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Research Article

Influencing Factor Analysis for the Implementation of Transport Research Results

Athanasios Giannopoulos[1*], **Aikaterini Pramatari**[2], **Georgios I. Doukidis**[1]

[1]Athens University of Economics and Business, ELTRUN E-Business Research Center, Greece
[2]Athens University of Economics and Business, ACEin-Athens Center for Entrepreneurship and Innovation, Greece
E-mail: thanosgt@gmail.com

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Abstract: This paper investigates the conditions and factors that influence the decision to proceed to the implementation of the results of a given research project and (eventually) produce innovation. It does this with reference to research projects in the transport sector, especially Intelligent Transport Systems (ITS), by an investigation in two fronts. On the one hand, by a number of in-depth interviews with well-known experts in the field of transport and on the other by a comprehensive statistical analysis of the results of a pan-European questionnaire survey conducted among transport entities involved in, or related with, transport research. This investigation resulted in a number of interesting factors and conditions that seem to be influencing the (decision for the) implementation of research results in the ITS sector. These factors were derived from a longer list of initial potentially influencing factors that was formulated by our face-to-face interviews as well as an extensive bibliographic search of relevant previous work. Our analysis pointed as the most significant influencing factors: the so-called knowledge assimilation capability of the entity i.e., its ability to analyse, interpret and understand externally acquired knowledge; its ability to exploit new knowledge by changing its processes and adapting them for exploitation; its size; its research experience; familiarity (good working relations) with other research project partners; and issues relating to the thus called "implementation environment" e.g., the customisation and standardisation requirements; the ease with which new business models and entities can be formed and accepted; and the existence of substantial private funds interested in investing in research and innovation activities. Existence of an experienced team and especially the involvement of senior personnel in the research project itself, also plays an important role for the subsequent exploitation/implementation of the results of this research. The results of the study presented in this paper, can help in the planning and setting of the rules of operation (i.e., the terms of reference) for publicly funded research programmes as well as in setting incentives and procedures that would enhance and promote increased implementation of research results in the future.

Keywords: research exploitation, research implementation, research results, innovation, transport research

1. Introduction

This paper reports on the main findings of a multi-year research work aimed at investigating the factors and conditions that influence the decision to proceed to the implementation of research results and the ultimate creation of innovation. The decision is made by the management of a research related entity (i.e., a private or publicly owned

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organization or company performing research or closely related to it through commercial, financial, industrial, managerial or other activities). In the following, we will refer to these entities by the single word, entity. The term innovation is used as per its standards definition e.g., as in the business dictionary: "the process of translating an idea or invention into a good or service that creates value or for which customers will pay". Our work focused on publicly funded research in the ITS sector, i.e., research that is funded totally or predominantly from public sources (e.g., the European Union (EU), international organizations, national central or regional governments, publicly owned corporations, etc.). Such research is normally performed by a group of research performing entities (research consortia) under a clearly specified research contract.

In choosing the ITS sector for this investigation, we took into account the fact that this is currently one of the most innovative sectors worldwide with large amounts of (public or private) research funding dedicated to it (Wiesenthal et al., 2015). Also, the ITS and transportation sector are a key economic sector in EU countries and worldwide. Before the coronavirus (COVID-19) pandemic, the transport sector accounted for more than 5% of the EU's Gross Domestic Product (GDP) while on average 13.2% of every household's budget was spent on transport goods and services (EU Science Hub (European Commission), 2021). Furthermore, approximately 5% of the total employment in EU countries (i.e., some 10 million people) is working in the transport sector. In the transport sector, Information Technology (IT) applications are a fundamental enabler through ITS. These can be defined as the applications of advanced IT and Artificial Intelligence that aim to provide innovative transport services mainly for the "informed", safe, well-coordinated and "smart" use of transport networks [This definition is a combination of the ITS definitions given in the two references: a. (European Parliament and Council of the European Union, 2010), Article 4, and b. (Edwards & Zunder, 2018)].

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 the above, through the connected-ITS (or C-ITS) applications-providing greater efficiency to the transport system and service to the users.

Innovation creation in the transport sector can have a very substantial societal impact, and this justifies to a large extent the increased interest of the public sector in funding transport related research (Directorate-General for Research and Innovation (European Commission), 2017a). The EU's *Horizon 2020* research framework programme devoted most of its 70 billion Euro, 7-year funding, to research addressing seven social "challenges" one of which was transport (mobility). The outcome of this funding in terms of result implementation and innovation production, as found by the interim evaluation of the programme, was mixed (Directorate-General for Research and Innovation (European Commission), 2017b). Other independent and more recent evaluations (Sakkas et al., 2020) noted the increased value and importance of the EU funded research in motivating and steering the much larger research funding spend by the 27 EU-member countries especially in the current era of globalisation and the unfolding 4th phase of Industry 4.0.

The management of the implementation of research results (in any field) is being increasingly considered as a new and well distinguished field of study and research recognised as "implementation research" or "implementation science" (Measure Evaluation, 2012). Investigating the factors and conditions that can influence the decision of an entity to proceed with the implementation of research results and produce innovation, is therefore of increased relevance and importance. It is also closely related to the production of innovation as it is the first step in a series of steps that ultimately lead to the creation of new products or processes (services) that have commercial value and are wanted by the market (which is what innovation is all about). The importance of innovation creation is now fully recognized by the EU in its new 7-year research funding programme, the EU Horizon Europe (Horizon Europe, n.d.). In this programme, there are several innovation creation activities and tasks that are to be funded while one of the three main pillars of this new programme (Pillar 3), is dedicated to "Open Innovation" and aims to supporting creation of high risk, market-induced innovation. Similarly, in the US, the implementation of publicly funded research results has also been an early concern of US federally funded research programs which has focused since the '90s (Bikson et al., 1996) but also more recently (Measure Evaluation, 2012; Padian et al., 2011) in developing and promoting methods to improve the uptake and implementation of research results and through this, the creation of innovation.

The original research that is reported in this paper, was aimed at investigating the factors and conditions that influence the decision of a relevant entity to proceed to the exploitation of publicly funded research results (Giannopoulos, 2019). The present paper aims at reporting, in summary, the results of this research effort and by doing so provide information and insights towards answering the following three basic research questions:

a. What are the characteristics of the entities that can facilitate or induce research result implementation?
b. What are the characteristics of the research itself, i.e., the "research context" that favour its implementation?
c. What are the types of research projects that are likely to render implementable results?

Part of the aforementioned research effort (as regards the research context-related factors) was reported in an earlier paper by the same authors (Giannopoulos et al., 2019). These are the factors that relate to the intrinsic characteristics and effects of the technology that is being researched in the context of a particular research and development (R&D) project. These were found to be of two categories: A) technology related (that included the following: technology/system maturity; technology/system relevance; technology adoption cost; standardisation requirements; privacy requirements). B) implementation environment related (that included the following: personnel requirements; implementation data requirements; stakeholder cooperation requirements; customisation requirements).

2. State-of-the-art and methodology of the research

2.1 *Summary of the state-of-the-art research*

Implementation of research results in the transport sector, was first investigated as a major issue of concern in the US in the late '90s (Bikson et al., 1996). In this early report, a number of recommendations for factors that influence the implementation of research results in the transport sector were given among which, were the: creation and adherence to an implementation plan; adequate implementation funding; commitment of the Agency's best people to the job of implementation; addressing genuine needs; using results from pilot applications; promoting cooperation between users and researchers and other stakeholders, etc. In Europe, the research results implementation question is a question that is investigated since the beginning of the 2000s. In a paper about the "non-implementation" of research results in Europe, Dosi et al. (2006) referred to the so-called "EU Paradox". This "paradox" reflected the fact that although EU countries play a leading global role in terms of top-level scientific research output, they lag behind in the ability of converting this strength into wealth-generating innovations. Later on, US/NCHRP reports, addressed the same issue (of transport research implementation) adding more recent evidence and research results (Transportation Research Board, 2005; National Academies of Sciences, Engineering, and Medicine, 2014). It is of interest to note some of the factors affecting research result implementation that were mentioned in the latter of these two references:

1. Availability of implementation resources and "mature" implementation infrastructures;
2. "Culture" of innovation within the organization (processes-organizational structures, and positive attitudes for accepting change);
3. Utilization of implementation experience through a number of actions such as: creating a network of implementation experts (*National Implementation Research Network-NIRN*); partnerships with manufacturing enterprises; training for implementation; and others.

In a similar type of (qualitative) approach based on accumulated experience, a two-day symposium was held in Paris in 2014 with the subject of investigating the conditions favouring implementation of transport research results (National Academies of Sciences, Engineering, and Medicine, 2015). In this symposium, it was suggested there transport research implementation can be facilitated by the existence of: standardisation and clear guidelines for the approval and use of innovation; governmental funding policies and decisions that will create a favourable implementation environment especially one that favours and supports disruptive change; and also the (transportation) research governance framework i.e., the type of evaluation, monitoring, and financing of research projects that can produce clear incentives and commitment to implementation and innovation production.

In a recent book on transport innovation by Giannopoulos and Munro (2019), a comprehensive and in-depth account is given of the various factors and conditions under which transformative or incremental innovation can be developed in the transport sector. The book has a separate chapter about the factors that influence innovation production and puts forward an innovation production model based on the notion of "innovation ecosystems". These are defined as "the web of connections, linkages and interactions" between all relevant "stakeholders" that act together to produce *innovation cycles* (i.e., the series of activities resulting in individual incremental innovations) under the prevailing environment (i.e., rules, regulations, legislation) within specific boundaries that are geographical or virtual. The notions and concepts put forward in the book, are tested through a number of 10 case studies of successful transport innovation cases around the world.

A number of transport-specific research result implementation cases can also be reported in relation to specific innovative research projects in transport sector. To this author's experience the following five transport-related projects that resulted in innovative products are typical early examples of transport research implementation success stories:

1. *GIFTS*, a web-based platform for intermodal travel in freight transport. This project developed an integrated operational platform for managing door-to-door freight transport in an intermodal environment (i.e., using all modes).
2. *POD*, proof of delivery software. This software package was a product developed in a research project funded by an interested freight transport and logistics operator in Greece 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 a) the time and place of delivery, b) the correct delivery of the products and c) the invoicing (on-line) of the service.
3. *MyRoute*, an integrated portal for traffic conditions monitoring and trip planning. This is a web-based multi-modal routing application that was designed and developed under a research project with the same name for travel planning by using different transport modes e.g., car, cycle, pedestrian, or public transport.
4. *FRETIS-IFT*, which is an intermodal Freight Terminal Operating System (TOS) (the acronym stands for *FREight Transport Information Technology Solutions-Intermodal Freight Transport*). This was a most successful innovation that resulted from a number of related research projects and which is now used for the commercial operation and management of port container terminals.
5. *ENVIROPORT*, environmental planning for ports operation. This project created an IT application for "green" port operation, i.e., the optimization of the port terminal operations within the yard by efficiently integrating all TOS, and enabling environmental intelligence in container handling procedures by considering energy saving potentials.

The full details and characteristics of these transport-sector research implementation success stories are reported in Giannopoulos (2019).

On a more general and horizontal basis, an interesting quantitative analysis based on data from a cross-EU sample of collaborative R&D projects, supported by relevant qualitative evidence, was reported in Kostopoulos et al. (2015). That study introduced a number of factors and parameters that can influence the decision to implement some of which are also tested here. It also, indicated a number of factors which were found to have significant impact on research project implementation among which: innovation experience, innovation protection mechanisms, effective management of EU rules, and existence of commercially driven entities interested in opening up new technological areas.

For a more extensive state-of-the-art review see Giannopoulos (2019).

2.2 *Methodology of the research*

From the literature review, it would appear that most of the work in this area is evidence-based i.e., relying on qualitative assessments of the views and experiences of experts or case study assessments. This research adopted a combined approach i.e., one that is analytical, using statistical analysis of questionnaire survey data, and one that is more qualitative based on evidence derived from a number of in-depth face-to-face interviews with experts. Guiding both these streams of work there an in-depth review of the existing literature on the topic a summary of which was presented in the previous section.

The main aim of the analytical phase was to identify an initial set of factors that influence the ability of an entity to implement research results. This phase consisted of a number of steps e.g., formulation of a conceptual research model (which was modified and finalized following a first round of in-depth interviews with experts); formulation of a list of potential influencing factors (to be tested through the questionnaire survey); formulation of the appropriate web based questionnaires; distribution of the questionnaire and conduct of the survey through the web; collection and evaluation of the answers to form the analysis set; and finally full statistical analysis of the answers to derive the analytical results. These were then checked and discussed in detail with the experts following a second round of in-depth face-to-face interviews. The questionnaire used, consisted of six sections:

a. An introductory section which included general information, confidentiality issues, etc.
b. A section related to the "innovation impacts" of the research which relate to the dependent variables of our research model. These were traced through the answers given to questions related:
    - To the entity, i.e., company size (in terms of the personnel employed or the average yearly turnover); the size of the research department or team of persons; the area or field of activities; and of course, the innovation record of the entity.
    - Also, related to the project size, i.e., project duration; project thematic area; ITS sub-sector; project risk; and project complexity.
c. A section, aimed at collecting data relevant to the two categories of independent variables mentioned earlier, namely: project-related and research context-related variables.
d. A section, for the collection of entity-related data and information.
e. A section on general "demographic" information concerning the organization under examination.
f. A section on general "demographic" information concerning the "reference" project.

The language used was English, and this questionnaire was distributed at a pan-EU scale, through the web, to a sample of approximately 700 entities that were actively involved in EU funded collaborative transport research projects. The sample was drawn at random from a "population" of entities that participated in EU funded research projects of the H2020 Program. The data collection process lasted for two months, from September to October 2017 with a thorough and persistent data collection effort that resulted in a 20% response rate (approximately 140 usable survey answers).

The main aim of the qualitative phase was to provide confirmatory evidence (of the results of the analytical phase) as well as additional possible influencing factors based on the experience of those interviewed. The main tool employed in this phase was a small questionnaire to guide the face-to-face discussion (distributed to the experts in advance) but otherwise each interview was a free and open discussion on the issues. In total there were 30 in-depth interviews conducted of which approximately 20 before the analytical phase and 10 after it.

Based on our experience in implementing this methodology, we could recommend for any related future work to avoid some weaknesses such as: a) the fact that due to the need for short times necessary for the completion of the questionnaire, we had to ask the respondents to select one "reference project" relative to which they gave their answers. Perhaps a more widely representative way of drawing their experience should be found without increasing the time necessary to answer the questionnaire to prohibitive levels; b) the number and type of dependent variables that are tested could be increased (with an appropriate modification of the questionnaire's questions), both for the independent variables as well as for the dependent ones (i.e., the innovation capacity of the entity); c) the size of the sample could also be increased both in terms of the number of questionnaires sent and the number of questionnaires completed; this should enable inclusion in the sample of entities with a wide range of sizes as well as subject areas.

3. The analytical phase

3.1 *Research model*

A simplified view of the conceptual model used, is diagrammatically shown in Figure 1. This figure shows only an indicative number of factors (variables) in each category of variables. The full list, which is presented and briefly explained below, was developed from a large set of such possible factors that were found in previous relevant work as reported in the bibliography (Ahuja & Katila, 2004; Haines, 2009; Cohen & Levinthal; 1990; Damanpour, 1991; Leonard-Barton, 1992; Kostopoulos et al., 2015; Giannopoulos, 2019; Sakkas et al., 2020) as well as through our first phase interviews that were conducted with the experts. All the explanatory factors (explanatory variables) were distinguished in three categories:

1. *Entity-related*, i.e., relevant to the internal characteristics of the entity,
2. *Project-related*, i.e., relevant to the characteristics of the research project that originated the results, and
3. *Research context-related*, i.e., relevant to the characteristics of the technology or the type of research

"products".

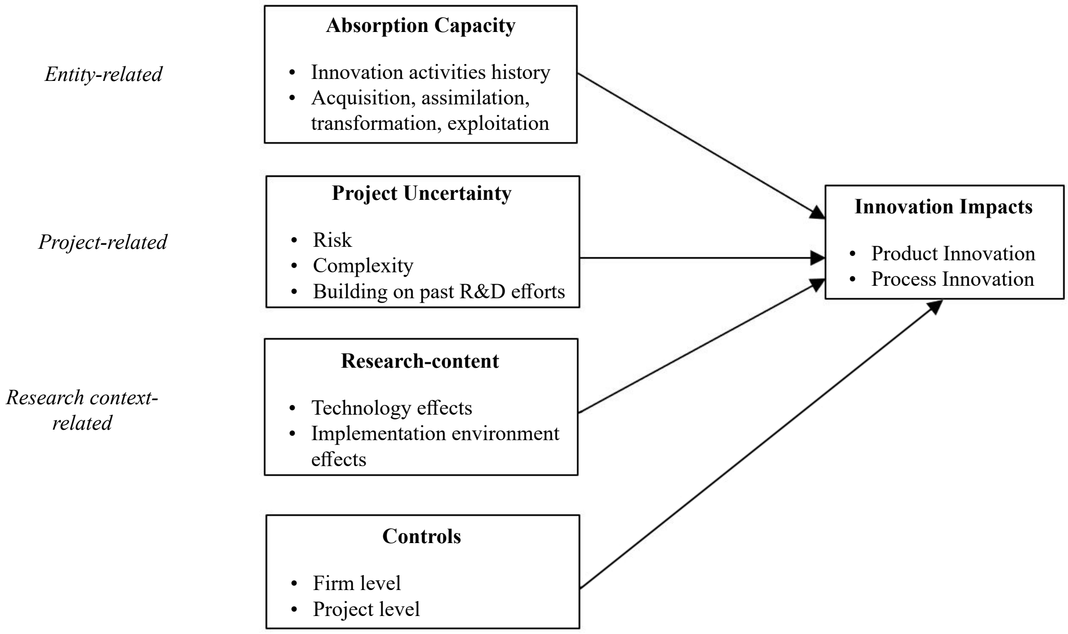

Figure 1. The research conceptual model used for the statistical analysis

3.1.1 *Entity-related factors*

These factors refer to the entity and express its "ability" to recognize the value of the research results and utilize them to commercial ends. Obviously, the typical factors that characterize an entity like size (in terms of the personnel employed or the average yearly turnover); the size of its research department or team of persons; or the area or field of activities-are factors that are included in the analysis. Also, the innovation record of the entity as reflected by its past R&D and innovation activities were examined as well as its past experience in working with other research or innovation relevant stakeholders.

Additionally, we have included a number of entity-related factors that were taken from the existing literature and are collectively known as the *absorptive capacity* of the entity i.e., its ability to acquire, assimilate, transform and exploit new knowledge (Cohen & Levinthal, 1994; Haines, 2009; Kostopoulos et al., 2015; Sakkas et al., 2020). The "absorptive capacity" has been defined in terms of the following four variables or factors all expressed in Likert-type scales (Flatten et al., 2011; Malhotra et al., 2005; Pavlou & el Sawy, 2006):

a. *Acquisition ability*: i.e., the ability to identify and obtain knowledge. In our questionnaire, this "ability" was determined by asking our questionnaire respondents to indicate: a) the extent to which they can define as "an everyday practice" the searching for relevant information concerning the industry in which the entity is active; b) the degree to which the top management motivates employees to use information sources within their core industry; and c) the degree in which the employees deal with information beyond their core industry.
b. *Assimilation ability*: i.e., the ability to develop processes and routines useful in analysing, interpreting and understanding externally acquired knowledge. This was estimated by asking respondents to indicate the extent to which there exists within the entity: a) cross-departmental communication of ideas and concepts; b) cross-departmental support to solve problems; c) quick information flows throughout the different business units; and d) periodical cross-departmental meetings to exchange knowledge on new developments, problems and achievements.
c. *Transformation ability*: i.e., the ability to develop and/or refine routines that facilitate the combination

of existing knowledge with acquired or assimilated knowledge, for future use. This was estimated by asking respondents to indicate the extent to which extend their employees have the ability to: a) structure and use accumulated knowledge; b) absorb new knowledge as well as to prepare it for further purposes and make it available; c) successfully link existing with newly acquired knowledge; and d) apply new knowledge to their practical work.

d. *Exploitation ability*: i.e., the capacity to improve, expand and use existing routines, competencies and technologies to create something new based on the ‘‘transformed’’ knowledge. This was estimated by asking respondents to indicate the extent to which they believed that their entity: a) reconsider their traditional technologies and adapt them according to newly acquired knowledge; and b) has the ability to work more effectively by adopting new technologies.

3.1.2 *Project-related factors*

These refer to the type of (research) project whose results implementation is considered. Based on our in-depth interviews as well as on the findings in Kostopoulos et al. (2015), National Academies of Sciences, Engineering, and Medicine (2014), and Wiesenthal et al. (2015) the following project-related factors were included in our list to be tested:

a. *Project size*: In terms of the number of partners in the consortium and/or in terms of the budget.
b. *Project duration*: The total time from kick-off until the completion of the project contract.
c. *Project thematic area*: The thematic area in terms of the technology or the type of processes tested, or the scientific field it covered.
d. *ITS sub-sector*: The ITS sub-sector in which the project primarily fits (e.g., road ITS, rail ITS, traffic management and control, traveller info, other).
e. *Project risk*: The commercial or technical risk that the entity would face when implementing the project's results e.g., failing to produce substantial sales when introducing the new product into the market or having technical failures of the product.
f. *Project complexity*: The degree in which the various "elements" that define the final outcome are interdependent, misaligned or depended on "outsiders" (e.g., spillover from other entities or innovations).

In the questionnaire, the answers to the questions that corresponded to the above factors were given in Likert-type scales. The factors (a)-(d) were also used as control variables.

3.1.3 *Research context-related factors*

The research context-related factors were distinguished to those that relate to the technology or process being researched and those that relate to the implementation environment.

The technology related factors, included: adoption cost (i.e., an estimate of the cost for adopting the new technology that resulted from the research); standardisation requirements; technology or system maturity; technology/system relevance (i.e., if relevant in relation to the prime field or area of activity of the entity); privacy requirements; innovation potential (i.e., the degree to which the technology included in the project results, has a potential for commercial exploitation).

As regards the implementation environment, the factors examined were: stakeholder cooperation requirements; implementation data requirements; personnel requirements; and customisation requirements (i.e., whether or not the new product would need to be customized for its user before it is used see also Haines (2009)). The research context factors have been discussed and presented in Giannopoulos et al. (2019).

3.1.4 *Innovation-potential factors*

The "innovation potential impacts" (or simply "innovation impacts") are the measures that express the "capacity" of the entity to innovate i.e., its ability to proceed from the research stage to the implementation of its results and eventually the creation of innovation (right side of Figure 1). They are, defined as product and process innovation as they are defined in the harmonized survey questionnaire of the EU *Community Innovation Surveys* (Eurostat, n.d.). Their values were determined through relevant questions in our questionnaire survey. These questions were aimed at estimating the value and benefits that the implementation of the specific research results would bring to the entity.

We clarify that respondents of our questionnaire were asked to provide their answers with reference to a so-called "reference" research project. This is a research project of their choice that is judged as representative of their recent (i.e., within the last three years or so) research project portfolio.

3.2 *Statistical analysis*

The statistical validity of the relationships between all the variables was tested by use of the PLS-SEM (Partial Least Squares-Structural Equation Modeling) package (Sarstedt et al., 2017). The measurement model, shown in Table 1, shows the values of a select number of parameters that evaluate the reliability (i.e., consistency of a measure) and validity (i.e., the extent to which the scores from a measure represent the variable they are intended to represent) of each variable. As regards the reliability, it is measured by the *Cronbach's Alpha,* the *Rho_A*, and the *Composite Reliability* measures (Hair et al., 2021). For *Cronbach's Alpha*, the accepted values should be higher than 0.6. The *Rho_A* value tests reliability in the cases of multiple-question Likert scale questions, while the *Composite Reliability* measure (sometimes referred to as construct reliability) evaluates internal consistency in the case of scale items (Netemeyer et al., 2003). The accepted values of composite reliabilities should be higher than the threshold value of 0.70 (Pallant, 2013). Finally, Table 1 also shows the *Average Variance Extracted* which is a measure of the amount of variance that is captured by a variable in relation to the amount of variance due to measurement error (Fornell & Larcker, 1981). Its values should exceed 0.50 which is consistent with the guidelines given in (Fornell & Larcker, 1981).

Following the tests made in the measurement model, the structural model was constructed. This shows the relationship paths between all the variables indicating the total variance explained for each pair of them. Part of this model is shown in Figure 2. All beta path coefficients are in the expected direction and statistically significant (critical *t* values are 1.65 for a significance level of 10%, (two-tailed tests)).

A full partial least squares (PLS) multi-group analysis (MGA) was then performed following the measurement and structural model analysis results. The aim was to test which of the pre-defined independent variables had significant correlations with the product and process innovation potential of the entity using group-specific parameter estimates such as outer weights, outer loadings and path coefficients. The methodology followed here is described in (Hair et al., 2021).

Table 1. Statistical assessment values of the measurement model

Variable Constructs	Cronbach's Alpha	Rho_A	Composite Reliability	Average Variance Extracted
Innovation Impacts				
Product Innovation	0.83	0.84	0.90	0.68
Process Innovation	0.89	0.89	0.92	0.67
Entity-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
Customisation Requirements	0.84	0.90	0.96	0.90
Implementation Data Requirements	0.85	0.91	1.03	1.05

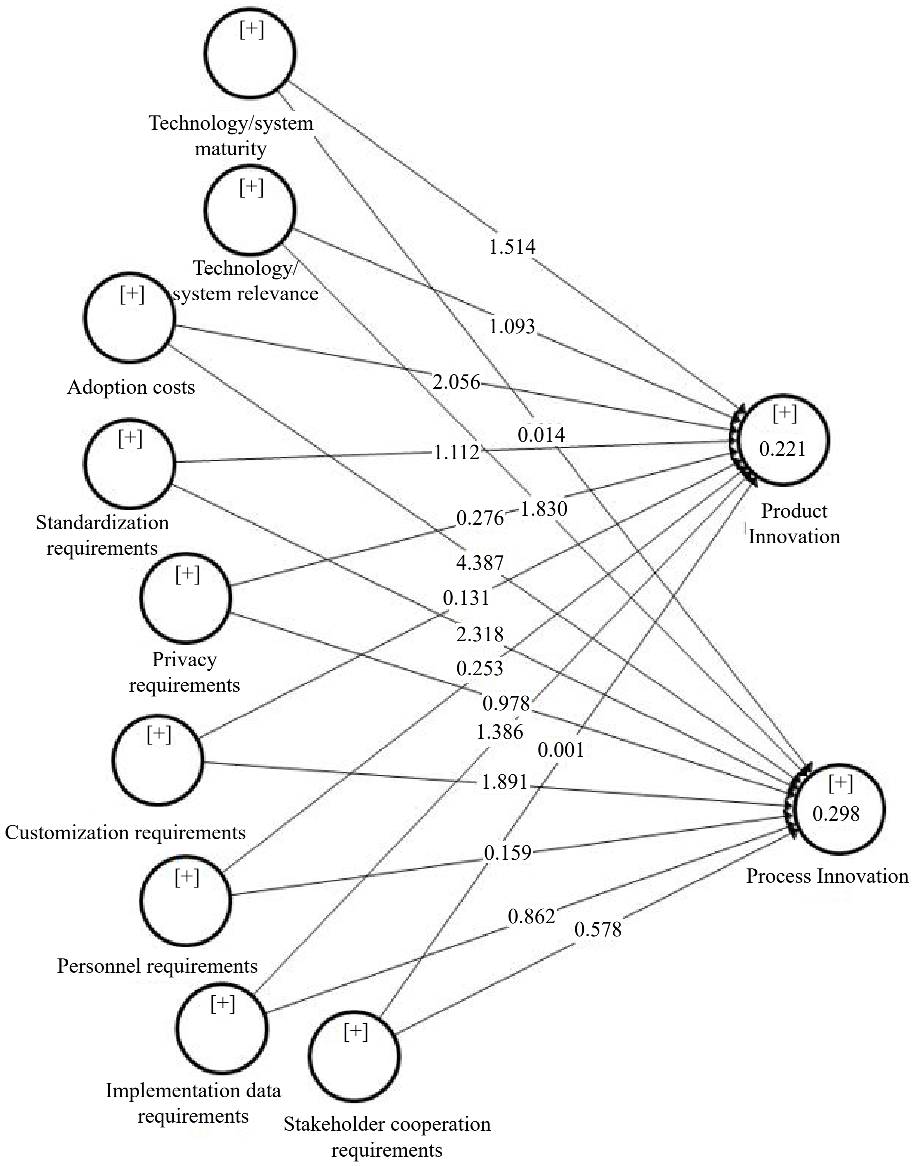

Figure 2. Example of the structural model (*part of the larger construct*)

The results of the PLS/MGA were the following (in summary):

a. As regards the ***entity-related*** variables, there is an overall statistically significant positive effect on both product (beta = 3.22, $p < .00$) and process (beta = 2.70, $p < .00$) innovation. Of the entity-related variables tested, those with values above the threshold measures which indicates significant correlation with the dependent variables (i.e., product or process innovation ability) was:
   - ***Assimilation ability***, significant for both product (beta = 1.81, $p < .07$) and process (beta = 3.39, $p < .07$) innovation,
   - ***Exploitation ability***, significant for product innovation (beta = 1.96, $p < .05$) and,
   - ***Acquisition ability***, showed results at the limit of significance probably because the "knowledge acquisition" questions were undervalued by the respondents in the sense that knowledge acquisition is an everyday practice in research performing entities.

b. As regards the ***project-related*** variables, these did not have a statistically significant impact on both product and process innovation.

c. Finally, for the ***research context-related*** variables, the results indicated that overall, there is a statistically significant positive effect on both product (beta = 3.76, $p < .00$) and process (beta = 3.62, $p < .00$) innovation.

Of the ***technology-related*** variables:

- The ***Adoption cost*** had a significant influence on both product (beta = 2.06, $p < .05$) and process (beta = 4.39, $p < .01$) innovation.
- The ***Standardisation requirements*** had significant influence (beta = 2.32, $p < .05$) on processes and product innovation (here however the beta value was close to the limit of insignificance).
- ***Relevance*** had a significant positive influence on process innovation (beta = 1.83), but non-significant on product innovation.
- The rest of the technology related variables tested, i.e., ***Maturity*** of the technology, and ***Privacy requirements***, ***Innovation potential*** did not show significant correlations.

Of the ***environment-related*** variables:

- ***Customisation requirements*** had a statistically significant influence (beta = 1.89, $p < .10$) on process innovation.
- ***Data requirements*** had a marginal significant influence on product innovation (beta = 1.39)
- The rest of the environment-related variables, i.e., ***Personnel requirements*** and ***Stakeholder cooperation requirements*** showed a non-significant influence on both product and process innovation.

4. The face-to-face interviews

As already noted, there were two rounds of interviews with well-known experts in the field of transport. The first round of interviews included some twenty interviews. The aim was to get their views, experiences, and recommendations regarding the implementation of research results and the factors that may affect/influence it. The second round of approximately 10 interviews, with the same experts, followed after the results of the statistical analysis of the questionnaire survey answers.

A full presentation of the results and findings from these interviews is given in Giannopoulos (2019). The face-to-face interviews gave additional factors that (in the opinion of the experts) influence research result implementation and also revealed some notable diversions between the opinion of the experts and the results of our statistical analysis. A summary of the main results derived from the interviews that are additional to the results from our questionnaire survey is given below:

a. The main factor of influence according to the experts' interviews is the prospect of *economic benefits* that the entity's management expects to accrue from the implementation/exploitation of the research results. If such benefits cannot be foreseen, it is not likely that additional effort will be invested by stakeholders in implementing the results. Many experts stressed the application here, of the Everett Rogers' innovation dissemination theory and curve (Rogers, 1995).

b. *Previous experience* and *involvement* of the entity in research projects and other research and development and innovation (R&D&I) activities, its called R&D&I record.

c. *Experience in working with* other research and innovation relevant stakeholders.

d. *Senior personnel involvement* with the research project has produced the results whose implementation is being considered. If senior personnel are involved in the research from the beginning, it is more likely to make the decision later on to proceed with implementation of the results. Usually, the problem occurs when such personnel do not have the time to be involved with the daily execution of the research project and allows more junior researchers to take over.

e. Existence of *close* and *continuous cooperation* between the R&D team (or department) and the rest of the entity's departments who usually are called upon to realise the implementation.

f. Existence of *close* and *continuous cooperation*-through appropriate agreements-between the research entity and its researchers with "practitioner" entities and individuals. "Practitioner" entities are those industrial or commercial entities that will normally undertake the transformation of the research results into commercial products. On several occasions, examples were stated of research entities having permanent contracts or memoranda of cooperation with practitioner entities relevant to their field of work.

g. The *size* of the implementing entity was mentioned as an influencing factor with big in size *entities* usually more prone to implementation but in these larger entities there is always the danger of creating "research silos" within their departments a situation that makes it harder to get the research results diffused into the rest of the entity.

h. The ease with which *new business models* for the implementation/exploitation of research results can be formulated and accommodated within the existing administrative and business environment.

i. The *transport sector* in which the specific research result applies is also an influencing factor. For example, a research result in the area of road management or maintenance may be funded more easily for implementation as in this area the private sector is very much involved and the public sector wants to show cost effective results. These conditions may not apply in other sectors.

5. Summary of results and conclusions

This paper dealt with the issue of the factors and conditions under which an entity is more inclined to decide to proceed with the implementation of research results and produce innovation. The basic research question was to determine what are the characteristics and factors that can influence an entity's management to decide to proceed with the implementation of research results with a view to producing innovation. Following the statistical analysis of the results of our-wide questionnaire survey and the face-to-face interviews, we can summarize the main findings as follows.

As regards the characteristics of the entity, influencing factors are:

1. The *size of the entity* (number of employees). According to our statistical analysis, the size of the entity is important especially in relation to the type of the research project whose results are being considered for implementation. There was a statistically significant difference in the results between small or medium sized entities (SMEs) and larger ones with the larger entities being more likely to proceed to implementation. Size was also important in the view of several of the experts interviewed, but they also pointed out to us that SMEs can also be expected to enable research result implementation as they are not hampered by "research silos" (i.e., isolating the research department from the rest of the entity) that are often the case in large entities.
2. The *size of the research department* (or group) within the entity also shows significant correlation with the entity's ability to implement, particularly as regards process innovation.
3. The ability of the entity to *assimilate* and *exploit* (new) knowledge which is made (more easily) available in the context of a specific collaborative research project, is also a positively contributing factor. We would add here as important also the (knowledge) *acquisition* and the *transformation ability* factors that were defined in earlier sections, as the results of our analysis on these factors were inconclusive.
4. *Familiarity with the* (research) *project's partners* was another influencing factor that also took its highest correlation value when considered in relation to the research context of the research project in question. Some experts, in our interviews, suggested that what is also important is to establish *close* and *continuous cooperation*-through appropriate agreements-between the *entity* (and its researchers) with other "practitioner" entities and individuals in the same field.
5. *Past collaboration history* i.e., the existence of previous collaborations between the same partners in the research consortium also proved to be a factor of significant (statistical) influence to research implementation capacity, again in relation to research context.

As regards the project-related characteristics, i.e., those that refer to the type of research project, its size and other characteristics, these were found to have negligible impacts. Only the size of the project i.e., the number of partners in the consortium, showed a significant impact and this, only in relation to the research context i.e., the type of the research being performed and more specifically its technology adoption costs. All other project-related factors such as the project duration; the ITS sub-sector in which it falls; the project risk; and the project complexity did not seem to have significant impacts.

As regards the research context-related factors, the technology adoption costs and the standardisation requirements that are associated with the technology being researched, were found to have significant correlation mainly in the cases of process innovation creation. From the implementation environment factors only the customisation requirements, i.e., the need to customize the application within the receiving entity, was found significant. All the other research context factors that were defined and tested, did not show significant correlation with the product or process innovation capability of the entity.

In addition to the above, our face-to-face interviews with the experts revealed a number of other influencing factors which were presented in more detail in the previous section. These factors are largely difficult to quantify and thus they are difficult to be included in a statistical analysis of the type presented here. They are nevertheless important. They include:

1. The prospect of *economic benefits* that the entity's management expects to obtain from the implementation of the research results.
2. The continuous involvement of the *senior personnel* in the work of the research project that has produced the results.
3. Existence of *close* and *continuous cooperation* between the R&D team (or department) and the rest of the entity's departments that are usually involved in implementation.
4. The ease with which *new business models* can be set up and supported for the implementation/exploitation of the results a factor that in reality means to have a flexible and supporting "implementation environment" in terms of the existing administrative, policy and business regulatory framework that is in place.
5. The *transport sector* in which the specific research result applies. Some sectors are more prone to accepting innovation than others.

As regards the limitations of our analysis, we can first refer to the measurement of our dependent variables. Asking respondents to report on innovation impacts with reference to a specific project may be considered as a "limitation" as the one specific project of reference may not be a very representative one. This was judged as necessary in this phase of the work so as to not confuse the respondents and create other types of inconsistencies and bias as well as refusals to cooperate as asking them to refer to more than one reference projects would increase the time necessary to answer the questionnaire to prohibitive levels. Another limitation was, perhaps, the number and type of dependent variables used i.e., the *product* and *process* innovations that result from a research project. It may be argued that differently formulated dependent variables might result to more direct relationships and correlations with the independent variables (influencing factors). However, the aim of this study was to examine the direct innovation impacts that organizations realize from their participation in collaborative (transport) R&D projects and these two dependent variables were the most likely to be better understood and quantified.

The findings of this research are promising and can be useful in forming policies that would increase the value of public funding for research through more implementation of the research results and creation of innovation. The relevant actions must be taken when planning the work-program of the research and setting the rules of operation (i.e., its terms of reference). The relevant public bodies could utilize the above findings also in forming the (research) proposal evaluations criteria as well as the terms of the research contracts.

Conflict of interest statement

The authors declare no competing financial interest.

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