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Article (Submitted version)
(Pre-refereed)

SEQUOIA: A Methodology for the Socio-Economic Impact Assessment of Software-as-a-Service and Internet of Services Research Projects

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Abstract

A methodology for the self-assessment of the socio-economic impact of Software-as-a-Service and Internet of Services research projects is presented in the context of EU-funded research. The SEQUOIA methodology was developed by assessing thirty existing projects with their close collaboration. This process was documented to provide a basis for future research projects to apply the methodology on their own. The model and the empirical findings are discussed in detail, focussing on five projects that qualified as "best practices". The main findings are that an "impact assessment culture" needs to be cultivated, encouraged, and strengthened by the European Commission and all the stakeholders. The five projects that scored highest were strong in three different ways: one group maximised internal return on investment (ROI), a second group maximised external ROI, and a third group was able to strike a balance between the two. To integrate better the assessment methodology within each project, its partners need to feel that they "own" it, and that it has been optimised for its specific institutional, organisational, and epistemological requirements. We therefore recommend the inclusion in project consortia of socio-economic experts who are able to translate the ICT research language into measurable (potential) socio-economic impacts. SEQUOIA's assumption that in the development of an effective socio-economic impact assessment methodology it is important to integrate the social and economic dimensions of potential impact was verified and validated through an *ex post* rationalisation informed by economic anthropology, the usefulness of our quantitative model, and empirical evidence obtained through in-depth qualitative-quantitative data gathering techniques.

Keywords

Socio-economic impact assessment, EU-funded research, self-assessment, Software-as-a-Service, Internet of Services, qualitative methods, quantitative data gathering

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INTRODUCTION: POLICY AND INSTITUTIONAL CONTEXT

This paper summarises the main findings of the EU-funded project 'Socio-Economic Impact Assessment for Research Projects' (SEQUOIA).[1] The SEQUOIA project was tasked with performing an assessment of the potential socio-economic impact of research projects in the area of Software as a Service (SaaS) and Internet of Services (IoS). In addition, it captured and documented this process in order to develop a methodology for on-going and future research projects to adopt and apply on their own. This paper recounts the main learning points and the insights we gained from the project's activities during its 2 years of activity.

The SEQUOIA project comes in the middle of a European Commission (EC) research policy shift which, from an emphasis in the early Framework Programmes (FP) on funding research that is 'far from the market', is leading to an increasing emphasis on the assessment and maximisation of socio-economic impact and exploitation of research results. For example, Horizon 2020 brings together different framework programmes that address not only research but also adoption and deployment:

> "Horizon 2020", the Framework Programme for Research and Innovation, brings together the successor of the 7th Framework Programme for Research, the successor to the Competitiveness and Innovation Framework Programme (CIP, comprising the innovation-related parts of the Entrepreneurship and Innovation Programme (EIP), the Information Communication Technologies Policy Support Programme (ICT-PSP), and the Intelligent Energy Europe Programme (IEE)), and the European Institute of Innovation and Technology (EIT). The decision to bring together all EU research and innovation funding in a coherent, from-research-to-innovation overarching framework was taken on 29 June 2011 by the College in order to make participation easier, increase scientific and economic impact, and maximise value for money. (EC 2011)

These two emphases are not necessarily mutually incompatible if one allows enough time to elapse between research and innovation. However, the EC seems increasingly concerned with shorter-term observable impact, and this is squeezing the space normally inhabited by fundamental ("blue-sky") research, which is generally regarded as responsible for the most disruptive kinds of innovation.

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[1] Funded under the European Commission's Framework Programme 7 (FP7) Objective ICT-2009.1.2.

This phenomenon could be explained in part by the strong performance in innovation seen coming out of the USA in the last 20 years, which raises questions as to whether a similar performance may be possible in Europe, coupled with the on-going global economic crisis, which is motivating a growing concern with an accurate assessment and the maximisation of EU investment outputs. However, European success stories like Linux, Skype, and Prezi, not to mention the old workhorse GSM, are also significant. Interestingly, they can be argued to have been related not only to **scientific** innovation but to an increasing share of **socio-technical** innovation, consistent for example with the Facebook and Skype phenomena or with the evolution from SMS messaging to Twitter.

Another possible factor can be found in the strong participation of large industry in the consultation processes whereby the EC periodically solicits input for research priorities in upcoming Framework Programmes. The strong influence of large industry (e.g. in the European Technology Platforms) has increasingly blurred the boundary between "fundamental"/potentially disruptive research and industrial R&D with shorter time-horizons dictated by market/marketing requirements. The latter seems to have an increasingly strong influence on EC research policy. Rather than a shortcoming, also this phenomenon can be argued to have been influenced by the growing importance of the social dimension, for instance through the blurring of the boundary between personal and professional spaces as Web 2.0 tools and environments increasingly permeate the (virtual) workplaces of large industry.

Furthermore, it is an oversimplification to claim a dichotomy between blue-sky and applied research. There are many academics who are mainly interested in applied research, and there are many companies whose labs are at the forefront of scientific innovation. Likewise, it is tempting to ascribe to academics the ability to engage in truly "fundamental" research, while relegating industry and business to well-trodden intellectual spaces within accepted epistemological boundaries. This second point may be closer to the truth in Europe, where the gap between academia and industry has traditionally been greater than that found, for instance, in the USA. However, we suggest avoiding a dichotomous approach and, instead, regarding the research domain as a continuum: in each project there can be a co-presence of blue-sky research and innovative service development, each requiring specific impact assessment instruments. However, over the past 10 years, and within DG INFSO[2] in particular, the growth of the importance of the social dimension in information and communication technology (ICT) innovation cannot be denied.

With the growing relevance of the Internet as a central-for-all infrastructure, innovation in social media and Web 2.0 in general is clearly within everyone's grasp, it is not merely the province of private or public research institutions. This has changed the environment within which research outputs are judged or assessed. And the coupling between social dynamics and new business models has taken the world by storm. From this point of view, therefore, it is not too difficult to accept that the categories "near the market" and "far from the market" have been superseded by a considerably more complex landscape.

It is this landscape that SEQUOIA has traversed, documenting our findings and observations along the way in a number of deliverables, reports, and presentations.[3] In the rest of this Introduction we hint at a theoretical framework that may help make sense of the increasingly complex interactions between the social and economic dimensions on the one hand, and the individual vs. institutional perspectives on the other, and that we hope will help the reader make sense of the main findings as summarised in the remainder of this paper.

THE CULTURAL PERSPECTIVE

The development of criteria by which the value generated by research projects can be assessed, as faced by SEQUOIA, had to distinguish between verifiable current impact and potential future impact, with most observations relating to the latter. Furthermore, monetisable and non-monetisable impacts had to be

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[2] Unit D3, which funded SEQUOIA, belongs to Directorate D of Directorate General Information Society and Media, known variously also as 'DG INFSO', 'DG INFOSOC', or 'DG ICT'. The DG has recently been renamed again into 'Communication Networks, Content and Technology'.
[3] Available at: http://www.sequoiaproject.eu.

recognised and, where possible, quantified. This was a very challenging exercise that is discussed in depth in deliverables D3.3a (Bellini et al. 2011) and D3.1 (Monacciani et al. 2012). In this section we propose a rationale through which such a wider understanding of impact can be developed.

The Perspective of Economic Anthropology

As discussed in some detail in Dini et al. (2012), it is helpful to introduce the perspective of economic anthropology because – by not identifying the economy only with the market – it does not make a strict separation between "economic value" and "social value". For example, Gudeman (2001) discusses how all economies strike a balance of market or commodity-based production and exchange and non-market and commons-based production, sharing, and exchange. As shown in Figure 1, Gudeman proposes a more granular classification of value domains which, importantly, is also dependent on scale: (1) base or commons, (2) social relationships, (3) accumulation or capital, and (4) trade or market. The first two are prevalent at smaller scales and are closely associated with community, whereas the latter two involve longer-distance interactions and are more impersonal. However, the domain of accumulation or capitalisation is equally important for community and for the market.
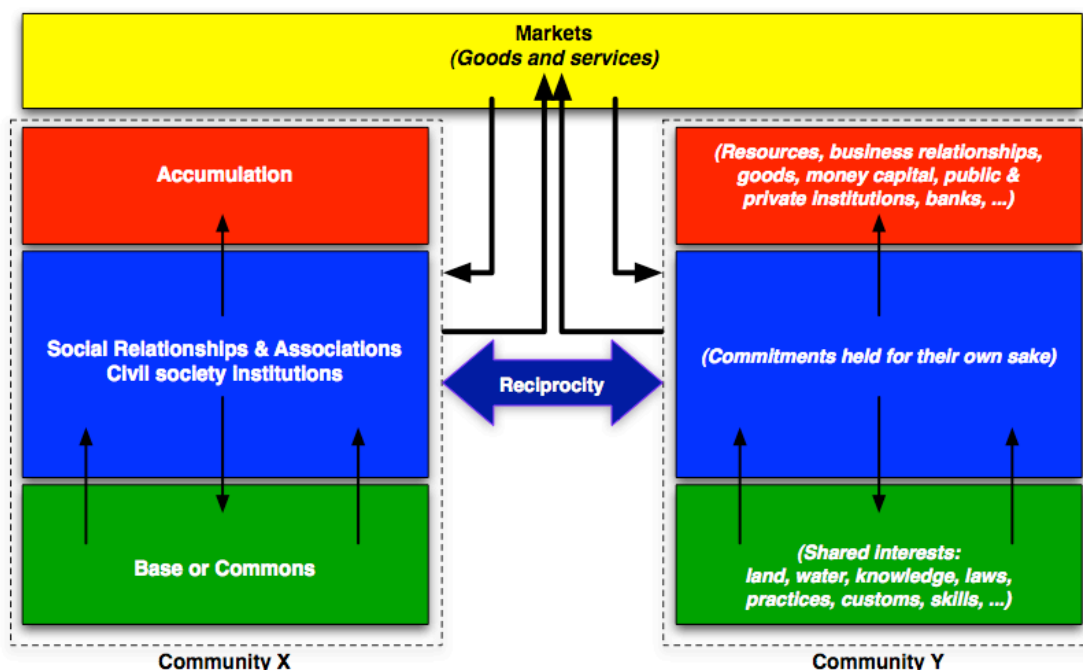
Figure 1: The four domains of value of the Economy according to economic anthropology

Figure 1 also captures the dependence of the value domains on scale, which shows a schematic that extends and adds to Gudeman's own graphic of how a local economy based on use-value relationships can interface to a wider market economy that spans and connects multiple communities. The diagram shows an intricate interdependence between different parts of the economy, of which the market is emphatically only a part and in which the value of social relationships can be recognised to have a central role. In such an economic framework the market exchange of commodities coexists alongside other economic mechanisms such as the sharing of public goods, barter, gifting, and reciprocity. The figure also implies that different mechanisms are operating at different scales and in different institutional contexts.

To begin understanding this figure it helps to note that 'the base in a system of social value is the counterpart of capital in a system of commercial value' (Gudeman 2001: 33). Unlike commercial capital which is usually measured with money as a common metric, the values in the base are measured in many different ways that depend on the type of base and the type of community. However, the function of base and capital to "store" savings that, for example, can be accessed in hard times is analogous. The figure shows the domain of accumulation as belonging to the scale of community because Gudeman's

perspective emphasises the real economy rather than the economy of financial markets. The fact that his object of study has predominantly been the village community in various "developing" countries probably also influences this interpretation.[4]

But the reason for using Gudeman's ideas is not to provide the ultimate model for a Western industrial or post-industrial economy, so the fact that it may not be complete is not at issue here. Rather, we merely wish to argue that a model that involves domains of value beyond the market is more expressive and therefore more useful for SEQUOIA's purposes. Although Gudeman's ideas are only one way of representing the extension of the economy beyond the market,[5] it suggests a way to see our social and cultural dimensions through an economics lens. The relevance to the present discussion of such a unifying view lies in providing an example of crossing boundaries between disciplinary perspectives that have mostly been considered to be incommensurate. By legitimising additional domains outside the market as integral parts of the economy, the latter is enlarged; and by showing how different domains of value can work together local economies are more likely to discover new sources of sustainability.

These concepts can be mapped to the SEQUOIA context as shown in Figure 2. The figure shows how direct funding by the EC of market activity or capitalisation is not allowed. By funding the domain of research and knowledge creation the EC strengthens the cultural base and the commons that underpin the many collaborative research communities that by now crisscross Europe. Whether or not these research outputs then find their way to the market is mostly an open question, and one to which SEQUOIA paid particular attention. However, especially in the area of ICT we can see how the domain of social relationships plays a pivotal role in bridging from the base to the market and capitalisation.
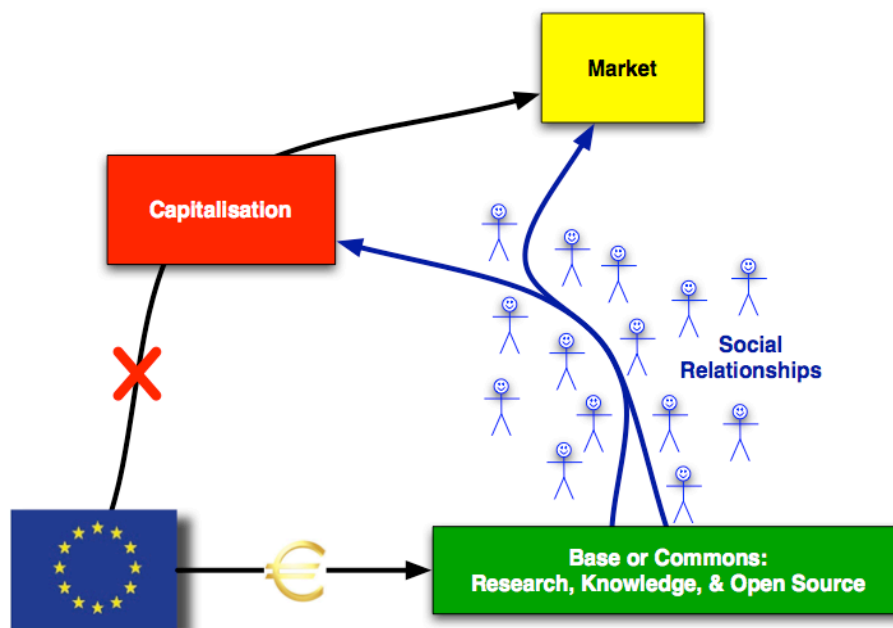
Figure 2: Gudeman's domains of value in the context of EU projects

Therefore, whereas most of the SEQUOIA work was carried out using more traditional categories for conceptualising the social and economic value generated by the SaaS/IoS projects we worked with, in hindsight it seems that the perspective of economic anthropology could be quite helpful for understanding

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[4] Another shortcoming of this diagram is that it does not address the labour market explicitly. This is not surprising since it was developed mainly through the ethnography and analysis of agrarian economies. Regardless of whether we choose to think of labour as Marx's 'surplus value' or as Polanyi's 'fictitious commodity', labour is arguably the most important 'glue' or 'currency' that connects and strengthens the interdependencies between all four domains. This seems all the more so in 'post-industrial' service and knowledge economies.

[5] For instance, the emphasis on the role of communities with social norms is found also in institutional economic studies.

and rationalising *ex post* especially the potential-impact categories, which we have found to be strongly associated with the social dimension.

The Importance of an Impact Assessment "Culture"

The project as an organisational entity is understood by management and organisation scholars as a temporary organisational form and is increasingly prevalent in contemporary society. While some consider such forms of organisation as the 'organizational equivalent of a one-night stand' (Meyerson et al. 1996: 167), others view the project as a temporary organisation 'to which resources are assigned to undertake a unique, novel and transient endeavour managing the inherent uncertainty and need for integration in order to deliver beneficial objectives of change' (Turner & Müller 2003: 7). Moreover, research has shown that a temporary nature does not necessarily equate to a lack in culture. Generally, for the duration of a project, it can be said that projects are organised following an accepted system of meanings, have certain values, and have an operating philosophy that is embedded in the relationships established within a given consortium (cf. Turnley 2002). The concept of culture highlights the role of individuals and their actions in an organisational context underpinning the improvement of their working capacity (Schein 1992).

If a project's organisational culture offers unreserved support for its strategic processes, and if these in turn provide a valid response, then a robust foundation is laid for successful performance (Bakker 2010; Schein 1992). In other words, project culture seems to have an impact on its strategic development associated with setting priorities and processes. And, while it cannot be claimed that culture precedes strategy, it does seem to underlie the uptake rate of strategic goals. Aptly put by Küng (2000: 108): 'Culture not only governs how environmental developments are perceived, but also defines the acceptability of strategic responses to those developments, and, by extension, determines the level of commitment to achieving those responses'.

The SEQUOIA team was less interested in validating claims associated with the dynamics of leveraging culture for strategic planning, and more in detecting disequilibrium between the elements involved. From SEQUOIA's research we have learned that there is a lack of assessment of projects' socio-economic impacts in their various stages from proposal writing to the evaluation phase. While mechanisms of quality control such as activity-execution monitoring, deliverable internal/external review, etc are in place in most projects, impact assessment is not a visible organisational process. Moreover, project culture seems to operate mainly by reporting activities and costs, according to an *ex post* logic.

However, such a strategy is less desirable from a more future-oriented approach, which is needed for aiming at and realising sustainable and maximum potential impacts. An explanation for this may be related to poor definitions of what impact is or entails, as well as 'methodological confusion' due to a lack of a clear-cut approach or widely acknowledged guidelines (Turnley 2002). This has raised questions concerning the replicability, validity and credibility of the work. In particular, the issue of bias became apparent as a weak research design makes it harder to control for it, i.e. conducting the investigation and documenting the findings (Goldman & Baum 2000). Also, in some cases there seems to be some resistance to socio-economic impact assessment as it tends to use data that generally is gathered for other purposes, and which must be used by individuals with little or no formal training in the social sciences (Burdge & Johnson 1998).

It is our belief, however, that with an increasing recognition of the complexity of society and policy there is an increasing need to assess prevailing socio-economic conditions under scrutiny; to analyse their impacts on the socio-economic structure of the research site or project; and to develop a set of guidelines for establishing viable projects.[6] Consequently, the SEQUOIA team saw the need to establish a standard impact assessment methodology that should be flexible and modular so as to be able to adapt to different

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[6] Examples of "viable" projects are the 5 "best practices" projects discussed further below, but further variables for better defining viable projects can be defined by the EC looking at new policy objectives.

types of projects (IP, STREP,[7] etc) and to the great diversity that characterises the SaaS/IoS domain. A standard methodology will allow the EC to have the kind of data that is useful when analysing the socio-economic impact of a domain or of a funding programme. In parallel, it will help projects in positioning themselves on the continuum that goes from blue-sky research to product/service development.

Generally, socio-economic conditions tend to be hard to identify and assess because of human characteristics and dynamic variables. However, there is a number of sets of socio-economic impacts that were developed in the SEQUOIA project: for example, we took into consideration impact on employment and working routines, impact on knowledge creation and diffusion, and impact on social capital. Moreover, the SEQUOIA methodology also considered some of the 2020 Digital Agenda[8] goals as points of reference for recognising expected impacts.

Our research found that some of the strategic development tasks associated with assessment were "outsourced" to non-social science experts. This meant that some of these people were not privy to underlying reasoning processes involved in assessment exercises. As a result, in some cases, a limited exposure to the underlying socio-economic rationale was detected in the strategic planning of the project proposal and execution phases. The new strategy of socio-economic impact assessment meant re-assessing many of the intrinsic beliefs and values that seemed to strengthen the project culture. Thus, strategic planning and execution based on an increased and realistic understanding of the project's potential impact seem to necessitate such socio-economic responses.

The establishment of a robust and well-executed socio-economic assessment culture therefore requires:

- analytical rigour (critical for replicability and credibility) including a clear problem statement, explicit definition of the targeted community, clear methods and assumptions, etc.
- repetition at several intervals of socio-economic assessment throughout all stages of the project, accounting for the emergent properties of what is truly a dynamic society
- a data collection methodology that accounts for and supports the analysis of differences in impacts
- a dedicated budget (small but adequate) to ensure a proper fulfilment of the task

This underscores the importance of the involvement of a specialist or expert skilled in this type of analysis, who will be familiar with these types of research designs and methodologies.

THE SEQUOIA MODEL FOR THE SOCIO-ECONOMIC ASSESSMENT OF RESEARCH PROJECTS

In the economics literature, impact assessment methods for evaluation investments in the ICT domain are addressed in broad outline (Hallonsten 2004; Henry & Kilpatrick 1998; Hirschheim & Smithson 1999; Pilat 2004). Unlike assessment studies that concentrate on software development as part of a product development cycle, the main challenge we encountered is not only to treat the quantitative and qualitative analyses within the same methodology, but to be able also to analyse **research** projects, which are not always oriented towards commercial markets, in a context of public funding and maintaining consistency with the EC concept of project assessment.

Many techniques for assessing R&D impact used in the EC context (bibliometrics, collection of statistics, feedback from collaborators, case studies, peer review, etc.) or in the literature (cost-benefit analysis, financial methods, multi-criteria analysis, input-output models, etc.) are not able, by themselves, to fully satisfy this need. For this reason, in the SEQUOIA project we defined an *ad hoc* methodology (Bellini et al. 2011) based on the combined use of different techniques in order to overcome the limits of each single method and in order to gather quantitative and qualitative data within the same analytical framework.

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[7] IP = Large-scale integrated project; STREP = Small or medium-scale focused research project.
[8] http://ec.europa.eu/information_society/digital-agenda/publications/index_en.htm

More specifically, the SEQUOIA methodology is structured in four main steps:

1. Mapping the areas of impact
2. Baseline identification
3. *Ex post* scenario description
4. Final assessment analyses

The **first step** aims at broadly identifying the stakeholders impacted by the outputs of the project and how they are going to be impacted, through a classification based on 1st- and 2nd-order impacts: 1st-order impacts are the effects on the consortium partners and on the direct users of the project's outputs – e.g. the researchers; 2nd-order impacts, instead, are the effects on the wider public – e.g. the impacts that the research outputs have on the quality of life of the average citizen/user.

The **second step** aims at collecting information regarding the *ex ante* scenario, i.e. the situation before the project started. The aim is not just to describe the state of the art, but rather the products – software or service(s), similar or alternative – on the basis of which improvements brought by the results of the project output(s) can be demonstrated. In brief, the *ex ante* scenario is the context in which the users "live" before the delivery of the outputs of the project under analysis.

The **third step** aims at describing, through the use of appropriate indicators, the situation after project completion and after research output exploitation. The *ex post* scenario describes both the output(s) of the ICT research project and the way in which they could be used in practice. For the *ex ante* and *ex post* scenarios detailed information was gathered in order to quantify two kinds of impacts:

- economic impacts: defined by SEQUOIA as 'the contribution that a project makes mainly to the competitive performance both of the project consortium and of the users of the research outputs'. Such effects are quite easily measurable and experienced relatively early by the various stakeholders;
- social impacts: defined by SEQUOIA as 'the contribution that a project makes, at any level of social interaction, to either the users or the direct and indirect beneficiaries of a project's outputs.' Such impacts are very difficult to measure in quantitative terms and may take rather a long time to be experienced by the stakeholders.

Each of these two kinds of impacts was further subdivided into more specific impacts, and each of the latter was further specified in more detail, in order to capture as accurately as possible the specificities of the IoS and SaaS domain. Figures 3 and 4 summarise all the economic and social impacts considered in the SEQUOIA study. Bellini et al. (2011) provide an accurate description of each impact considered, of the indicators/proxies chosen for their assessment, and of the metrics used for their qualitative/quantitative judgment/measurement.
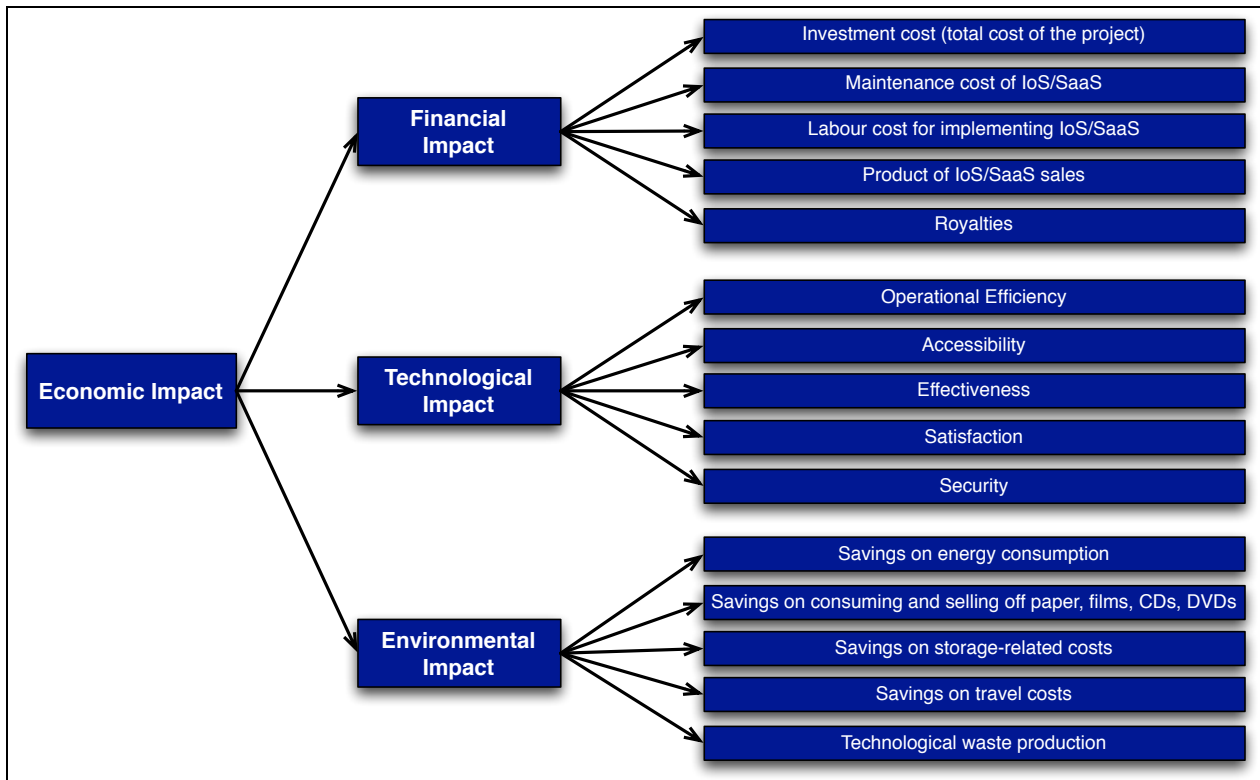
Figure 3 - Overview of economic impacts
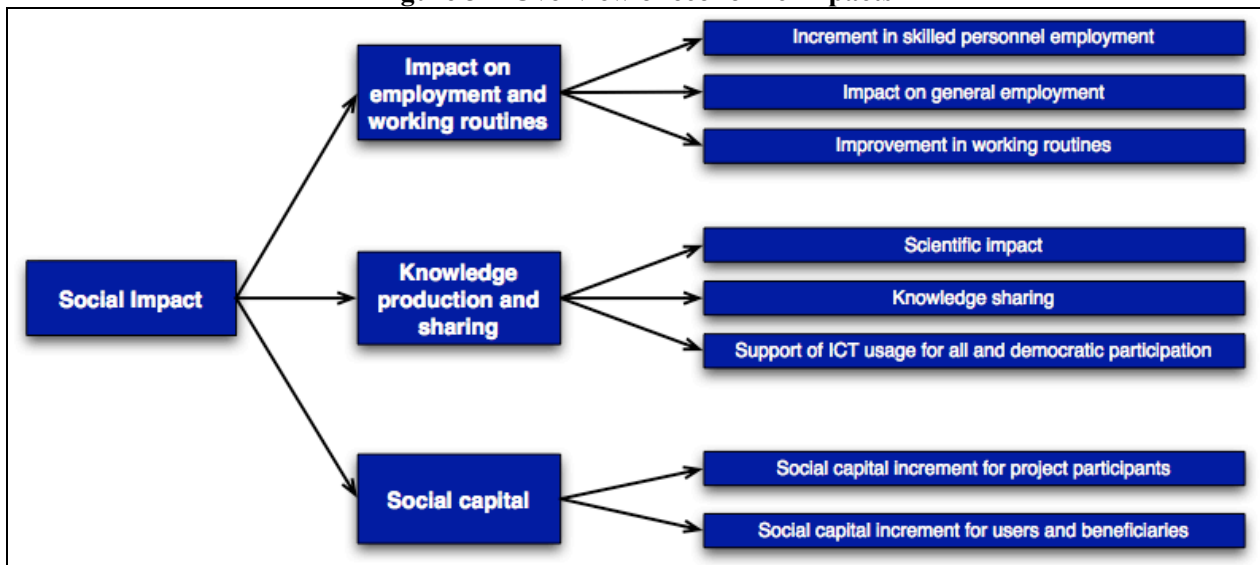
Figure 4 - Overview of social impacts

The **fourth step** of the SEQUOIA assessment process consists in gathering all the information generated in the previous steps, processing the collected data through the use of appropriate techniques, and deriving composite indices for the performance evaluation and benchmarking of the projects. For this purpose, we customised the assessment methodology into 4 different phases, each based on the combined use of different techniques (Figure 5).
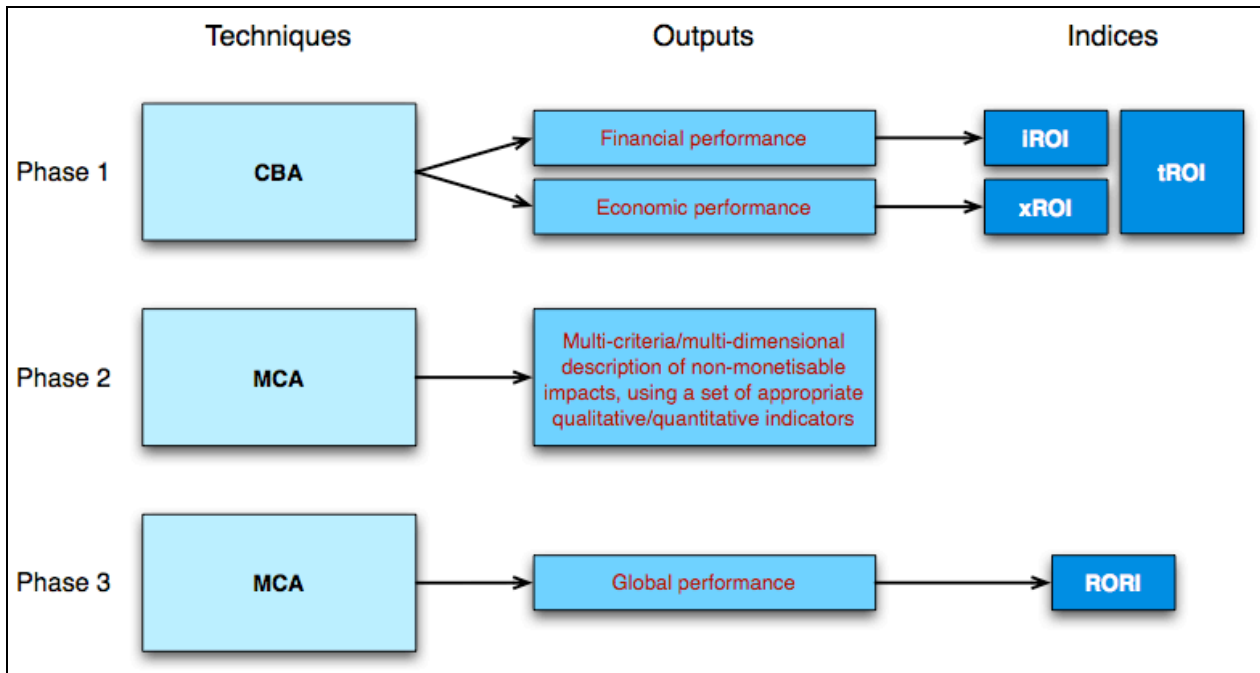
Figure 5 - The SEQUOIA methodology for IoS/SaaS research project socio-economic assessment

1. The **first analytical phase** is inspired by the fundamentals of CBA (Boardman 2006; Brent 2007; Snell 1997; European Commission 2006); it is divided into two sub-phases, aiming at assessing first the financial performance of each project (Phase 1a) and, then, its economic impact (Phase 1b). The results of this analysis are condensed into three composite indicators, each with a different meaning and robustness:

   • **iROI** (**i**nternal **R**eturn **O**n **I**nvestment): this indicator measures the financial return to the consortium partners and, therefore, provides information about the financial sustainability of the project. The iROI indicator is based on the financial evaluation of the total cost of executing the research project and on the identification of the financial returns for the consortium partners, derived mainly from selling[9] the outputs produced. A positive iROI value means that the financial returns estimated over the project lifetime cover the expenses that the consortium itself must sustain in order to run the project, both during the research phase and during the exploitation of results phase. The iROI is calculated from the following formula:

$$iROI = \frac{\text{financial investment inflow - financial investment outflow}}{\text{Investment cost}} \quad (1)$$

   • **xROI** (**e**xternal **R**eturn **O**n **I**nvestment): this indicator quantifies the net economic benefits that the project generates for society at large (both for users and non-users of the research outputs). To contribute to the xROI each quantifiable impact that is not already financial is expressed in monetary terms by using appropriate proxies. A positive xROI value means that the economic benefits estimated over the project's lifetime are higher than the economic costs society has to pay for enjoying the outputs of the project itself:

$$xROI = \frac{\text{Socioeconomic Benefits - Socioeconomic Costs}}{\text{Investment cost}} \quad (2)$$

   • **tROI** (**t**otal **R**eturn **O**n **I**nvestment): this indicator quantifies the total monetisable impacts of the project, both internal and external. It is calculated by adding the iROI and the xROI:

$$tROI = iROI + xROI \quad (3)$$

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[9] For non-commercial projects, revenues like fees or IPRs-related cash inflows are treated as revenues due to sales.

2. The **second analytical phase** (Phase 2) of the SEQUOIA assessment model is inspired by the fundamentals of Multi-Criteria Analysis (MCA) (Köksalan et al. 2011; Dodgson et al. 2009), according to which each of the various impacts should be expressed in its most suitable metric, by using appropriate indicators. This is justified by the fact that most of the impacts generated by SaaS and IoS development (e.g. the impacts on quality of life, on scientific production, or on technological improvements brought by the development of ICT services) cannot be expressed or transformed into monetary terms. Therefore, the result of the second step is a multi-criteria/multi-dimensional description of the non-monetisable impacts of each project assessed, through the use of a set of appropriate qualitative-quantitative indicators.

3. The **third analytical phase** (Phase 3) is also based on MCA, and aims at synthesising the results of Phase 1 and 2 into a composite indicator called **RORI** (**R**eturn **O**n **R**esearch **I**nvestment). This indicator synthesises all the impact information produced by the SEQUOIA assessment, summarising the global performance of each project. It is calculated as the weighted sum of the iROI and xROI and of the multi-dimensional indicators. The issue, here, is to bring together all the information provided by the questionnaires, both qualitative and quantitative, both monetary (or monetisable) or not. The resulting index, therefore, does not have a strict economic meaning but, at least, it provides a measure of the whole performance of each IoS/SaaS research project that is comparable to other projects':

$$RORI = \sum_{n} (X_n \cdot w_n) \tag{4}$$

where

$n = 1, ..., N$
$\Sigma_n w_n = 1$
N is the number of variables
w are the weights of the normalised indicators[10]
X are the normalised indicators[11]

EMPIRICAL METHODOLOGY AND MAIN FINDINGS

Data Gathering

As mentioned above, SEQUOIA aimed to develop a self-assessment methodology for socio-economic impact, to transfer the methodology to its users, and to render them as autonomous as possible in applying it. In order to reach this goal, we engaged the SaaS/IoS projects from the very beginning, opening up the methodology definition process to their inputs. More specifically, the project representatives were asked to comment on the SEQUOIA questionnaire, which was the main data gathering instrument used for applying the SEQUOIA method.

In addition to face-to-face meetings and workshops, the SEQUOIA team organised five online focus groups sessions, involving a total of 27 projects. The project representatives were asked to check if the questions and indicators chosen were, in their opinion, understandable, adequate to their project, and useful for evaluating their project's impact. The information gathered was then used to finalise the SEQUOIA questionnaire. The focus group sessions represented also an opportunity to learn more about the projects under analysis and their potential beneficiaries, in order to customise the methodology better. The activity was also very useful in developing a factual and focused channel of interaction between the SEQUOIA team and the projects. Finally, it enabled a discussion about the meaning and the approach of socio-economic impact assessment. The resulting familiarity of the projects with SEQUOIA's perspective and approach was an important element that helped achieve a high level of participation in the methodology testing phase.

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[10] The formula used for weights normalisation is the following : $w_n = p_n / \Sigma_n p_n$

[11] Indicators must be previously normalised, in order to avoid the differences among the measures used for expressing each. Normalisation of indicators is obtained dividing each original indicator i by an external value T set by the analyst (in SEQUOIA T is the indicator mean value). The formula used for indicators normalisation, therefore, is the following : $X_n = i_n / T$

The methodology was then applied to 30 SaaS/IoS research projects. The data was gathered using a semi-structured questionnaire and in-depth interviews. The interviews were carried out after the analysis of the questionnaires with the aim to collect more detailed information and complete the questionnaire where needed. The evaluation of targeted research projects presented several difficulties, mainly arising from the fact that many projects were still in their early stages[12] and from the consequent inability to both predict stable application scenarios of the projects' output(s) and to answer some key questions generally related to the exploitation of the projects' main findings. Furthermore, most of the projects assessed were working on the creation of new "enabling technologies", whose concrete applications can be so diverse that their associated impacts are only partially measurable and quantifiable. This caused an unavoidable "underestimation problem" of the potential socio-economic impacts attainable. Finally, other difficulties arose from the fact that SEQUOIA's assessment work was applied to a significant number of projects aimed at devising very heterogeneous kinds of new products/services, requiring a degree of individual tailoring of the assessment. With these assumptions in mind, conscious of all the above-mentioned evaluation difficulties and biases, the rest of this section presents the main findings of the SEQUOIA assessment exercise.

Main Findings

The projects assessed had an average total cost of about €5m, the maximum and minimum costs being €19,558,600 and €149,830. Most of the expenses were devoted to personnel (73% on average). Average travel costs of the project sample represented 11% of the average project cost; demonstration (use cases) and dissemination activities had approximately the same weight (respectively 8% and 6%). Finally, sub-contracting costs were generally very low or absent altogether.

Most of the projects performed their research/studies in more than one specific domain. In particular, in 55% of the cases, they were operating in the field of context-aware services and of Service-Oriented Architecture (SOA), while 50% of the projects focused on mobile technologies. Cloud technology was also a focus of attention for the sample (45%), while Grid computing turned out to be the least explored domain (15%)[13]. All the projects interviewed asserted that their project had more than one output. In particular, most of the projects had as one of their main outputs the improvement of an existing software platform/virtual infrastructure (70%) or the development of a new software platform/virtual infrastructure (63%). Another relevant output, shared by more than the half of the projects, was the development of new methodologies/design processes (59%) or their improvement relative to the state of the art (56%); by contrast, relatively few projects were developing new languages (22%) or improving existing ones (30%).

Considering the stakeholders that will be affected by these projects, the most targeted category of stakeholders (66%) was software developers and software engineers. Another important category of stakeholders was service providers (41%). The category of industry and small and medium-sized enterprises (SMEs) working in the ICT domain was targeted by 34% of the projects; researchers and research communities, instead, were addressed by 41%. It is important to highlight that society at large (citizens, consumers and end-users in general), instead, was addressed only by 10% of the projects; this fact means that the project outputs were mainly addressed at ICT sector/developer communities, with little attention paid to socially-relevant applications that may derive from their use/development.

The most widespread expectations of impacts were: to improve the quality of services/ products/systems (77%), to reduce the costs of performing some specific activities (63%), to reduce the time to deliver a service (57%) or to deploy it over the network (47%), and to increment the number of users/beneficiaries (53%). With reference to the cost reductions, most of the projects generating cost reductions (79%) stated that their project outputs would help lower software development costs by 18% on average; in addition,

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[12] 40% of the projects sample were in their initial phase, 30% of projects were at an intermediate stage, and the remaining 30% were almost completed or ended.
[13] The sum of percentages of projects working in various domains is higher than 100% because each project could select more than one option.

more than half (57%) of the projects claimed both a decrease in maintenance costs (8% average), and cost reductions due to higher software reusability (14% average).

The economic impacts described above are based on a qualitative self-assessment made by the projects. In fact, we can say that for most of the projects the figures represent the *expected* impact, while the concrete evaluation of the projects' economic impacts will only be possible at or after the end of their life-cycles and only if they introduce and use self-evaluation instruments (such as the SEQUOIA methodology) consistently.

With reference to the impact on reaching more users, at the time of the assessment most of the projects (64%) thought that the number of persons benefiting from the use of project outputs was very low and less than 100, while only 18% thought that their project's outputs would soon be used by more than 2000 people. Instead, in a time-frame of 3 years from project end, the number of expected users would be much higher: 41% of the projects, in fact, believed that they would succeed in reaching more than 2000 users, while the percentage of projects with a low impact on reaching users was expected to decrease from 64% to 23%.

33% of the projects answered that their outputs will not be commercialised and, therefore, no financial revenue will ever be generated, the remaining 67% achieving commercialisation only at the end of the project. As mentioned above, due to the projects' early stage at the time of the assessment, there were no business plans available and the financial dimension had not been explored yet. Since the projects were not able to identify a commercialisation or exploitation plan, unfortunately we could not quantify this contribution to the projects' financial impact.

With reference to technological impacts, the main expected results were improvements in "portability", and especially adaptability, while reliability scored below-average on a scale from 1 to 10. This is perfectly understandable considering the research nature of the projects considered.

In addition to economic, financial, and technological impacts, SEQUOIA turned its attention to social impacts that, as mentioned when describing the project stakeholders, should be seen mainly as indirect impacts. For respondents, in fact, it was very difficult to map and describe potential social impacts. This was due, on the one hand, to the disciplinary background of the respondents who were not necessarily accustomed to thinking about socially-related issues; and, on the other hand, to the fact that most of the projects were developing **enabling technologies/solutions** that may have very diverse and partially non-predictable applications and uses.

As shown in Figure 4, social impacts are articulated in three aspects/components:

- Impact on employment and working routines
- Impact on knowledge creation and sharing
- Impact on social capital

Most of the projects expected to contribute to increasing employment. In fact, 44% estimated that they would generate more than 200 jobs, 11% between 20 and 200 jobs, while 33% would engage up to 20 new workers. Only the remaining 11% did not expect to generate any jobs. These expected results are very positive, even if in some cases it was not clear how the new positions would be created. We could see that some projects could also generate new positions by supporting the competitiveness and growth of SMEs. Other projects expected to have an impact on employment by creating new technology-specific professional roles that would emerge in the job market. Moreover, projects had already had an impact on the creation of highly skilled personnel by supporting and sponsoring PhD and post-doc positions. Each project sponsored an average of 6 PhD scholarships, for a total number of sponsored PhD students of 117. In addition, 3 post-doc positions were sponsored on average by each project for a total number of 45 new post-docs.

When analysing knowledge production and sharing, we considered various forms of systematising knowledge: peer-reviewed journal articles, articles presented at conferences or published in proceedings

(also non-peer-reviewed), books, book chapters, and scientific deliverables (i.e. project deliverables other than those related to management or dissemination). Each project produced an average of 6 articles, for a total of 72 articles. This result is very positive considering that most of the projects under analysis were still running and the publication of an article requires at least several months. We expected this number to grow considerably during the remaining time in which the projects were active. Similarly, the number of scientific deliverables that at the time of the assessment was at an average of 12.50 and a total of 200 was expected to grow significantly during the remainder of the projects' time.

To engage a more diversified audience conferences and knowledge exchange initiatives are also very important. On average, each project took part in almost 20 public dissemination events. Unfortunately we do not have data about the number of participants to those events, or about the nature of such conferences, but we could see a significant effort on the part of the projects in disseminating their results to the scientific community.

Finally, one of the pillars of European Research Area (ERA) policy is to reinforce the relationship and the knowledge transfer from research to training. For this reason we asked the projects to indicate the number of training modules developed or planned. The great majority of projects had developed or were planning to develop more than 10 training modules.

The third and last dimension considered in the social impact assessment was social capital. With this term we mean the value that each project has and can generate in terms of new and stronger relational and collaboration links. We considered the capability of a project to create new relationships for its partners as well as for its stakeholders. In addition, we considered "trust" as an important dimension of social capital. We examined the number of collaboration links established as a consequence of the participation in the projects. This is an important added value of EU projects: the creation of new research networks and the enlargement of existing ones. In this regard, each project created – on average – more than 10 new links. More specifically: 59 new partnership agreements with other universities research centres, enterprises, or public bodies; 13 new commercial collaborations with actors outside the consortium; and 49 submitted new projects proposals that would not have been prepared had the partners not met through their participation in the projects we assessed.

47% of respondents agreed or strongly agreed about the fact that their projects supported the creation of networks and the collaboration between enterprises and academic actors. 33% said that they had enlarged already existing networks, and 27% expected to have an impact in terms of collaboration among citizens. About half of the respondent saw their project as an instrument for improving trust among users in their online interactions and user trust in ICT and the Internet in general. This would be a positive outcome of the projects and would foster the achievement of a more and better-connected Europe. The ability of the projects to foster trust in the Internet and in other users is often ascribed to the improvement in security and data management that projects in this domain are expected to achieve.

Due to the fact that the projects were in their early stages, it was difficult to calculate the xROI, iROI and tROI, but we used a simplified version of the RORI for mapping the average performance of the 30 projects and for selecting 5 "best practices".

The Best Practices Report (Passani et al. 2012) uses a case-study approach to better describe the potential social and economic impact of the 5 projects that scored highest in the assessment. These projects can be seen as "best practices" because they appear to know their stakeholders' needs and expectations and engaged with them in development activities from the beginning to a greater degree than the other 25 projects. Moreover, these projects, even if research-driven, have a clear idea of the SaaS/IoS market and know their potential competitors. In this sense the link between academia and industry is a positive one, as testified to by the attention given to collaborations and to the definition of bilateral agreements with industrial partners.

In addition, we analysed the weighted average score of the 5 best practices projects, calculated on the basis of the following formula:

$$\frac{\Sigma(\text{project cost} \cdot \text{tROI})}{\Sigma(\text{project cost})}$$

The weighted average is 0.6244, hence at the time of the SEQUOIA evaluation the 5 projects had already generated fairly good economic returns relative to their total lifetime and had covered their running costs. Considering that all the 5 best practices projects are research projects, this value is acceptable in terms of socio-economic impact, also considering their early and pre-commercialisation stage.[14] However, the aggregated analysis of the best practices hides relevant information. Based on the different socio-economic performance uncovered by the aggregated analysis, the projects can be divided into three categories:

1. Projects that achieved the highest iROI of all the projects analysed by developing a noticeable financial ROI for the consortium partners, almost reaching the break-even point and leading us to infer that in the next year they can generate substantial internal returns on investment. Indeed, the iROI of these projects in general contributes to 80-90% of their tROI value. In terms of xROI, these projects have not produced significant external positive results in the form of socio-economic benefits.
2. Projects that are mainly aiming to generate a high xROI value, by producing noticeable external returns on investment in terms of socio-economic benefits for their consortium and for society at large. In general, these projects reached a higher xROI than iROI. The greater emphasis on xROI may limit the projects' financial sustainability.
3. Projects that are the most balanced in terms of financial and socio-economic sustainability. Indeed, for this group the difference between the iROI and the xROI values is not very remarkable, with each in the range of 40-60% of tROI.

Hence, the results of the SEQUOIA socio-economic impact assessment exercise demonstrate that the methodology can constitute a useful instrument in terms of future investment decisions for the phase of the full development and exploitation of SaaS/IoS projects. It is able to distinguish the potential categories of project investment. In line with the objectives of investors and decision-makers, from the analysis of the 5 best practices we can estimate the characteristics of projects in terms of financial and socio-economic sustainability. The best practices report also demonstrates that the SEQUOIA methodology is very useful for accurately evaluating the areas of impact under which the EC can analyse whether the objectives of each project have been achieved.

DISCUSSION

Maximisation of Socio-Economic Impacts

In this section we briefly summarise the activities performed by the SEQUOIA team. We summarise the main findings and identify those aspects that the projects in the SaaS/IoS domain should take in consideration for maximising their socio-economic impacts.

The SEQUOIA methodology was developed with the support of SaaS/IoS projects by using a participatory approach. Face-to-face and online meetings were organised in order to present the methodology to the projects and to gather their feedback. This collaboration was very important in defining the final set of indicators and for understanding the "shared culture" of this scientific community. The SEQUOIA assessment found that this research community has a weak assessment culture. At the time of our assessment only two projects were performing any sort of impact assessment activities: monitoring and evaluation in general were very rare. Consistent with this, only a few projects had business plans and

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[14] This qualification is mostly relevant to economic impact.

a concrete sustainability strategy. This can be partially explained by the fact that the projects were still in their early stages at the time of the assessment.

Another important observation that emerged from our analysis is that most of the projects target mainly developers and software engineers, and the wider society is not their main focus. As mentioned above, only 10% of the projects see citizens and end-users as relevant stakeholders in their activities. It was difficult for many of the people engaged in the assessment to reflect on the potential impact of their research outputs at the social level. This highlighted to us the need to maintain an explicitly interdisciplinary outlook and to foster the emergence of a common language between social scientists and technologists. SEQUOIA supported the projects in reflecting more on societal impacts, but more needs to be done in this direction. As the link between technology, research, and social goals is clearly stated in the Digital Agenda 2020, more attention should be dedicated to its objectives when writing and carrying out a project in the SaaS/IoS domain.

Moreover, technology development is oriented towards the Open Source approach, and it is difficult for SaaS/IoS consortia to identify appropriate business and revenue models for future exploitation. It is, therefore, necessary to support the SaaS/IoS consortia in learning more about the business models associated with Open Source software and to support them in linking this with the appropriate choice of licences and organisational models (e.g. Berdou, 2011). In parallel, also a future development of the SEQUOIA methodology should include a more accurate analysis of Open Source approaches to exploitation.

The early/immature stage of most of the projects was an important factor in carrying out only an *ex ante* assessment; we recommended to all the projects that collaborated with SEQUOIA to run a new assessment at the end of their projects, for instance relying on the SEQUOIA How-To Guide (Monacciani et al. 2012, also available in brochure form from the project website[15]). Finally, we recommended that projects dedicate more effort to defining – from the very beginning of their activities – their stakeholders (particularly end-users) and specific case studies/pilots to test the application of their outputs in concrete scenarios. This would provide useful feedback both for understanding the exploitation features of the projects' main findings and for assessing the economic value they generate.

In the next section we touch on how the SEQUOIA methodology and impact assessment approaches in this field generally can be improved.

The Need to Improve Impact Assessment Metrics/Methods

The first challenge of impact assessment is related to data availability. In order to avoid duplication, the SEQUOIA qualitative-quantitative questionnaire included some of the questions that the EC already asks the projects as part of their Final Report[16]. In this way, projects can collect the information once and use it both for assessing their expected impacts and for reporting their achievements to the EC. This can be seen as a first attempt to build a stable database to support the EC and the projects when analysing their expected impacts. This first attempt calls for more actions to reduce the burden for the projects and to build a database that will be useful for the analysis of socio-economic impact at European level and on a Framework Programme basis. In addition to this challenge, there are issues that are specific to the SaaS/IoS domain and that call for greater attention.

The main difficulty in assessing the socio-economic impact of SaaS/IoS projects is related to the nature of the "project" as a time-limited and process-oriented institutional form. In order to perform an effective impact assessment, data need to be gathered from the beginning of the project (or even at the proposal

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[15] www.sequoiaproject.eu

[16] We refer here to the questionnaire each project coordinator has to respond to at the end of a project. The questionnaire is divided into several sections, including information workforce statistics, information about scientific outputs and dissemination activities performed. See "Template for Project Final Report" at http://ec.europa.eu/research/participants/portal/page/fp7_documentation.

stage) and after project completion. A dedicated task for data collection and assessment should be planned at the proposal/negotiation phase. There is a need not only for a standard methodology and data gathering process but also for a formal commitment of project consortia to gather data during and after the end of the projects.

By interacting with the SaaS/IoS projects, we found that scientific impacts are expected to be observable in the timeframe that goes from the end of the projects to one year after that, while economic impacts are expected to emerge 2-3 years after project end and social impacts after 5 years. It is evident that – in order to describe concrete impacts – it would be necessary to interact with project partners and coordinators after the end of their work. This is a complex task in itself and particularly for a Support Action such as SEQUOIA that focused its activities mainly on **potential** or **expected** impacts.

Even with a formal agreement, the *ex post* impact assessment exercise is not easy considering the fact that after the end of a project the consortium is no longer operational, participants act as separate entities no longer committed to the project, and researchers may change affiliation over time, making the data gathering process even more difficult. Moreover, many research impacts are unexpected and difficult to quantify, so the reasonable expectation of having numerical, clear, and comparable results needs to be counterbalanced with qualitative, in-depth analysis better able to spot unexpected, soft elements and better able to re-construct the "life" of research outputs after the end of the project that generated them.

Another important characteristic of the SaaS/IoS domain is that it groups projects that are very different in terms of funding instrument (IP, STREP, Network of Excellence, etc), in terms of research typology (closer to or farther from the market), in terms of topics (developing programming languages, software services, Cloud infrastructures, etc), and so forth. This diversity is the richness of the domain and needs to be taken into account when developing impact assessment methodologies. Consequently, methodologies need to be developed in a modular way, allowing each project to select those metrics that best fit the typology to which it belongs. Clearly, this leads to a certain level of methodological complexity and to a more time-consuming, knowledge-intensive data gathering process. The investment is rewarded by a richer set of data and more precise outputs able to orient and guide project partners when developing their sustainability and exploitation plans.

Finally, there is a need to define at the level of the SaaS/IoS community the categories of impact that it is reasonable to consider, and how to measure them. The SEQUOIA methodology considers various categories, among which are economic efficiency, economic ROI, scientific excellence, social capital, and others. Although these categories were discussed with the community in a participatory way, it is important to remain open to adapting such categories to the needs of the EC as part of future activities that may be seen as necessary.

Similarly, the spectrum of scientific outputs should also be extended beyond the classical centrality of patents and impact factors. In order to better fit with the domain culture, for example, participating in well-known conferences may be considered an important scientific output and a significant channel for knowledge diffusion. In some cases, domain-specific conferences are even more important than journal articles in this respect because they allow a quicker dissemination of research output without reducing the quality of the contributions. Moreover, when analysing economic impact, new business models such as those linked to Open Source Software (OSS), which appears to be especially relevant to the SaaS/IoS domain, should be added to more traditional ones.

SUMMARY AND CONCLUSION

Over the life of the EC Framework Programmes, government policy has led to greater investment in fundamental research. Current policy aims to increase the potential impact of research on the market and on society, thus maintaining a long-standing contradiction. However, the growing importance of the social dimension of innovation, observed since the advent of the web in many areas of science and technology,

can mitigate this contradiction. For example, the wider definition of "economy" afforded by economic anthropology offers a pattern of interaction whereby EC investment can be seen as strengthening the commons and the social relationships domains of the economy which, in turn, can then be expected to have an impact on the market and capitalisation domains. This increases the legitimacy of policy as well as EC expectations for measurable potential socio-economic impact.

In hindsight, the qualitative aspects of the SEQUOIA methodology acquire greater relevance in their complementary roles next to the quantifiable/monetisable economic impacts. In order to benefit from this perspective, however, a greater awareness of the importance of socio-economic assessment – and the ability to perform it – is also required on the part of the research projects. An "impact assessment culture" needs to be cultivated, encouraged, and strengthened by the Commission and all the project stakeholders. In fact, the lack of a future-oriented strategy in the consortia analysed is a risk, and more effort should be invested in fostering a medium-term vision; to this extent the time-limited nature of EU projects represents a potential obstacle and mitigating measures need to be developed and experimented.

In the specific assessment exercise that SEQUOIA performed on 30 SaaS/IoS projects, the 5 projects that scored highest were strong in three different ways: one group maximised the internal ROI, a second group maximised the external ROI, and a third group was able to strike a balance between the two. These case studies (D3.2) are probably the most valuable output of SEQUOIA, since any present or future projects will be able to see, by example, what initiatives, activities, and strategies worked best. Our interpretations for why these projects did well are discussed and explained in D3.2 and D3.3b, on the basis of a detailed explanation of the methodology in D3.3a.

Looking to the future, the assessment methodology needs to be better integrated within each project. The partners of each project need to feel that they "own" it, and that it has been optimised for their specific institutional, organisational, and epistemological requirements and peculiarities. In this respect, we recommend the inclusion in project consortia of socio-economic experts who are able to translate the ICT research language into measurable (potential) socio-economic impacts. Introducing socio-economic experts will speed up the process of internal data gathering and will offer the opportunity to customise better the SEQUOIA methodology to projects' needs. Moreover, such experts will also be effective in orienting sustainability plans based on assessment outputs, and in embedding them in their projects' dissemination strategies.

In conclusion, SEQUOIA's assumption that in developing an effective socio-economic impact assessment methodology it is important to integrate the social and economic dimensions of potential impact was verified and validated through an *ex post* rationalisation informed by economic anthropology, the effectiveness of our quantitative model, and the empirical evidence obtained through in-depth qualitative and quantitative data gathering techniques.

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