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Results assessment and impact creation in collaborative research—An example from the ECOLEAD project

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Abstract

Assessing research progress and results in collaborative projects is a rather difficult subject for which there are no clear effective methods, and yet researchers are accountable to their funding sponsors. Based on some experiences with European projects, this paper contributes to the discussion of assessment methods and their limitations in the case of collaborative projects. The impact creation process is also analyzed and linked to the assessment process.

Keywords: Impact creation; Research assessment; Collaborative networks; Collaborative research

1. Introduction

During last decades a considerable investment has been made in collaborative research in Europe. As a result of the research programmes of the European Commission (EC) the pattern of the research process fundamentally moved from isolated excellence groups and large regional heterogeneity to a strong network based cooperation with higher opportunities for all independently of geographical location. The quality of most research groups clearly increased thanks to the international exposure. Much stronger links between academia and industry were established, creating a dynamic breeding environment for collaboration research.

Doing research in a collaborative framework, involving actors with very diverse goals, working methods, and cultural background brings an added dimension of complexity, in addition to the challenges of the research subject itself. The success of any collaborative project depends, to a large extent, on the effectiveness of the coordination principles and the established operational mechanisms for monitoring and assessment. This is even more delicate in the case of large collaborative projects due to the size of the consortium, comprehensive scope, and geographical and cultural diversity of partners.

When it comes to assessment of research projects, most methods and metrics were developed with the focus on activities being carried out by a single group/organization. There is a need to better understand the characteristics of the collaborative research process in order to design methods and metrics that better fit this reality. The notions of impact and effectiveness of research taking place in a distributed multi-organization context clearly need a different understanding.

This article intends to be a contribution to a better characterization of the impact creation process in collaborative research projects.

2. Evaluating research

Research is the driving force of modern society. To a great extent the quality of research determines the future. Clearly a society that aims to play a leading role needs to not only invest on research programs but to also carefully monitor progress and assess the impacts of the various research initiatives.

Evaluating research is however a difficult subject for which there are no clear effective methods, as recognized by many authors. In fact the impact of research may not

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occur until years later. This is one of the reasons R&D is often treated by companies as a "cost generating" center. The created impact also depends on a number of external factors not under control of the research community. Therefore, to evaluate an R&D initiative we should mainly measure the creation of capabilities and the capacity produced or induced by research, i.e. the potential for creating impact.

But what is the purpose of evaluating a research project? Assessment is not only a way to ensure accountability, but also an instrument to help projects keep on track. In this sense, and specially in the case of a joint investment initiative, like the EC funded projects in which resources come both from an EC grant and partners own investment, experience shows that it is very important to devise evaluation methods that are constructive rather than punitive (McEachran and Askew, 2001). In other words, research evaluation shall be a process that tries to give valuable indicators to the project coordination, namely in terms of assessment of directions and practices, and to create incentives and challenges for the participants to excel and continuously strive for innovation. A proper assessment can also be a way to identify additional added value that the researchers did not identify at first (McEachran and Askew, 2001). In this context, an evaluation process that would only convey a punitive message, even unintentionally, would be rather inappropriate and may even cause the risk of expensive disruptions and a potential unsuccessful end.

Europe continues to loose ground in comparison with the USA and Japan. In fact the 2003 edition of the European Innovation Scoreboard, confirms that—on almost all measures for which comparable data is available—the EU's innovation performance remains significantly weaker than that of the United States (Baglieri et al., 2001). This problem is not only due to the amount of the investments and directions of strategic research programs but, perhaps to a large extent, this is also due to the traditional monitoring/assessment methods being used. These methods have been, in most cases, driven by an immediate, short-term economic perspective which, very often, seems to lack attention to the research dynamics and R&D impact creation processes, and thus not in the spirit of risk taking, what is inherent in research leading to innovation.

As pointed out by Mr. Brinkhorst, the Dutch Minister of Economic Affairs, in the informal Competitiveness Council in Maastricht (Cordis, 2004): "in the USA everyone understands that when someone takes a risk, there is the possibility of failure, while in Europe if we take a risk and fail we are almost criminalized". It is interesting to note that all EC funded projects claim to be very successful. It is almost impossible to ever listen to lessons learned with some failures in these projects. We need to change the mindsets in Europe towards more innovative approaches, being able to accept and also learn from failures that are inherent to risk taking.

As presented, this forced image of "full success" is totally in disagreement with a common view of the "funneling" process represented in Fig. 1.

According to this traditional view, it requires hundreds of research projects in order to end up with one successful development which results in effective commercial exploitation. It shall, however, be noted that this view is too reductionist as it ignores and does not present a large number of other results and impacts that surrounds these efforts, e.g. the increased level of knowledge and experience, training of higher quality human resources, new ideas for other developments, creation of links among organizations, etc., which are also indirect impacts and drivers for economic development.

Furthermore, it is important to note that research often goes beyond the anticipated boundaries, resulting in new directions. In other words, not all results come from systematic planning as in traditional engineering. In research there is an element of "trial & error and unpredictability" that needs to be respected and valued.

A discussion of these issues becomes particularly relevant when Europe, through its sixth Framework Program, is focusing on larger projects, the so-called Integrated Projects, with the ambition of having a large impact on selected target areas. In the case of the Integrated Projects, which typically involve around 20 partners each and represent a substantial investment both

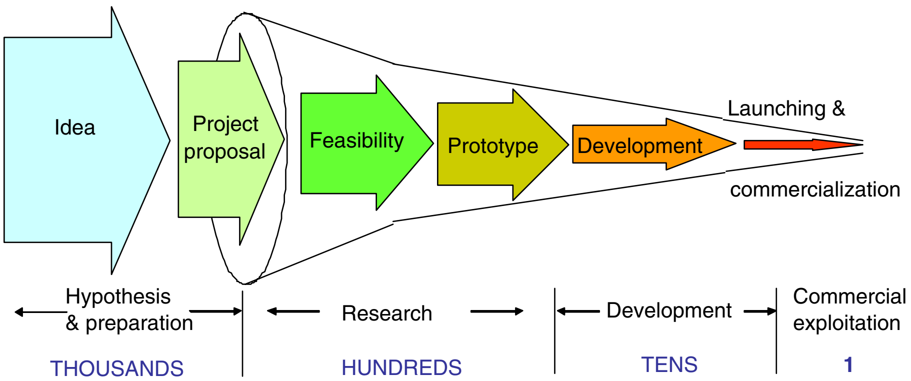


Fig. 1. From research ideas to commercial results.

from the society and from the participating organizations, it is very important to establish criteria and mechanisms to evaluate their progress and results. On one hand researchers are naturally accountable to their funding supporters, and on the other hand feedback is a fundamental mechanism in guaranteeing such a complex system properly pursues its goals without loosing track.

ECOLEAD is an Integrated Project funded under the 6th Framework Program and aims at creating necessary foundations and mechanisms for establishing an advanced collaborative and network-based industry society in Europe (Camarinha-Matos et al., 2005). The ECOLEAD vision is that in ten years, in response to fast changing market conditions, most enterprises and specially the small and medium size enterprises (SMEs) will be part of some sustainable collaborative networks that will act as breeding environments for the formation of dynamic virtual organizations. Collaborative networks of organizations provide a basis for competitiveness, world-excellence, and agility in turbulent market conditions. They are expected to help SMEs to identify and exploit new business potential, boost innovation, and increase their knowledge. Networking of SMEs with large-scale enterprises also contributes to the success of the big companies in the global market. Reinforcing the effectiveness of collaborative networks, mostly based on SMEs, and creating the necessary conditions for making them an endogenous reality in the European industrial landscape, are key survival factors.

The fundamental assumption in ECOLEAD is that a substantial impact in materializing networked collaborative business ecosystems requires a comprehensive holistic approach. Given the complexity of the area and the multiple inter-dependencies among the involved business entities, social actors, and technologic approaches, breakthroughs cannot be achieved with the incremental innovation in isolated areas. Therefore, ECOLEAD addresses three most fundamental and inter-related focus areas—constituting the ECOLEAD pillars—as the basis for dynamic and sustainable networked organizations including: Breeding Environments, Dynamic Virtual Organizations, and Professional Virtual Communities. Furthermore the ECOLEAD pillars are supported and reinforced by two horizontal developments—a theoretical foundation for collaborative networks and the ICT support infrastructure.

Given the ambitious goals of ECOLEAD it is clear that a well-devised periodic assessment of the project is a crucial contributor to its success. Therefore, in the next sections, we try to contribute to a better understanding of the impact creation process and to introduce mechanisms that can be used to assess research results.

Traditional evaluation methods have been too much focused on a judgment by economic (expected) benefits. In the fifth Framework Program this trend was pushed to the extreme of requiring research consortia to invest a substantial amount of resources in elaborating *fictional* business plans/technology implementation plans that rarely (if ever) had any concrete realization. Very often real innovative results were just overlooked when the discussion was centered on the return on investment (ROI) and the expected market shares or geographical coverage.

Although recognizing the importance of the EC funded programs, the French Academy of Sciences states (FAS, 2004):

> Unfortunately, these positive elements are countered by the weight of an invasive and punctilious bureaucracy, and insufficiently competent or partisan assessment, and excessive bias towards targeted and industrial research, and an absence of ambition against international and, in particular, American competition.

This negative perception of the effects of the traditional assessment methods and criteria is shared by many participants in EC funded projects and also by some reviewers.

This is also a typical criticism from some American colleagues that have studied the European programs, such as Ted Goranson (Goranson, 2004) who is a recognized researcher and expert in the area of Virtual Organizations.

In fact there is a dilemma when performing a R&D project—to focus on the (potential) economic/societal impact or to focus on the qualitative impact (i.e. contribution to innovation and new knowledge generation). A scientific innovation might have a great impact on the existing knowledge without necessarily having an immediate economic impact.

This dilemma is also stressed by the different legitimate goals of the industry and academic partners. When looking for a proper balance between these different goals it is important to have a clear perspective of the high overheads and costly logistics that are inherent to the nature of collaborative research (Wagner, 1998).

Traditionally research is divided into two categories: basic or fundamental research, and applied research. In this context there is a consensus that different assessment methods and metrics are necessary for each category. The useful outcomes of basic research cannot be measured directly during a project execution, as the usefulness of the generated knowledge is inherently too unpredictable. Therefore, for basic research what is meaningful is to "measure" quality, relevance, and leadership, as *predictors* of future usefulness or impact potential. For applied research it is simpler to apply traditional evaluation methods to assess progress towards planned milestones.

However, when international (or multi-institution) collaboration is considered in a R&D initiative, the above categorization is somehow misleading. International collaboration projects are not an effective mechanism for the development of immediately exploitable products and technologies. The large overheads and logistics of collaboration (to cope with cultural diversity, geographical dispersion, diversity of goals, members' autonomy, etc.) can only be compensated when addressing innovative and risky challenges for which diversity and richness of perspectives is a leveraging instrument.

Therefore, another categorization can be considered:

(a) basic or fundamental research,
(b) strategic (risky and innovative) applied research,
(c) incremental, short-term innovation applied research.

Only categories (a) and (b) can make sense in typical European collaborative R&D projects. Category (c) can be more effectively pursued by a single group/organization (even in collaboration with a number of end-users).

Misuse of assessment mechanisms and metrics can lead to obvious negative results. Measuring fundamental and strategic research on the basis of short-term impacts can have an extremely destructive effect on the quality of research.

The very nature of the innovative processes makes measuring performance of research projects difficult. The actual economic exploitation of results depends on a number of factors, many of them external to the project, and it can take some years before impact is actually caused.

3. Methods and their limits

The most typical assessment methods include peer-reviewing and quantification.

Peer reviewing is one of the most traditional assessment methods in scientific research and also a common practice in the EC programs. The assumption is that the people best qualified to evaluate research are those with knowledge and experience to understand the quality and level of innovation of research projects (NAS, 1999).

Evaluating strategic research requires deep scientific and technological knowledge as well as the capability to recognize potential applicability of the results. The panel of experts needs to have significant stature, objectiveness, and perspective to assess the quality and relevance of research (NAS, 1999).

In a broad area such as ECOLEAD, the effectiveness of a peer review depends of having reviewers with a comprehensive and multi-disciplinary knowledge of the state of the art and trends (i.e. qualified as peers). The complexity of an Integrated Project also demands reviewers with a wide and proved experience in coordination of international research projects and a good multi-cultural experience. Although these are tough requirements, if not met there is a considerable risk of not reaching unbiased assessments. This will in turn not only create a sense of unfairness and frustration but also can force the project into not so promising directions.

Nevertheless, when performed by a competent panel of reviewers, following proper and clear set of evaluation criteria, the peer-reviewing becomes a fruitful and very important (if not the most important) instrument to help projects improve their results.

From our experience in the past, it is a good option to have a two level reviewing process:

- *Internal reviewing*, resorting to an advisory board recruited by the project consortium, but whose members are not part of the project, as well as to project members that were not involved in the work being reviewed.
- *External reviewing*, performed by a panel recruited by the funding organization.

This two-stage reviewing provides a better chance to comprehensively cover both the scientific content and the public/contractual accountability aspects. This approach is also consistent with the shared funding model in use in European projects.

The results of a peer reviewing process naturally depend on the expectations and commitments, and therefore a clear set of milestones and key results shall be planned upfront.

Quantification. Due to the difficulty in identifying the impacts of research, quantitative (and also qualitative) indicators have been developed as proxies to assess research results (Li, 1997).

Some examples of the most common quantified measurements are:

- publications and citations,
- patents, licenses,
- invitations to committees and boards,
- interactions with other bodies/entities,
- other indicators.

3.1. Publications and citation analysis (bibliometrics)

Counting the number of publications in peer-reviewed channels (journals, books chapters, and high-quality conferences) is a standard indicator of the innovative contribution of a research project. A manuscript is typically published in a good quality channel only when the peer reviewers and the editor consider it to have enough merit. Therefore, this indicator is another form of peer reviewing.

Regarding this indicator it is necessary to take into account the common practices in each scientific discipline. For instance, while in the computer science field a journal paper typically has more than 15 pages, in micro-electronics it is usual to have journal publications with two to three pages. As a consequence, the average number of publications per year and per researcher is quite different in the two communities.

The number of citations a publication receives is usually considered as a reflection of the importance of the contribution or its excellence. As citations are made by other researchers they can be regarded as recognition of merit and thus an extension of the peer reviewing. But there are some well-known difficulties with this metric (Evaluation UK, 1997):

- Collecting citations. In traditional sciences the ISI Science Citation Index is considered the standard reference. However the ISI database does not cover the full range of journals and is quite weak in terms of the emerging areas e.g. related to CNO research. Therefore it is likely that new journals more focused on the ECOLEAD topics are not scanned by ISI. Other databases (e.g. Citeseer, DBLP, RAM) suffer from similar limitations.

- Patterns of publication. Unlike the traditional sciences, it is a common practice in ICT-related areas to publish in peer-reviewed conferences, which are not considered in ISI (unless the proceedings are published in the Lecture Notes in Computer Science series from Springer-Verlag).
- Timescale for citation. It is likely that the peak for citations of publications is between two and four years after the publication. On the other hand it usually takes longer than 1 year to have a paper published in a good journal. Therefore, the actual measuring of citations can only take place after the end of the project.
- Citations are not of equal value. A paper may be cited to recognize its excellence, but also sometimes to reject its arguments.

It is important to notice that the metrics used also change the behavior of people. The dramatic rule of "publish or perish", so common in the academic world and reflecting a purely quantitative perspective, has many negative effects on the quality of work. Therefore a single metric is obviously insufficient.

3.2. *Patents, licenses*

Patents and licenses, as alternative to publications, represent another indicator of the innovative quality of project results. But this indicator cannot be easily used in all branches of science and engineering. For instance, there is still controversy regarding the appropriateness and even possibility of registering patents on software. For some algorithms patenting can be considered as a suitable knowledge protection mechanism. On the other hand the European patenting system is still quite inadequate and geographically fragmented. Knowledge and experience on how to handle intellectual property rights (IPR) is also limited in Europe (European Commission, 2004).

Considering the scope of ECOLEAD and the typology of the expected results (frameworks, models, architectures, prototype systems, guidelines) there is not much "space for patents".

There is also a non-solved conflict between registering patents (knowledge protection) and publishing results (knowledge dissemination). It shall also be considered that patents are more recognized in industry (having an economic factor associated with them), while academic careers very much rely on publications and, in many cases, do not value much patents.

3.3. *External esteem: invitations, committees, boards*

The number of invitations to Program Committees of technical events, participation in technical/scientific boards, etc. (directly or indirectly based on the work of the researcher in the project being assessed) although not an absolute measure can, to some extent, reflect the quality of the results and a kind of "footprint" that may help in tracking impacts of the research.

On the other hand, many of these invitations/participations also depend on the network of contacts (and prestige) of each researcher and his/her availability to participate in such activities. Therefore, this measure needs to be taken just as a complementary indicator.

In addition to the publications in conferences it is also important to notice when a project is involved as *technical co-sponsor* of activities in major (recognized) conferences and workshops (to some extent, but not always, recognition of the merit/prestige of the project).

Other evidence of esteem can be given by the number of plenary addresses/keynotes, honors and awards, editorship, participation in advisory, review, funding, standards and planning bodies.

3.4. *Interactions with other bodies*

Similarly the number of interactions with other national and international projects, particularly those that involve some actual cooperation, as well as the interactions with other bodies (e.g. scientific or technical organizations) can give some qualitative indication of the potential of the project to cause impact.

3.5. *Economic indicators*

Estimates of the economic benefits that organizations receive from the investments in R&D are an important element to help demonstrate the value of the R&D. Assessment methods in this perspective include return on investment, the production function, customer surplus, and increased benefit to industry and society (Jordan and Malone, 2002; DoE, 1999). However the measurement of such indicators is hindered by the long time period between the R&D investment and the final realization of the economic benefit.

A discussion of indicators to be used by an enterprise regarding its R&D strategy can be found in Germeraad (2003). Another contribution is given by the Technology Value Pyramid of the Industrial Research Institute. Nevertheless all these proposals of indicators are tailored to the long-term research strategy of an organization and not to the life cycle of a single project.

3.6. *Customer and user evaluation*

Measuring customer and user feedback is a way to determine performance. However the customer of R&D is not always easy to identify as the outputs of new knowledge go into a general "pool of knowledge". Quantitative indicators can be obtained through web sites, surveys in meetings, etc. Although customer evaluations are typically quantitative, they are also subjective, what makes them prone to a number of sources of bias.

3.7. Human and social capital

One way of looking at research performance is to consider the value of human resources, in particular the "capacity", the ability of groups of scientists, engineers and other researchers to grow and sustain and to make the most of the available talent reservoir (Jordan and Malone, 2002).

One aspect of relevant importance here is the *evolution* of the perceived importance of research results by the different groups in society. For instance, it is interesting to notice that some banks, when deciding on a credit requests, are starting to evaluate companies not only with basis on the traditional assets, but more and more on the "*capital of relationships*" the companies have. Therefore, the number and quality of the new connections a company establishes as a result of a research project is an important success indicator.

3.8. Other indicators

Furthermore it shall be noted that the wide dissemination and implementation of the collaborative networks paradigm very much depends on education and training. Therefore, an account of the *contributions to education and training* is an important indicator of the creation of potential (future) impacts of the project. In fact the education and training of people can be very important legacies of a research project. A country or region cannot really benefit from the advances of a project if a continuous flow of well-trained experts is not maintained (NAS, 1999). One measure of excellence in research is excellence in training.

Another perspective of the *usefulness* of a research project is its *contribution to start new research,* namely in terms of becoming the origin for new project proposals.

Finally when young and dynamic new areas are addressed it is important to consider the contribution to the consolidation/*re-enforcement of a research community* in those areas.

Multifaceted approach. "We become what we measure" (Merrill Center, 2001), therefore it is important to choose the indicators wisely. For instance, it is known that there are cases of organizations that are extremely effective in their "social networking activities" (building social capital), which gives them better access to opportunities (e.g. invitations to consortia) but without actually contributing to the generation of any real innovation or research results. As it has been discussed, the "publish or perish" dilemma has also caused several "deviating" behaviors in the academic community.

Therefore multifaceted approach, combining as many indicators as possible, is recommended. Any qualitative assessment which is based on these multiple indicators has to take into account the limitations/constraints of these measurements. It is also important to consider these indicators in the context of the different phases of the impact creation process.

It is also likely that the process of relating metrics to the goals of a project and phases of impact creation will provide substantial insight into the objectives formation process. In other words, the number and structure of the project goals become clearer once the measurement and impact creation processes are better understood. In fact in order to select an appropriate set of indicators it is important to first identify what are "valuable" results from a research project.

This is particularly important in international collaboration projects where reaching an alignment of views and objectives among all stake holders is quite difficult. Therefore it is advisable that this process is pursued in close cooperation between the project consortium and the funding organization under a constructive perspective and for mutual benefit. Both the consortium and the program managers are accountable for the final results. Therefore, pursuing a principle of co-responsibility is worth trying (without limiting the independence of either party).

Lessons learned. As mentioned above, in a risk taking process, and when examining an innovative approach to solve a problem or trying to reach an ambitious aim, it is possible to discover that the approach is not appropriate or the aim is unreachable in the given time/criteria. Nevertheless, such a result is not necessarily an indication of lack of performance or lack of progress.

In a R&D project the result of a task is negative if and only if no lessons are learned from it in order to improve and to benefit the next steps!

Being overly risk-averse is clearly unwise when the aim is to producing excellence, competitiveness, impact and leadership (Denker, 2003).

As a contribution to change the mindsets in Europe regarding risk taking, it is important to start considering the lessons learned even from failures (including their proper explanation and possible steps to avoid their future occurrence) as a very valuable result of a research project.

4. Impact creation process

As mentioned above, impact creation is typically a process that goes far beyond the time frame of a research project. Before discussing what can be monitored and assessed during the life cycle of a project it is thus important to identify and characterize the phases and actors in the (typical) impact creation process.

Creating impact out of research results is a multi-phase, long-term process. Fig. 2 illustrates some of these main

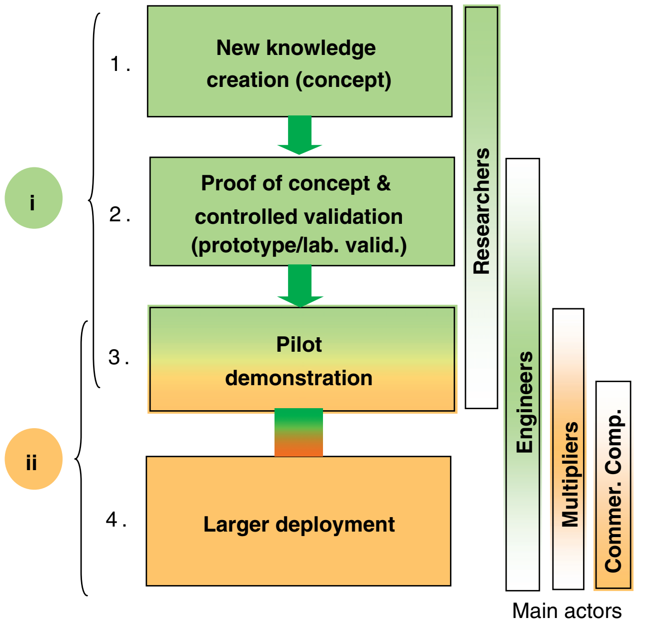


Fig. 2. Main phases in impact creation from research results.

phases. This figure also shows the main actors involved in each phase.

Implicit to this model, there are two main stages:

- knowledge generation/innovation (phases 1, 2, and part of 3), in which the main actors include the researchers and some engineers (for the prototyping and case studies), and
- dissemination and deployment (part of phase 3 and phase 4), in which the main actors include the “multipliers” and commercial companies (supported by engineers, in the case of technology development).

A multiplier in this context is an entity, external to the project, which thanks to its role and position in the society can help multiplying the impacts of the project. Examples of such entities include innovation promotion institutions, regional associations of SMEs, or professional associations. It is not realistic to expect that a research consortium can, by itself, cause a significant impact in the society. Even if good quality results are achieved and if the consortium is composed of organizations from a large number of countries, it is unlikely that such consortium has the resources to create impact at the European level (for instance). This is a persistent myth that is still present in the *ex ante* evaluation criteria used for the European project proposals. A promising alternative is however to establish cooperation links with carefully selected multipliers. With this approach a better use of the competencies of each party is possible and the likelihood of an effective impact on society increases.

Fig. 3 illustrates the main groups in society where multipliers for ECOLEAD have been identified.

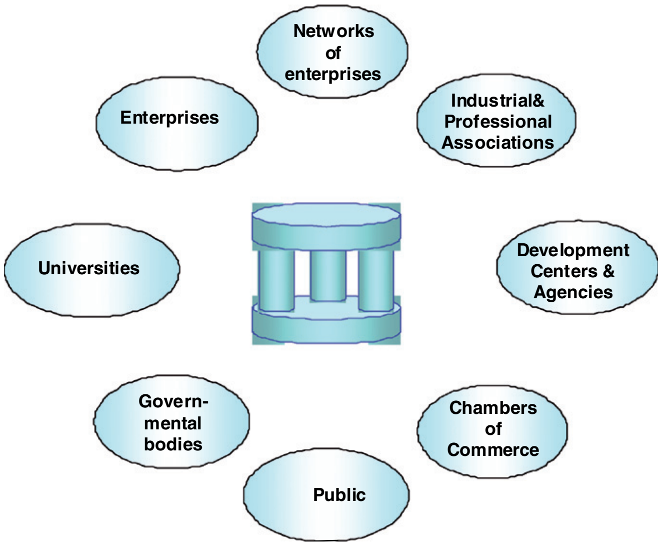


Fig. 3. Relevant classes of multipliers for ECOLEAD.

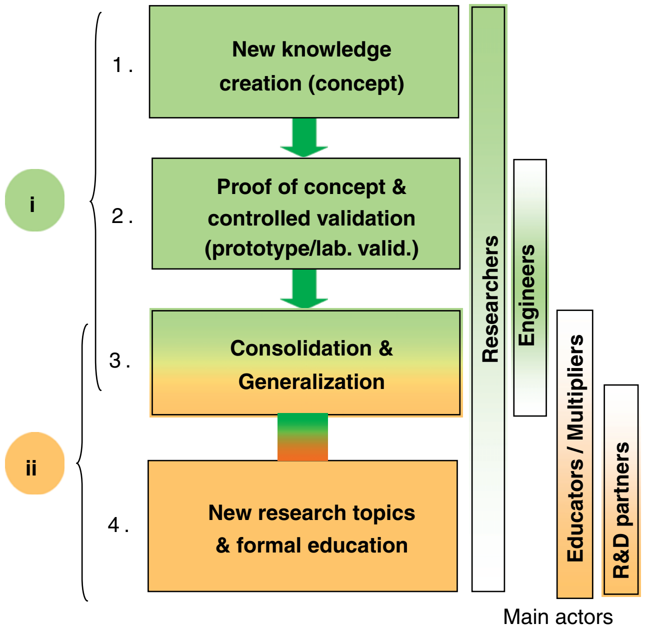


Fig. 4. Impact creation in the research community.

In order for such entities to play this role there is a need to formalize some kind of cooperation agreement with the project consortium. In ECOLEAD this agreement is expressed as a Memorandum of Understanding that specifies under which conditions the multiplier has access to the project’s knowledge and what “multiplication” mechanisms will be applied (e.g. pilot implementations, demonstrations, training events), and how the feedback will be provided to the consortium.

A particular instantiation (or variation) of this process is derived to represent the impact on the research community, i.e. the impact of the project on scientific progress (Fig. 4).

The role of "multipliers" is played here mainly by "educators" and, to some extent, by the R&D planners as well as the decision makers on strategic research programmes. On the other hand researchers are involved in all phases of this process.

ECOLEAD, like any other typical R&D project, covers the first 3 phases of the process and part of the 4th phase (namely in interaction with external multipliers).

Based on this model four main impact assessment phases can be considered:

(a) assessment of on-going (initial) R&D,
(b) assessment of (lab) R&D results,
(c) assessment of "multiplication" process,
(d) "Traditional" assessment of impacts.

Fig. 5 superimposes the two processes of impact creation and impact assessment.

The time frame of ECOLEAD (as well as most other R&D projects) covers only phases (a) and (b) and part of phase (c).

Fig. 5 also illustrates some of the typical "indicators" that can be considered in each phase. For instance, in phase (a) (i.e. early stage of the project) it makes sense to consider: the number of papers in conferences (too early to have journal publications), the number of presentations in qualified events, and the plans for case studies (as an indicator of potential impact), while market (economic) indicators and (full) citations list can only be considered in phase (d).

As implicit in this model, during the initial assessment phases of the general impact (i.e. during the project duration) it is not possible to measure the actual impacts, but rather measuring the creation of capacities and capabilities (i.e. potentials) to cause future impact. While having a good set of "potentials" is not an absolute guarantee of achieving large impacts (please also note that actual impacts will depend on external factors, as well), it is the definite pre-condition.

Therefore, what can be assessed/measured during the project's life cycle is a set of *pre-impact indicators*, i.e. indicators that do not measure impact per se but reflect the "seed" for future impact.

5. Success criteria and mechanisms

The final success of a research project will be judged based on the impact it will create both in the research community and in the society. This is a long-term process as stated in the previous sections. Consequently, the final success cannot be judged during the duration of the project itself. A project consortium cannot guarantee a-priori that revolutionary results will be achieved. However, it shall aim to prepare the bases for sustainable foundations. In a longer run such foundations will likely have an impact. The approach should thus be to identify the mechanisms to create impact. The evaluation indicators should both measure how well these mechanisms are followed and the possible efficiency of these mechanisms. The latter part is difficult to quantify. It has to rely on qualitative measures, which try to ensure that the mechanisms are of high quality

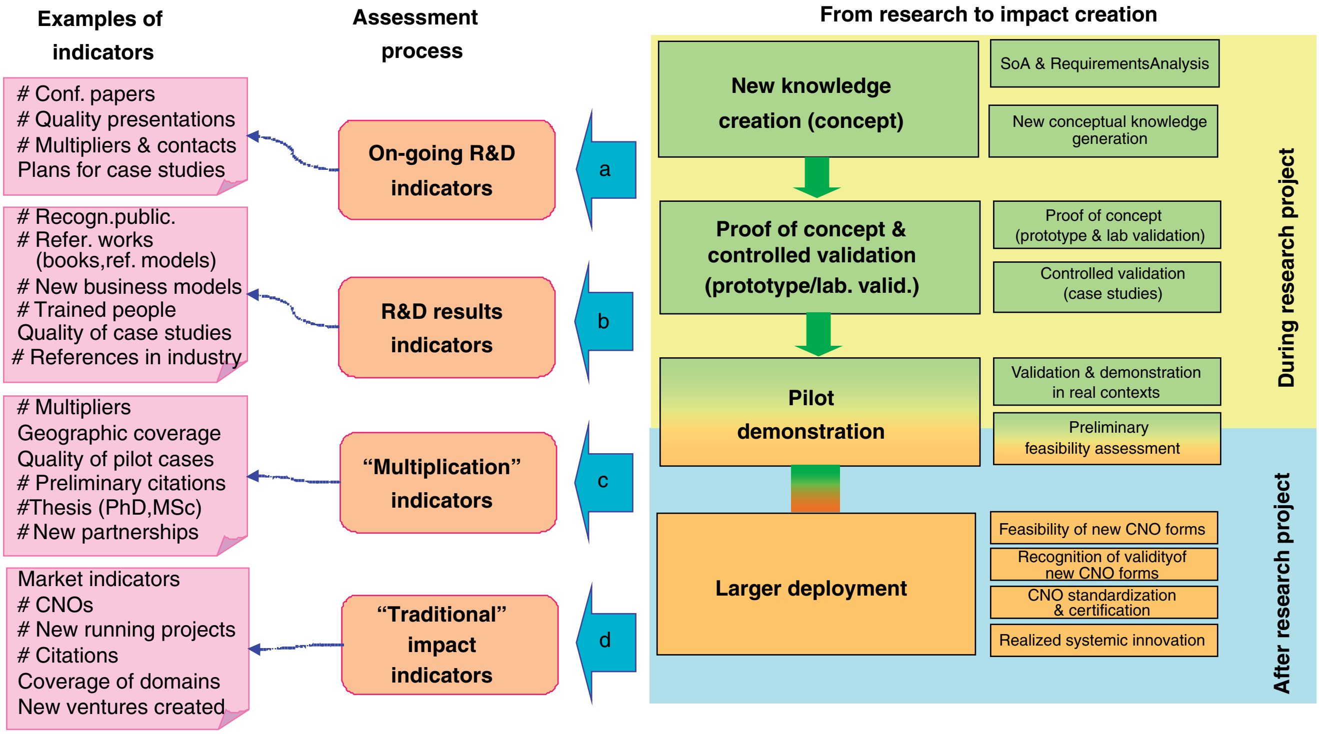
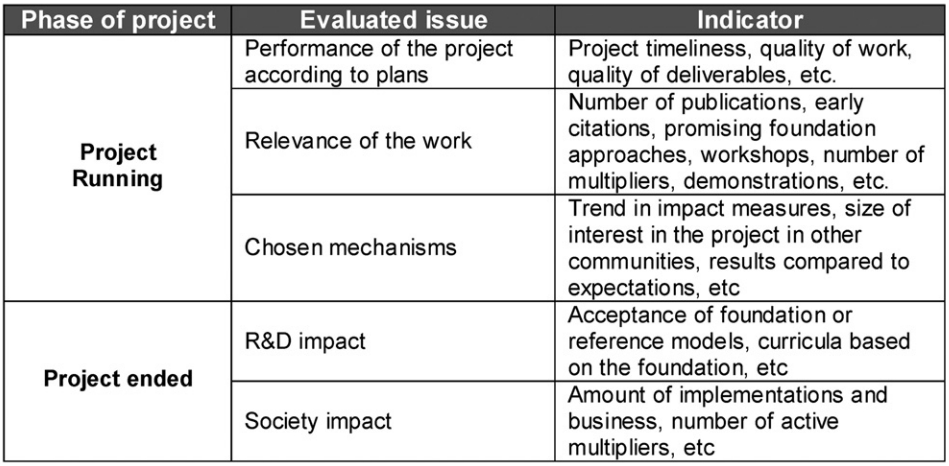


Fig. 5. Impact assessment process and indicators.

Table 1
Research indicators from different "users" point of view

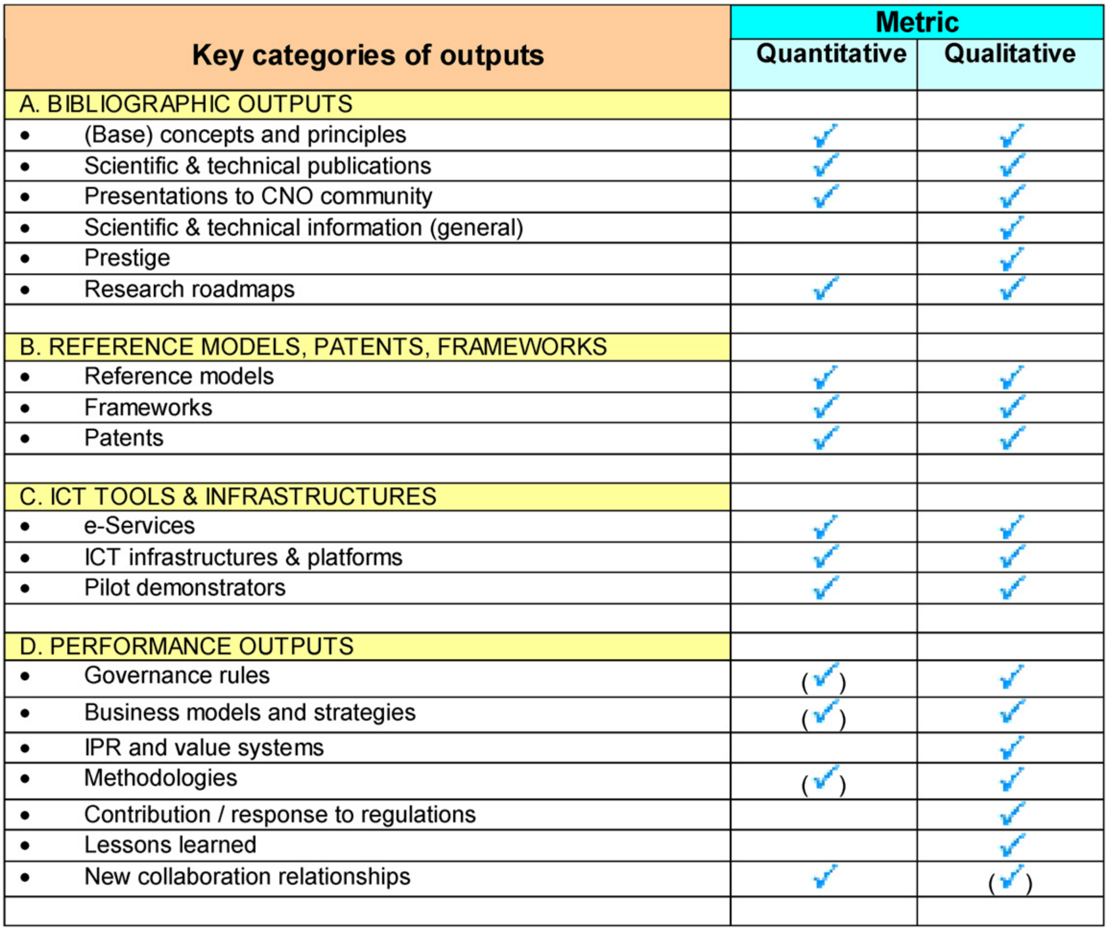
Innovation process		Classes of indicators	Research (success) indicators			
Main phases	Detailed steps		Research & Academic entities	ICT developers & Business entities	Society and policy makers	
1. New knowledge creation	State of the Art and Requirements analysis	**On-going R&D indicators**	# Journal papers # Conference papers Plans for case studies Interactions with related initiatives	# New development ideas # Case studies / scenarios # New CNO-related contacts (customers & developers) Increase in collaboration & networking New organizational & management ideas # Trained people, increased competencies # Internal dissemination actions # Multipliers	# Trained people # People with new capacities # Proposals for new policies	**During ECOLEAD**
	New conceptual knowledge generation					
2. Proof of concept & controlled validation	Proof of concept (prototype & lab validation)	**R&D Results indicators**	# "Recognized" publications # Journal papers # Conference papers # Thesis (ongoing) # Training actions # Invited talks # "Prestigious" participations	Simulated (emulated) solutions Small scale realization of main functionality of prototypes Participation in training # Industry sectors addressed # Multipliers & prospective customers addressed # New business models Size of skilled teams Market size evaluation	# Trained people # People with new capacities # Proposals for new policies Level awareness for CNOs	
	Controlled validation (Case studies)					
3. Pilot demonstration	Validation and demonstration in real context	**Multiplication indicators**	# Prestige publications (journals, high quality conferences) # Books / chapters # Thesis (PhD, MSc) Inclusion in education programs # Preliminary citations Reference models # Trained people # Patents & technology transfer agreements	# Realized prototypes or solutions #Evaluated/demonstrated methods & organization models # New business relationships # Indirect business opportunities found # Trained people Increase in networking (# contacts, interactions) Lessons learned Cost / benefit indicators SWOT indicators ROI estimation # Business plans developed # VBE, VO, PVC addressed Attendance to project events # References in industry publications # Contributions to standards and best practices	# Trained people # References in general media # PhDs and MSc # People registered to the VLC # Multipliers actively involved # People with new capacities Prospects for new businesses # European regions contacted # Interactions with non-European entities and regions	
	Preliminary feasibility assessment					
4. Larger deployment	Feasibility of the new CNO forms	**Traditional Impact indicators**	# Citations # New projects CN established as a new discipline # Trained people # Patents, licenses & technology transfer agreements	# Implemented pilots # New ICT solutions # Engineered frameworks and methodologies Business volume (or its derivative) for solutions from ECOLEAD Increase in networking among ECOLEAD end user partners (# of contacts, interactions, etc) Increase of collaborative support in general # VBE, VO, PVC addressed / created / improved # New technology ventures created # New customers # Marketing leads # Companies and individuals reached	Networking is a natural part of the society Collaboration & networking is supported by the rules and legislation in the society Infrastructure support of connections and interoperability # New ventures created # New / improved CNO-related education programs Leadership in collaborative networks	**After ECOLEAD**
	Recognition of the validity of the new CNO forms					
	CNO standardization and certification					
	Realized systemic innovation					

Table 2
Project phases and corresponding relevant indicators



Phase of project	Evaluated issue	Indicator
Project Running	Performance of the project according to plans	Project timeliness, quality of work, quality of deliverables, etc.
	Relevance of the work	Number of publications, early citations, promising foundation approaches, workshops, number of multipliers, demonstrations, etc.
	Chosen mechanisms	Trend in impact measures, size of interest in the project in other communities, results compared to expectations, etc
Project ended	R&D impact	Acceptance of foundation or reference models, curricula based on the foundation, etc
	Society impact	Amount of implementations and business, number of active multipliers, etc

Table 3
Categories of outputs and corresponding metrics



Key categories of outputs	**Metric**	
	Quantitative	**Qualitative**
A. BIBLIOGRAPHIC OUTPUTS		
• (Base) concepts and principles	✓	✓
• Scientific & technical publications	✓	✓
• Presentations to CNO community	✓	✓
• Scientific & technical information (general)		✓
• Prestige		✓
• Research roadmaps	✓	✓
B. REFERENCE MODELS, PATENTS, FRAMEWORKS		
• Reference models	✓	✓
• Frameworks	✓	✓
• Patents	✓	✓
C. ICT TOOLS & INFRASTRUCTURES		
• e-Services	✓	✓
• ICT infrastructures & platforms	✓	✓
• Pilot demonstrators	✓	✓
D. PERFORMANCE OUTPUTS		
• Governance rules	(✓)	✓
• Business models and strategies	(✓)	✓
• IPR and value systems		✓
• Methodologies	(✓)	✓
• Contribution / response to regulations		✓
• Lessons learned		✓
• New collaboration relationships	✓	(✓)

and have appropriate references. Such judgements can mainly be done by recognized experts active in this research field.

As an example, Table 1 is an attempt to collect relevant indicators in the context of ECOLEAD. It is important to note that the notion of success of a project is perceived differently by each particular group of society that will be a potential "user"[1] of the project results. Therefore the following main categories are considered:

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[1] The term "user" is here considered in a very broad sense as any entity that might benefit or be affected by the project results.

Table 4
Generic outputs from S & T

Generic outputs from Science & Technology	Covered in ECOLEAD	Potential "users"		
		Research & Academic	ICT & Business entities	Society & Policy makers
Science and technical ideas	🟩	✓		
Scientific and technical publications, reports, and citations	🟩	✓		
Intellectual challenges	▨	✓		(✓)
Technical assistance	▨	✓	✓	
Presentations to learned societies	🟩	✓		
Training of scientific and technical people	🟩	✓	✓	
New and improved products, materials, and processes	🟩	✓	✓	
Patents	?		✓	✓
Transfer of technology	▨	✓	✓	
Development of new testing methodologies				
Development of R&D/S&T management practices and techniques	▨	✓	✓	✓
Start-up of new ventures, new companies, establishment of partnership	?		✓	
Development of strategic technology alliances	?		✓	
Development of scientific and technical benchmarks and standards	▨ (reference models)	✓	✓	
Cost-savings in production, product design, and redesign	?		✓	
Increased productivity and utilization of resources	▨		✓	✓
Improved product / process / service quality	▨		✓	✓
Reduced dependence on outside sources				
Facilitator in ability to outsource	🟩		✓	
Savings in materials				
Contribution to maintenance / protection of lead or position in the discipline / industry / market	🟩	✓	✓	✓
Facilitation of use by client				
Contribution to adequate response to environmental and other regulatory pressures				
Contributions to potential adaptability of manufacturing to new processes and methods	🟩	✓	✓	
Contributions to the competitive features of a product or product line	🟩		✓	
Contributions to creation of new market, market segments, and new customers	🟩		✓	
Contributions to technology and business planning, and to the strategic management of the organization	🟩	✓	✓	(✓)
Development, manipulation, and exchange of new knowledge in S&T	🟩	✓	✓	
Provision of scientific and technical information to assist managers in areas such as licensing, mergers and acquisitions, and other activities imbued with content of S&T	▨	✓	✓	
Contributions to institutional memory	▨ (value systems)	✓	✓	(✓)
Contributions to the identification of opportunities and needs for S&T	🟩 (roadmap)	✓	✓	✓
Contributions to improved project selection and resources allocation for S&T and for the innovation process	🟩 (roadmap)	✓	✓	✓
Contributions to sales, profits, and other economic criteria of performance	▨		✓	
Contribution to the perception of S&T by the sponsors of this activity and by the public at large	▨	✓	✓	✓
Increased ability to anticipate and to effectively deal with barriers to application and implementation of results from S&T	🟩	✓	✓	✓
Contribution to expanding the state of the art in S&T	🟩	✓		
Contribution to the prestige of S&T organizations and their impactees	▨	✓	✓	(✓)

🟩 Directly covered
▨ Partially or indirectly covered
? Not known yet
☐ Limited or not covered

- Research and academic entities, which are typically interested in the traditional scientific indicators (e.g. publications, citations, thesis).
- ICT developers and (other) business entities, which are usually interested in the economic aspects (potential turnover), new technologies/products, new processes.
- Policy makers and society in general, which typically focus on general macro-indicators related to structural changes, regulatory issues, and global numbers of affected people and organizations.

The indicators collected in Table 1 are also distributed according to the main phases of the innovation process. As mentioned above, the ultimate impact indicators cannot be measured during the duration of the project.

Clearly, different indicators must be used depending on the issue to be evaluated and depending on the phase of the project. This fact is illustrated in Table 2 below. It is a very rough table indicating the type of indicators needed in each case.

On the other hand the type of metrics—quantitative or qualitative—to be used depends on the specific category of project results (Geisler, 2000), as illustrated in Table 3.

Table 4, which is based on the Geisler's categories of S&T outputs (Geisler, 2000), shows in more detail what are the results expected from the ECOLEAD project and who are the main categories of (potential) users for those results.

As outlined above, the impact creation process involves phases which go beyond the four year duration of a research project. Accordingly success criteria must be linked to the corresponding phases.

The two main areas of activity for impact creation and exploitation planning during the project are the dissemination and the demonstration:

- *Dissemination* is intended to raise awareness on relevance of project activities for societal and economic innovation, thus building the acceptance (and even endorsement in some cases) of the project results.
- *Demonstration* is intended to create confidence in the exploitability of results, in terms of effectiveness of benefits and of actual control of innovation risks.

For the traditional assessment of impacts (exploitation) it should be noted that impact creation and exploitation are intrinsically linked activities, as the correct valorization of project results creates the basis for a future successful exploitation.

6. Conclusions

Understanding the impact creation process in the context of strategic collaborative research initiatives is a crucial element for effective coordination. Some old practices, namely in use in EC programs, are clearly inadequate to promote innovative R&D. Therefore it is necessary to further invest on conceptual and exploratory work on this issue through collaboration among all stakeholders.

As a contribution in this direction, this paper introduced a model of the impact creation process for collaborative research projects and suggested a number of assessment steps with performance indicators fitted to each phase of the process.

On the other hand, besides the quality of the research results, impact creation very much depends on three main factors:

- Investing on "foundational work", i.e. producing results that can be re-used by others. The coordination principles adopted in ECOLEAD are more focused on the "results" rather than on the activities. Truly "foundational results" are the ultimate goal.
- Using proper communication channels, focused on the target communities. In terms of dissemination it is important to clearly distinguish two main directions: "business-related dissemination" (for companies, industrial associations, other social bodies), and "scientific dissemination" (for the research community). These two dissemination directions address different audiences, requiring completely different channels and approaches.
- Establishment of cooperation agreements with external entities that have the capability to act as impact multipliers.

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