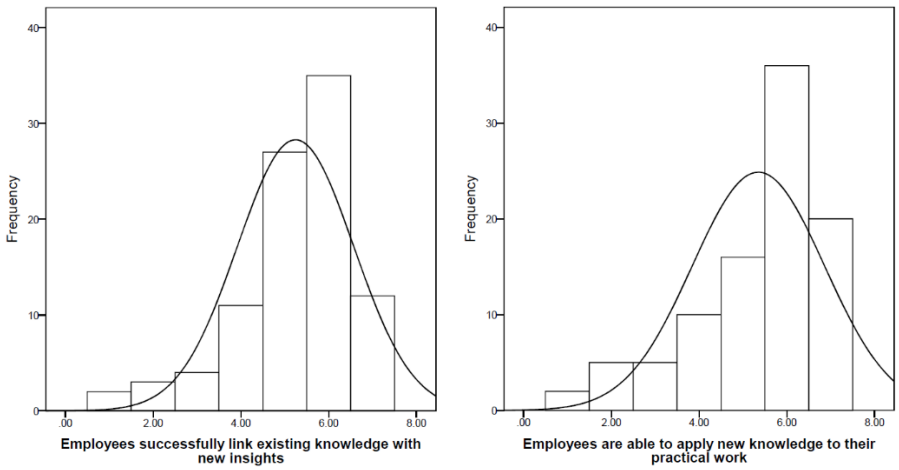

Figure 0.4: Capacity of their employees to successfully link existing knowledge.

Furthermore, as our sample indicated, it is highly important for an Organisation to utilize its existing resources, competencies, and technologies to create something new, based on the newly transformed knowledge it has acquired. More specifically, respondents in our sample indicated that their Organisation regularly reconsiders technologies and adapts them according to newly found knowledge, which also enables the Organisation to work more effectively (Figure 0.5).

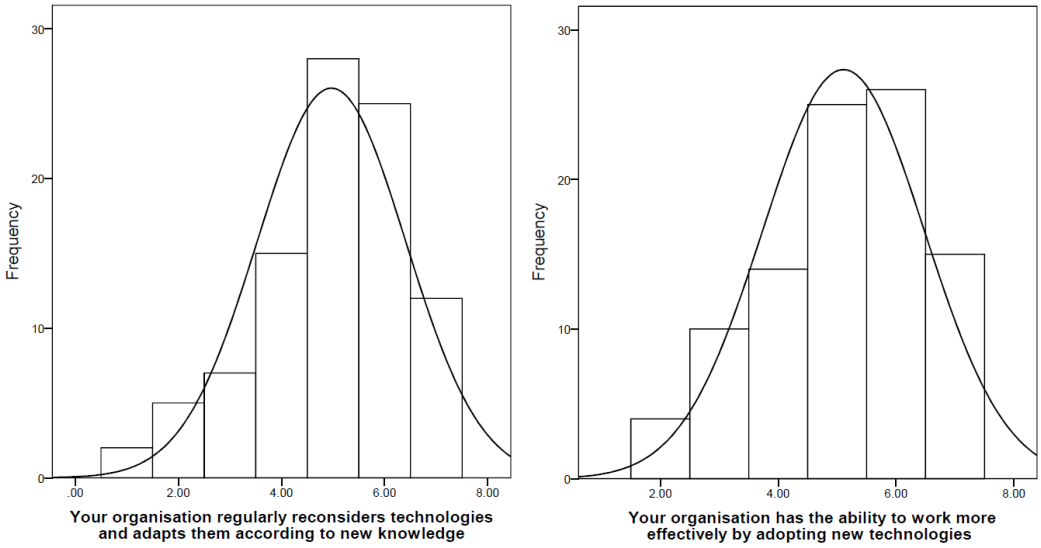

Figure 0.5: Utilization of resources, competencies and technologies.

The "reference" project

In terms of the degree of change in the "reference research project" relative to prior research projects the Organisation has been involved with and the extent of familiarity with them, our sample indicated that respondents chose to complete the questionnaire while referencing projects that were considered of low risk and very close to the core area of technological expertise of their Organisation (Figure 0.6).

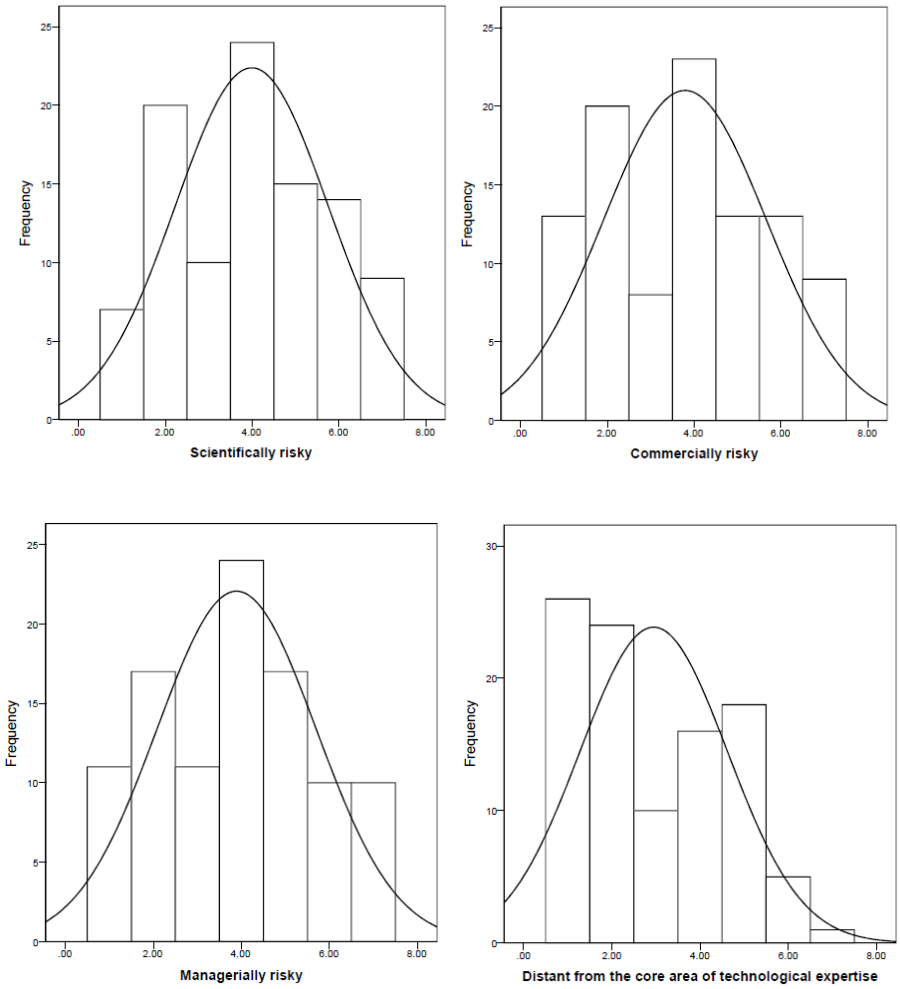

Figure 0.6: Project risk and distance from the core area of technological expertise.

On the contrary, with regards to complexity (i.e. the level and nature of interdependence between the technical and scientific expertise of the Organisation and the research project's overall scientific/technological scope) our sample indicated that the "reference projects" selected where mostly characterized by high levels of scientific, technical and managerial complexity and where considered as "long-term" projects with regards to their time horizons and potential impacts (Figure 0.7).

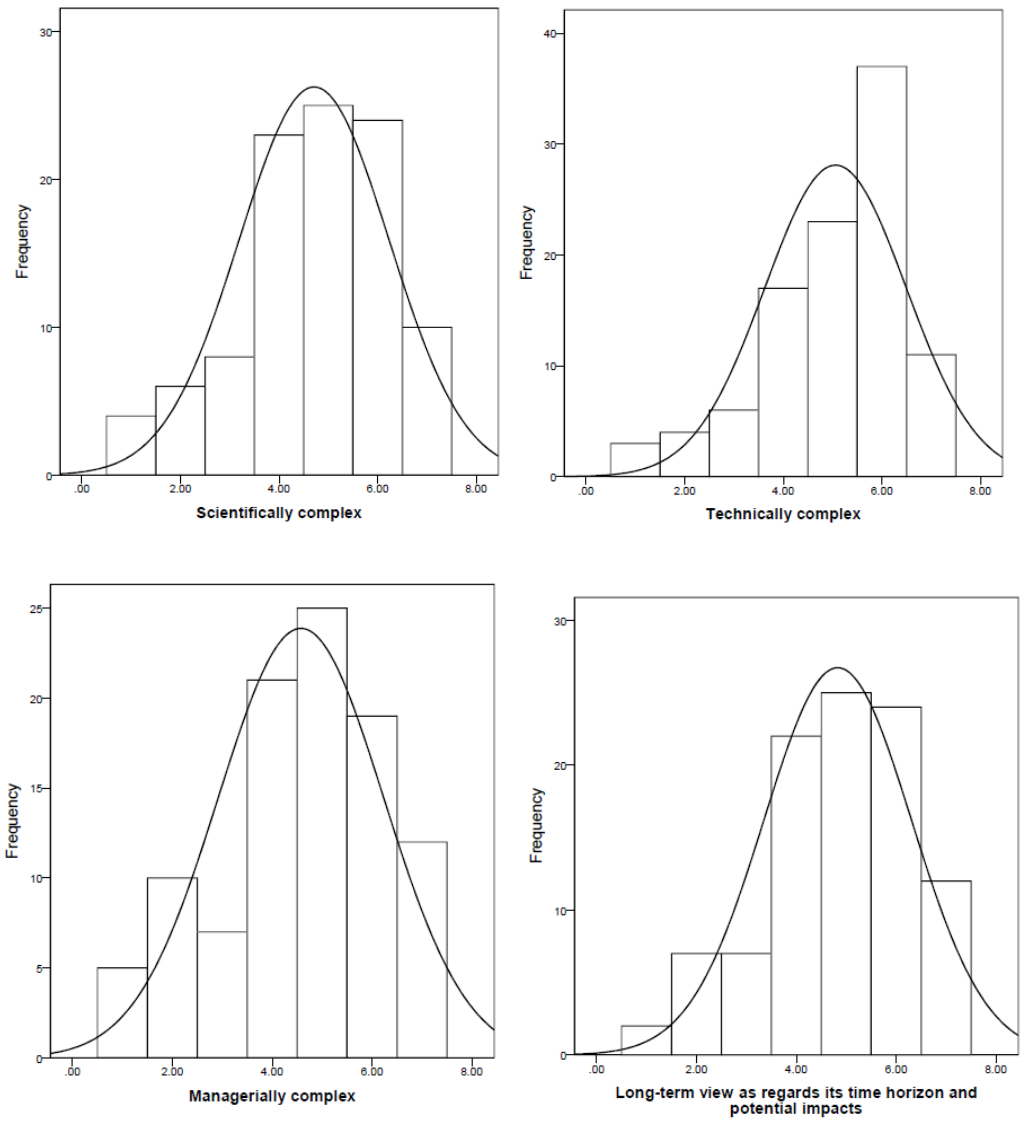

Figure 0.7: Complexity and "long-term" view of projects in our sample.

Profile of Interview Participants

1. ***Robert (Bob) E. Skinner Jr*, Immediate past Executive Director of US/TRB.**

Mr. Skinner has been for the past 20 years the highest administrative director of this large Transportation Research Organisation, which is the largest in the world, with vast experience in managing research projects and promoting their implementation in the US.

2. ***Prof. Phil Blythe*, CEng, FIET, Professor of Intelligent Transport Systems, School of Civil Engineering and Geoscience, Newcastle University and Chief Scientific Advisor, UK Department for Transport.**

Prof. Blythe currently holds the most relevant to my PhD Thesis position in the UK. He currently has the most ITS research projects at the University of Newcastle and at the same time is the head of the Council of Experts at the UK Ministry of Transport, responsible in particular for innovative research products on Intelligent Transport Systems (ITS).

3. ***Mr. Sigfried Rupprecht*, CEO RUPPRECHT CONSULT - Forschung & Beratung GmbH, Clever Str. 13 – 15 50668 Köln (Cologne)/ Germany.**

He is the founder and CEO of one of Germany's largest consulting company on mobility and Transport. The company prepares research projects and studies in the field of Transport across Europe and at the same time implements projects which are based on the company's product portfolio.

4. ***Prof. Alex Skabardonis*, UC Berkeley professor and California PATH program manager.**

Prof. Skabardonis is an internationally recognized expert in traffic flow theory and models, traffic management and control systems, design, operation and analysis of transportation facilities, intelligent transportation systems (ITS), energy and environmental impacts of Transportation. He is former Director of California PATH, a statewide ITS research center. He has worked extensively in the development and application of models and techniques for traffic control, performance analysis of highway facilities and applications of advanced technologies to transportation. He has published over 300 papers and technical reports and served as the principal researcher for over 75 research projects.

5. ***Prof. Jorge A Prozzi.*** **Ph.D., Associate Professor and Fellow Clyde Lee Endowed Professorship in Transportation Engineering, the University of Texas.**

Dr. Prozzi is researching testing and behavior of road building materials, design and rehabilitation of pavements; asphalt technology; mechanistic and empirical design; accelerated pavement testing; applications of probability and statistics to pavement engineering problems; reliability and pavement management systems. He has also conducted analytical research on the application of quantitative methods by applying advanced econometrics for the development of performance models for the optimum management of the pavement infrastructure.

6. ***Prof. Angel Aparicio***, **UPM (Universidad Politécnica de Madrid), Director General of the Spanish Research Center in Civil Engineering (CEDEX)**.

Prof Aparicio has experience from both the Academic as well as the administrative parts of research and an extensive experience with EU funded research projects.

7. ***Prof. Barbara Lenz,*** **Head of the Institute of Transport Research, German Aerospace Center (DLR).**

The DLR Transport Research Institute is one of Germany's most renowned research centers in Transport. Ms. Lenz as Director of this Institute has tremendous experience in implementing research, as the German Government entrusts it with many innovation promotion projects in Germany.

8. Mr. Bret Johnson, **Associate Director, Northwestern University Transportation Center Director, Center for the Commercialization of Innovative Transportation Technology Northwestern University.**

Since July 2009, Bret has been the Associate Director at the Northwestern University Transportation Center (NUTC). Since 1954, the Center has been recognized as a leading interdisciplinary education and research institution dedicated to the long-term improvement of domestic and international systems for the movements of materials, people, energy, and information. At NUTC, Bret also manages the Center for the Commercialization of Innovative Transportation Technology. Prior to joining NUTC, Bret managed the Homeland Security Innovation and Entrepreneurship Center (HSIEC) at NU.