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ASSESSING THE IMPACT OF LARGE RESEARCH PROJECTS

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Abstract: Assessing the actual impact in the context of research projects constitutes a major challenge from the management point of view. Especially in large scale cooperative projects, an appropriate management can help to ensure the achievement of the objectives. However, the question of whether the initially expected impact is achieved or not remains open. In this paper, we discuss how to deal with this and introduce a methodology for the assessment of impact in research and innovation related projects. The methods discussed are illustrated with the example of the impact study performed in the project 3D-LightTrans.

Keywords: impact, research, innovation

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Introduction

Assessing the real impact in the context of research projects in general, but very especially in European cooperative research, is not only a key issue, but also a major challenge from the management perspective. Contrary to development of engineering projects, where the expected output is to a large extent known in advance, research is often characterized by a wide range of possible answers to an initial question. Especially in the case of high risk-high gain projects, investigation on scientific questions can easily lead to a relative large degree of uncertainty, which makes difficult to predict the actual project impact. As a consequence, the statements on expected impact, which research funding bodies commonly request the applicants to provide, can only be an estimation based on a number of assumptions (e.g. by estimating how many products will be sold worldwide incorporating a given research result – or how many persons will benefit each year from a given resulting process). Indeed, the impact is often only considered at this phase and, once the proposal is approved for funding, no further follow-up is done on whether the impact is achieved or not-nor on how to influence it.

The management of European co-operative research projects involves frequently the follow up of progress, risk assessment and deployment of contingency plans. Nevertheless, this is mostly oriented solely to the monitoring of the degree of achievement of the project objectives, and not to the actual impact that the project will generate. The project objectives are often quantified either in terms of an increase in accuracy, degree of miniaturization, speed, repeatability, efficiency, or in terms of decreased complexity, size, energy consume, etc. referred to a specific target process, system or prototype device. In other cases, the objectives refer to finding a solution to a specific scientific problem, or being the first ones in demonstrating a technological possibility. Especially in large scale cooperative projects, an appropriate management can help to ensure the achievement of the objectives.

However, the question of whether the initially expected impact is achieved or not remains open. As a matter of fact, the impact is not only affected by the degree of achievement of the project objectives, but also on the evolution of many other aspects of technological, economic, social and environmental nature. The project might fail to achieve the expected impact, for example, as a consequence of the emergence of competing technologies based on different approaches, new standards that might influence the acceptance of the research results, the protection of intellectual property rights through external parties leading to a limitation of the rights of the Consortium's to exploit their newly developed technology, etc. It becomes therefore crucial to assess and review the foreseen impact of the project during the whole project duration, with independence of the monitoring of progress towards achievement of objectives.

Scope, purpose and targeted audience of an impact study

Scope of an impact study

In an impact study research is done on a certain topic to determine if a certain action would, or is, having some sort of an effect on its environment or other related issues. A similar, more specific and much more frequently used term, is "impact assessment". The International Association of Impact Assessment (IAIA) defines impact assessment (IA) as the process of identifying the future consequences of a current or proposed action (*What is Impact …*, 2010).

The oldest, most well-established aspect of IA, is Environmental Impact Assessment (EIA), which is defined by IAIA as "the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made". In this context, impact analysis (the process of identifying and predicting the likely effects of the proposal) and environmental impact statement (the final report documenting the impacts, proposed measures for mitigation, significance of effects and others), are defined as a part of the EIA process. Impact assessments can also cover social, economic, health, cultural and biodiversity aspects, among others. The expression Integrated IA is sometimes used when different forms of impacts are covered, whereas the term Sustainability Assessment is also used by some professionals, referring to the integration of the environmental, social and economic dimensions of assessment (*What is Impact …*, 2010; *Principles of Environmental …*, 2013).

Purpose and targeted audience

Irrespective of the topic under investigation and of the chosen nomenclature, the first step in any impact study or assessment is to define its purpose and scope.

Generally speaking, the aspects covered, level of detail and scope of an IA depends strongly on the topic subject to analysis, the institution or body preparing it and the objectives pursued. For national or European legislation initiatives, the impact assessment can give decision-makers evidence regarding the need for an action and the advantages and disadvantages of alternative policy choices. In the humanitarian sector, impact assessment can be concerned with making judgments about the effect on beneficiaries of humanitarian interventions, and constitute an integral part of Monitoring and Evaluation frameworks (*Handbook for Monitoring ...*, 2002). Impact analysis of commercial goods and services is often done in the context of economic and environmental sustainability, but it can also include social and socioeconomic sustainability aspects, as discussed in (Benoit, Mazijn (eds.) 2009, p. 33-42). IAs for commercial products and services may give evidence for suppliers, manufacturers and service providers in favor of a given procedure, specific choice of material and product properties, manufacturing technology and process location, among others.

The assessment of impact in publicly funded research projects may have aspects in common with one or more of the impact study types discussed above, but also has many distinguishing aspects. In the light of this, within the scope of research and innovation related projects, we define purpose of this study as follows:

– To inform decision making and result in appropriate levels of economic benefit, environmental protection and community well-being. Decision makers can be: a) persons at a higher management level within the participating companies, b) potential customers and c) other stakeholders. Within the participating companies, the impact study is expected to provide sufficient, reliable and usable information to plan in which way to go ahead with the exploitation of the project results. It can also help in the planning of additional research activities or to decide whether the technology should be modified or applied to other products in a future. Potential customers are provided with arguments to make informed decisions on the appropriateness of the developed technology for a specific product, depending on the specific requirements, economic constraints and environmental aspects. Other stakeholders (e.g. technology platforms, public authorities and funding bodies) can take the impact study results into consideration when drafting research programs or developing technology roadmaps, for example.
– To provide a tool for project monitoring and evaluation by the project consortium itself and report to the funding authority on the progress towards the project objectives and their associated expected impact. The impact study results in an iterative and adaptive process, which can be adjusted to the reality of the research results. It can also be adapted to take into consideration the evolution of other relevant technologies, normative or other issues appearing during the life-time of the project, which may influence in the project impact. The process should result in information and outputs which assists the consortium, if necessary, with problem solving and may consider the development of mitigation measures to avoid negative impacts, as well as the monitoring of their efficacy.

– To supply information of interest to communicate with the general public, providing arguments which justify the advantage and usability of the research results. The purpose is both to increase awareness and to demonstrate the benefit of the work funded with public funds (ultimately paid by the tax-payer).

Methods

General methodology

There is no standard methodology which can be universally applied to assess the impact of any science and technology research project. In the following, we propose an ad-hoc methodology which makes use of elements commonly applied to the different types of impact assessment discussed in the previous section. The methodology proposed pulls data from all appropriate sources and looks at all aspects of relevance. Its main process steps are described next:

1. Scoping – to identify the issues and impacts that are likely to be important and the level of detail required and to define the alternatives against which the project results will be compared.
2. Use of research and performance indices or indicators as the project evolves. The indicators are computed from the comparison between baseline data at a given point of time and baseline data previous to the project (initial baseline), in order to assess the degree of project progress resp. of achievement of goals. This information will be crucial to estimate the real technological impact of the results achieved. The specific data assigned to the indicators are calculated using the most appropriate method on a case-to-case base (e.g. laboratory testing of material samples, manufacturing chain simulation results on the base of a hypothetical scenario, nominal values for machine performance provided by the equipment manufacturers, etc.)
3. Collection of additional information from literature review, expert opinions, available databases, feedback from other project tasks (LCA, marketing) and other sources. This provides relevant background information and additional input data for establishing comparisons with other state-of-the-art technologies and for providing a holistic view.
4. Impact analysis – to identify and predict the likely effects of the project results in the technology, environment and economy, and to evaluate the importance of the findings. This analysis is done on the basis of the information retrieved and collected in the previous steps.
5. Mitigation and impact management (if applicable), proposing measures to prevent or minimize adverse impacts or any obstacles detected which could hinder the fulfillment of the expected impact.
6. Preparation of the report. Final conclusions are drawn and the main statements on the project impact are listed in the final report.

The techniques to be used in the second and third phase have been selected after evaluating different types of techniques applicable in impact studies. A complete list can be found in (Canter, Sadler 1997, p. 4-5) and includes, among others, case studies, checklists, expert systems, indices or indicators, laboratory testing and scale models, literature review, matrices, monitoring, qualitative and quantitative models (conceptual), risk assessment, scenario building and trend extrapolation. In the following, we will introduce some of the methods and tools used for impact assessment, illustrating them with.

Indices or indicators and monitoring

Quantitative and qualitative indices or indicators can be used to measure the results and progress of a project as it evolves. In research projects, research and performance indicators may be defined in such a way as to enable an assessment of the degree of achievement of the impacts associated to the program objectives. For example, in the service contract "IEE Project Performance Indicators" (EACI/IEE/2011/001), impacts are defined as identifiable changes which demonstrate the extent to which the project activities have an effect on the target group, and can take place during its lifetime (specific or short term impacts) or beyond its lifetime (strategic or long term impacts). The use of performance indicators is recommended to determine the success of the project in reaching its objectives and creating energy related impact. In the case of this program (Intelligent Energy Europe), the Common Performance Indicators were defined as the sustainable energy investments triggered, renewable energy production, primary energy savings, and reduction of greenhouse gas emission (*Guidelines for the Calculation …*, 2013, p. 4-5).

In other projects, research and performance indicators are stated in terms of percentage of reduction, degree of improvement, grade of enhancement, etc. of the actual values (measured at a specific point of time) of technology related baseline data in comparison with the initial baseline (baseline data at the beginning of the project or value known or estimated for state-of-the-art comparable processes). For example, the baseline data defined in the 3D-LightTrans project in order to provide measurable means to assess the work progress (Almansa 2016, p. 133-140) were stated in terms like processing time and yarn displacement, among others. The initial baseline (where the project work starts), and the corresponding value of baseline data to be determined at a specific point of time for assessing the progress in the project, were obtained from diverse measurement objects at the different stages of the project lifetime, namely:

a) Different test pre-forms, during the development phase.
b) Final demonstrations objects (a spare wheel well and a tailgate), during the demonstration phase.

Impact in the innovation capacity

From a broader perspective, research and innovation programs seek as ultimate impact not only the emergence of individual breakthroughs and innovations, but a global improvement of the innovation capacity, as a key to the promotion of economic and social development. A. López-Claros and Y.N. Mata have defined the Innovation Capacity Index (ICI), a tool for assessing the extent to which nations have succeeded in developing a climate that will nourish the potential for innovation. Such an index is intended to allow policymakers and entrepreneurs around the world to examine the broad range of country-specific factors which underlie innovation capacity, creating a quantified framework for formulating and implementing better policies for the creation of an environment supportive of innovation (see *Figure 1* – below) (López-Claros, Mata 2010-2011).

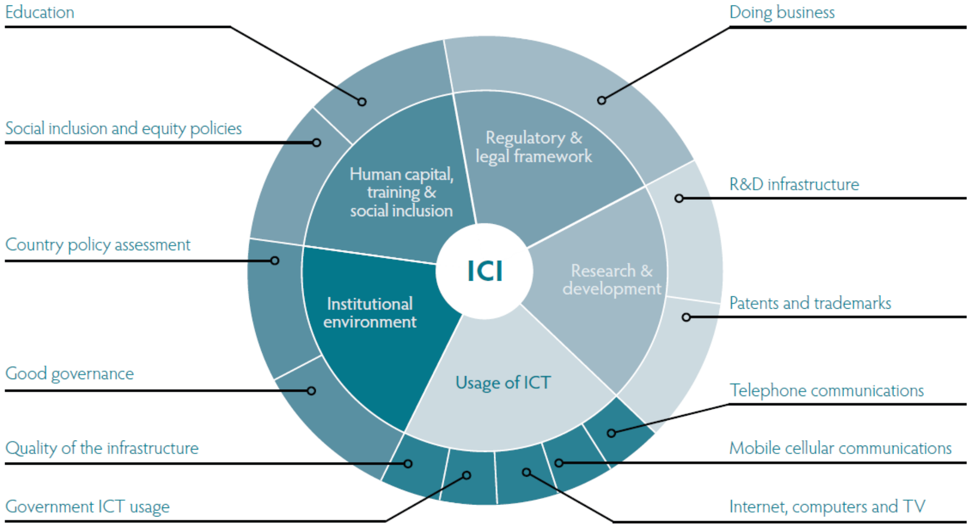

Figure 1. The innovation capacity index (A. López-Claros, Y.N. Mata)

Source: (López-Claros, Mata 2010-2011, p. 18)

Depending on the nature of the distinct types of research and innovation related project, different dimensions of the innovation capacity are more or less relevant. For example, research and training projects in the frame of publicly funded project address both Research & Development, on one hand, and Human capital, training & social inclusion, on the other. The impact assessment of the project must therefore address also the impact of the training activities in enhancing the human capital. In the long term, this is directly related to the competences acquired through training and to the professional path to be pursued by the persons trained. Such impact can be maximized by developing a research training program of “targeted competence building for efficient professional development in science and research”, an original concept proposed by the author of this paper whichleans on example of the human resources information and management system developed for the competence assessment of Bulgaria’s workforce (http://en.mycompetence.bg).

Technological and impact

Large research collaborative project often do not only involve a unique technological or innovation result, but encompass a wide range of developments.

The aimed progress beyond the state of the art is normally defined in the project objectives. Nevertheless, the real technological impact of these developments depends actually on their potential to serve as a basis for enabling further developments. This can be easily illustrated in the case of the already mentioned 3D-LightTrans Project (http://en.mycompetence.bg; Almansa et al. 2014b) a large scale cooperation project which was awarded with the JEC Innovation Award 2015 (a top level innovation programme created in 1998 to reward outstanding companies and their cooperation partners for the excellence of their composite innovations) in the Reinforcements category. Within a project of 4 years duration, 18 scientific and industrial partners joined efforts to develop a manufacturing chain for low-cost high performance composites. The major impact of this project was directly related to the introduction of thermoplastic textile reinforced composites as a viable alternative for low-cost manufacturing of structural parts in the automotive sector (see *Figure 2* – below).

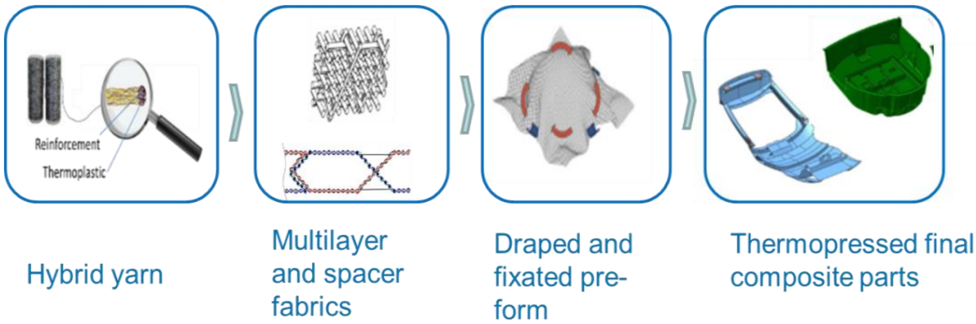

Figure 2. 3D-LightTrans innovative manufacturing concept for thermoplastic textile reinforced composites

Source: (Almansa et al. 2014a, p. 230-234)

However, although the main aim of this project was to develop a manufacturing chain for low-cost high-performance composites, the individual breakthroughs attained in several technologies led to significant progress and exploitation opportunities also in other applications going well beyond the originally foreseen manufacturing chain. For example, the main outcome of a work package specifically devoted to modeling and simulation was a comprehensive simulation toolbox covering in a holistic approach the whole manufacturing, process related, material and product simulation aspects of the textile reinforced thermoplastic composite technology developed. This result has a large potential impact in the up-scaling capability for industrial manufacturing. Indeed, this tool might be used as a basis for easing the redesign of the entire automotive supply chain with regards to materials, product design, and process design, which is a vital need and one of the major challenges which contribute to hinder the wide-spread introduction of composite materials in the automotive sector.

The project also delivered two modified weaving machines for producing 3D-shaped textile structures, creating an impact which goes well beyond the originally foreseen applications with the hybrid yarn (combining glass and plastic) developed in the project. This impact is clear from the fact that the breakthrough achieved (capability for industrial production of more complex weave architectures and thicker fabrics with a large degree of flexibility, keeping reduced fiber damage and guaranteeing highest quality final product quality) is theoretically not limited to its use with the hybrid yarn developed in the project. Similarly, the draping, fixation and consolidation processes developed in the project encompass a range of technological developments in the fields of robotics and material processing which have an impact on its own, as the knowledge generated can be further transferred to new processes and applications.

Life cycle analysis (LCA) and carbon footprint

Product environmental life cycle analysis (LCA) is used for identifying and measuring the impact on the environment of industrial products, including not only the effect on climate change, but also other impact categories, such as acidification potential and ozone depletion potential (*Carbon Footprint …*, 2009, p. 1-2). This kind of EIAs consider the technological activities used for various stages of the product life: from the extraction of raw material for the product and for ancillary materials and equipment, through the production and use of the product, right up to the disposal (or recycling) of the product, the ancillary equipment and material. On the other hand, a Carbon Footprint – also called Carbon Profile – is an LCA with the analysis limited to carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions (e.g. methane, laughing gas, etc.) (Berners-Lee, Clark 2010).

In order to provide an insight into the implications of this type of study, we will illustrate it with a very basic and rough analysis for the specific case of the 3D-LightTrans project. Concerning the energy and carbon footprints, we will consider both the contribution to the footprint of both car manufacturing and car service. Using known data on industry emissions by sector, we reach for car manufacturing a footprint of 720 CO2 per £1000 (around 17 Tons for a Ford Mondeo with medium specifications). Of this amount, 33% corresponds to metal extraction (for a Ford Mondeo with medium spec., 5,61 Tons). A second major contribution to the car manufacturing footprint is related to the gas and electricity used by the automobile industry itself, including all the component manufacturers as well as the assembly plant, and it accounts for 12% (around 2 Tons for a Ford Mondeo with medium spec) (*Carbon Footprint …*, 2009). The 3D-LightTrans technology has some aspects that could decrease the manufacturing footprint of cars in several ways, e.g. by reducing the footprint associated to obtaining raw material, by using lower temperature processing (in comparison with metals) and avoiding the need for low temperature storage and transport of pre-forms (in comparison with thermoset composites). However, other contributions would add on in the energy consumption balance, like those of the fabric weaving and automated draping. Therefore, the environmental impact considering only this aspect might not necessarily account positively.

However, the environmental impact of the project is also related to the abatement of CO2 emissions through vehicle weight reduction, which is a key aspect justifying the large potential of composites in supporting long-term development of the automotive sector, according to (*Overview of the Worldwide …*, 2011).

Using yearly average data for passenger vehicle (cars, minivans, pick-ups, vans and SUVs), we come to an average footprint of 0,1954 Kg CO2/Km (*A Carbon Conundrum …*, 2014). Assuming 100.000 Km/vehicle, this means 20 Tons CO2 per vehicle during its entire lifetime. The reduction of the mass of a single structural component in 2 Kg. using 3D-LightTrans technology would mean, if we assume a linear relationship between CO2 exhaustion and the vehicle's weight, a decrease of the order of 32 Kg. CO2 per vehicle for its entire lifetime. If component is integrated in only one thousand part of the cars produced in a single year throughout the word, this could lead to a reduction of CO2 emissions of between 1.000 and 2.000 Tons. Further, if the 3D-LightTrans technology is generalized and used for manufacturing other components, in the long term we could be speaking of an abatement of many thousands Tons CO2.

Economic impact

Market studies and business cases are good tools to obtain an accurate analysis of the expected economic aspects. From a general point of view, in order to gather a comprehensive perspective, different perspectives need to be taken into consideration. In the case of the 3D-LightTrans project, this involved, for example, the issue of the material costs, manufacturing costs and added value.

Concerning material costs, if we consider the indicator price/strength, compared for different materials, we can conclude that glass/polymer materials composites constitute a very cheap option in comparison both with steel and with other light-weight solutions. However, the mechanical behavior of glass/polymer based composites is generally speaking worse, which restricts the range of potential applications of this material in transport. With the 3D-LightTrans technology, we achieve an improvement of the properties of the glass-thermoplastic composite which brings it to the level required by structural automotive components. In this way, our technology can comply with the needs of products which required till now the use of more expensive materials, in order to become lightweight. To provide an idea of the potential economic impact, we assume the price of a glass-carbon-epoxy composite could be reduced in 75% if it was produced in glass/PET using 3D-LightTrans technology. For an automotive component with a medium to large volume of parts manufactured per year, this could lead to annual savings in the order of magnitude of several millions.

Manufacturing costs play also a key role. Improved properties of glass/plastic composites can be achieved with different processes, from braiding or conventional weaving with autoclave to structural reaction injection molding (SRIM). However, the production costs and/or required investment are higher than with 3D-LightTrans.

The economic impact can also be related to the added value which the new technology brings. In the case of 3D-LightTrans, by enabling the manufacturing of more complex structures in one piece (e.g. by weaving thicker textiles instead of using sandwich structures with thin fabrics) the material properties can be significantly enhanced. The use of automation for draping will lead to higher repeatability and an increase in quality. Another example of added value is the potential to extend the functionality of the parts produced with the 3D-LightTrans technology, e.g. by integrating cabling or ventilation channels within parts made with spacer fabric. The increase in added value has also direct economic implications, since components can be sold with a larger profit margin and/or the number of customers can increase significantly.

Conclusions

In this work we have presented an ad-hoc methodology for assessing the impact or research and innovation related projects. We have also illustrated it by providing an insight into some of the results obtained within the project 3D-LightTrans, a research project devoted to the development of a manufacturing chain for low-cost, high performance automotive composite parts. The paper shows that the proposed methodology is appropriate for the different impact dimensions, including technological, environmental and economic impact.

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OCENA EFEKTÓW DUŻYCH PROJEKTÓW BADAWCZYCH

Streszczenie: Ocena rzeczywistych efektów w kontekście projektów badawczych stanowi duże wyzwanie z punktu widzenia zarządzania. Odpowiednie zarządzanie może pomóc w osiągnięciu celów, zwłaszcza w przypadku wspólnych projektów na dużą skalę. Otwarta pozostaje jednak kwestia, czy pierwotnie oczekiwane efekty zostaną osiągnięte. W niniejszym opracowaniu rozpatrzono sposoby radzenia sobie z tym problemem i wprowadzono metodologię oceny oddziaływania w projektach związanych z badaniami i innowacjami. Omówione metody zostały zilustrowane na przykładzie analizy oddziaływania przeprowadzonej w projekcie 3D-LightTrans.

Słowa kluczowe: wpływ, badania naukowe, innowacje