Societal returns of scientific research

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Summary
This paper addresses the societal returns of research in more detail. It presents a conceptual framework that builds upon logical models, science communication and productive interactions. It describes social, cultural and economic returns from science in professional, public and private domains that are connected to research through specific stakeholder interactions. Creating societal relevance is a four-step process: defining a societal mission and objectives of a research group; defining stakeholders an specific activities and interactions to connect to the stakeholders; measuring societal relevance based on indicators that relate to mission, objectives and activities not all that can be measured is relevant); and finally reflection on the result and adjustment of mission and objectives if necessary. The four steps are addressed by executing four case studies in the medical domain, in order to stimulate awareness on research evaluation at large. More explicit strategic attention for the concept of societal relevance may eventually result in more systematic attention for the operational process of assessing societal relevance, which in turn could end up in an integrated model of assessing scientific and societal quality that fits into the ambitions of a knowledge based society.

Introduction
Questions regarding the socio-economic and cultural relevance of scientific research have been on the science policy agenda for decades (Bush 1980). The combined processes of globalization and commercialization (Mirowski 2011) have created a new need for the evaluation of the social, economic, cultural and ecological impact of scientific research. This demands for other evaluation methods that do more justice to the full variety of goals and activities of researchers. This development can be seen in the context of "the new mode of knowledge production" in which the social and economic context of research has been put central (Nowotny et al. 2001).
The importance of a knowledge-based society is shown by the fact that our society is more and more depending on scientific and technological breakthroughs. In the 21st century the interaction between science and society is ever increasing in the light of a speeding global economy (Crespi and Geuna 2004). The ambitious European knowledge agenda in order to become the most competitive economy in the world, some urgent societal problems, such as an ageing population, climate change and sustainable energy, and open innovation models are developments which further decrease the gap between science and society (Gibbons et al. 1994).
This explains the emphasis on "knowledge valorisation". This term is used for the transfer of knowledge from one party to another with the aim of creating (economic and societal) benefits (Feldman and Kelly 2006). Valorisation is a term mainly used in European countries: it is a French word which means 'to make useful, to use, to exploit'. Essentially, it should be understood as *the process* of making use of knowledge. Valorisation often only describes the transfer of knowledge into companies or to the commercial sector for economic benefit (Audretsch 2004). Then valorisation refers to exploitation and commercialization, such as business development and business generation. The value of research in other domains, for example in the health sector or for policymaking, is often not taken into account. Societal valorization such as absorption by professionals, dissemination through education, networking platforms, communication to the broader public, is however equally relevant. The added value is different for different users or stakeholder groups and therefore it should be seen in context (KNAW 2005). Valorisation is also often used to describe a one-way-interaction:

the dissemination of scientific knowledge to society while it should be a more mutual, bi-directional learning process (Etzkowitz and Leydesdorff 2000).
Research can be more successful in terms of valorization and socio-economic relevance and impact when it is based on clearly defined objectives; when it is being monitored and evaluated in the light of the objectives; and finally, when it is planned, executed and evaluated with the involvement of users and other stakeholders. Strategies that involve users and other stakeholders from the start in research programming, execution, and evaluation are more likely to realize socio-economic relevance, use and impact. Thus, public involvement of users and other stakeholder's results in research carried out 'with' or 'by' members of the public rather than 'to', or 'for' them. Here the term "productive interaction" comes into play. It refers to a mutual way of learning: interaction between research producers and the stakeholder parties taking up the results. It is not limited to economic benefits, but also includes societal benefits (Andriessen 2005).
Nowadays, researchers are regularly asked to demonstrate the societal relevance of their research, as they operate in a number of social domains, such as the international scientific community, industry, politics, the public sector and the general public. The tools, methods and criteria for monitoring and evaluating however are mainly focussed on the scientific impact. Many researchers feel the need to use evaluation methods that do more justice to the diverse character of their work than traditional methods do that basically look at the research production in terms of articles in (high impact) journals and citation scores. The evaluation of scientific relevance is of vast importance and should not disappear. The point is that we need more comprehensive evaluation methods, which focus not only on scientific quality, but also on societal relevance. Evaluation methods to measure the 'societal relevance' are far less developed than the ones for scientific quality. Unfortunately, there is still a lack of clear instructions on how to incorporate socio-economic impact in the review process, so most of the evaluation committees ignore it or do not know how to deal with the information they gather. Perhaps one of the most important reasons for the lack of consensus is the fact that a more comprehensive kind of evaluation demands knowledge of the heterogeneous context of research (Spaapen 2007). So on the one hand, the importance of new forms of knowledge production and valorisation is stressed more than ever, but on the other hand we are not able to monitor and to evaluate the research performance to this end adequately.
The next step would then be to develop practical guidelines to monitor and evaluate the valorization and societal relevance of research, and to establish commonly accepted minimum methodological requirements for the measurement of societal relevance, just as there is for the measurement of scientific impact. In this paper, we address the topic of measuring socio-economic relevance of research, productive interactions with designated stakeholder communities; and the lack of awareness and systematic recording of data to substantiate productive interactions. Finally, we will discuss the value of these interactions in a broader context of research evaluation.

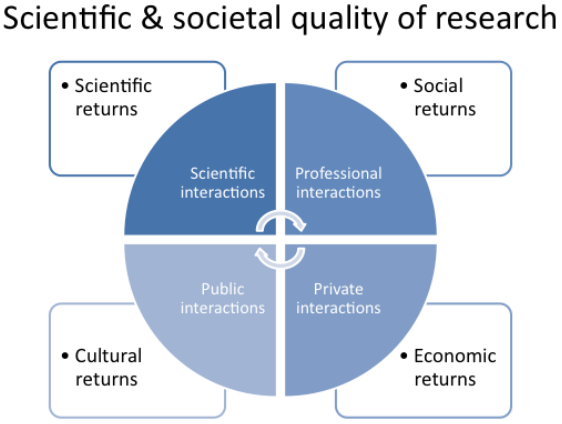
Conceptual framework

The research topic of this paper is valorisation and the socio-economic (societal) relevance of research. Based on the considerations described in the introduction, I use a concise definition of societal relevance: it is described as the value that is created by connecting research to societal practice and it is based on the notion that knowledge exchange between research and its related professional, public and economic domain strengthens the research involved. This definition encompasses explicitly more than economic value creation only (often referred to as valorisation). It also entails research that connects to societal issues and interactions with users in not-for profit sectors such as health and education etc. as well as to the lay public. The way to stimulate, monitor and measure societal relevance of research builds on three concepts that when

combined create a comprehensive framework:

- As mentioned above: the concept of "productive interaction" was developed and operationalised in the context of an EC funded project, SIAMPI (Spaapen and van Drooge 2011). Productive interactions are described as 'exchanges between researchers and stakeholders in which knowledge is produced and valued that is both scientifically robust and socially relevant'. Exchanges are mediated though various tracks and they are considered productive when stakeholders use or apply research results. The exchange in itself and the result of the exchange are both societal relevant and as such can be considered as proxies of societal impact. Stakeholders are the organisations involved in the exchanges; users are the individual groups or persons within that stakeholder community. Productive interaction between scientists and non-scientist stakeholders takes place in four broad domains: the private sector, the professional sector, the education sector, and the general, lay, public sector. To analyse these interactions, it is imperative to develop an overview of the type of activities aimed at societal stakeholders, which may differ depending on the scientific discipline.
- The logical framework approach (LFA) is often used in evaluation of policy measures in connection with accountability (Kellow Foundation 2004). Logical models are a management tool used in the design, monitoring and evaluation of projects, programs and institutes. Typical steps in the process include situation analysis, stakeholder analysis and problems analysis. Objectives and preconditions should be in line with the mission statement, and they ought to be SMART (specific, measurable, accepted, realistic and time-dependent). Objectives of performing research could range from a purely scientific objective (to obtain esteem), to an economic objective (to commercialize the research results), to objectives to improve society at large. When the objectives are well defined, it is easier to involve the right users and define activities that will lead to useful outcomes. It will also ease the monitoring and evaluation of the research. Defining mission, objectives, activities and specific stakeholders groups in order to create societal returns, in itself raises awareness. The incentive to create value thus contributes to the actual value creation.
- Science communication and outreach. While science communication often refers to the specific professional field of science communication, it can also refer to simply describing communication between scientists and non-scientists. Here it is used in the latter sense. It is relevant because some information is directly applicable, and may inform political and ethical thinking or stimulate public debate on specific matters. When societal relevance entails the valuation of communication of research groups with relevant societal communities (based on productive interaction), the resulting 'value' for the target groups is: Professionals > social returns; Private sector > economic returns; (Lay) Public > cultural returns, as compared interaction with scientists to create scientific returns (as measured by bibliometrics to assess the scientific relevance).

Figure 1 Conceptual framework societal relevance



Thus, when combining productive interaction, science communication and logical models, a general framework for scientific and societal relevance arises, that is depicted in figure 1. And we define the result of analysing and measuring productive interaction (of scientific research) with the non-scientific stakeholders as 'societal relevant' (in addition and complementary to the well defined 'scientific relevance').

The framework for scientific and societal relevance can be used for the evaluation of societal quality of a research group as the smallest entity. Likewise, it can be used for evaluation of programs and institutes. It is intended as a transversal, ex-post evaluation method that can be applied in any scientific domain; and it is related to the research-actor that reaches out to different societal domains. The next step needed is to measure the interactions and results of knowledge exchange in more detail.

Operating the framework

A first pilot was carried out in the Leiden University Medical Center (LUMC), which elaborates primarily on a (quantitative) approach to assess societal output and use of research performed by health research groups (Mostert et al. 2010). The method consisted of a process to get a societal relevance score per research department based on its (research) outreach to relevant societal stakeholders. These quantitative scores were then compared to standardised scientific quality scores (CWTS indicator) based on scientific publications and citations of peer-reviewed articles. Only a weak correlation was found between societal and scientific quality, suggesting that societal relevance needs additional activities to be performed by health research groups and is not simply the consequence of high scientific quality.

With the LUMC pilot, a discussion on metrics and indicators typical for a quantitative approach started, that concealed other useful elements of the framework: feedback to the research groups, defining mission and objectives by research groups and concomitant activities directed at one or more of the societal sectors, discussion on weighing factors, and peer review by external stakeholders in case of an external evaluation.

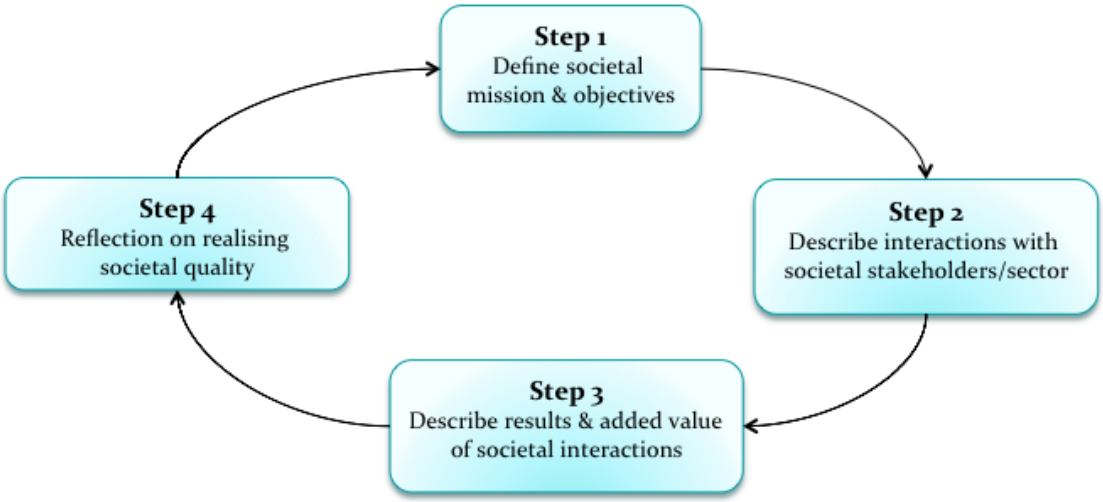
Often there is a struggle 'proving' the societal success of research, not only due to a lack of systematic datasets that can be used for evaluation, but also because it is not clear whether a success can be attributed to the research group in question. It is therefore important to develop activities and (performance) indicators at the beginning of a programming process (ideally when designing the logical framework) in order to be able to measure economic and societal success in the course of research. Monitoring gives insight in the progress of the research, and during the monitoring, useful information can be collected for the evaluation of the research. Ideally, the process of creating, monitoring and assessing societal relevance includes four discrete steps (see figure 2):

Step 1: Definition of mission and objectives

The start for evaluation of societal relevance should be describing / formulating the mission of the research group in terms of societal goals, which subsequently needs to be further developed into a number of discrete objectives. Essentially, mission and objectives describe how the research corresponds to the needs and expectations of societal actors. In addition, they are crucial as reference point in making explicit how a research group wants to achieve this: what activities are put in place in order to interact

with society. Ideally, the societal strategy and related activities are directly derived from the mission and objective. Interaction with key users and other stakeholders is necessary in various stages of the research and subsequent socio-economic 'valorisation' process: during the production of knowledge (inputs), during the exchange of information and knowledge with society (outputs), during the use of the knowledge by society (effects) and while institutionalized and appreciated in common practices and society at large (impacts) (Van Ark 2007).

Figure 2 Four steps to create, monitor and assess societal relevance



Step 2: Inventory of interactions with societal sectors and identification of stakeholders
The next step is to define who are the potential stakeholders, why they are important and in what way this is implemented in the research strategy. More specifically in this step both 'activities' and 'stakeholders' are defined. The stakeholder groups are divided in three broad domains as described above: the private professional sector (including private peers, business community, suppliers); the public professional sector (including professionals (the 'learned profession'), policymakers, public peers and students); and the general, lay, public. Especially in applied research, contribution to innovation of education is an important objective, in which case education can be included as fourth domain. Regarding the activities: it is imperative to produce an overview of the type of activities aiming at societal stakeholders and the number of occasions it is taking place. Depending on scientific discipline, activities may range from organising workshops, performing contract research to writing policy papers or taking part in a media event. Thus, information should be collected on the type of activities that have been executed to realize the socio-economic objectives, and the way the participants in the research group interact with the societal stakeholders.

Step 3: Analysis of the results and the value of interactions with societal stakeholders
While step 1 and 2 focus at the *process* of societal interaction, step 3 focuses at the output and the *results* of the interaction in order to define the value for both research group and the societal stakeholders. Results will be measured in two ways: Describe results by means of criteria and indicators on one hand, and describe and substantiate the value for stakeholders on the other hand.
To measure and value the socio-economic quality of research, indicators should be developed. These indicators ideally build on the interactions that are described in step 2, and useful indicators can only be identified in concurrence with the logic of the research

group, i.e. its mission and objectives. To choose useful indicators for the assessment of the research group, four rather simple criteria can be used (Deuten 2008).
1) Is the indicator relevant for the research group?
2) Is the indicator measurable?
3) Is the source reliable?
4) Is the assessment of this indicator repeatable?
In addition, different types of indicators measure

- the input: what effort or amount is spent on certain activities
- the output: what are direct results from the activities. These are often easy to quantify indicators, e.g. the number of visitors to an event.
- the outcome: how is the knowledge used, and how is it implemented in e.g. new methods or ideas. Here we can relate the outcome to the objectives.
- the impact: what are the societal effects that are achieved. Here we can relate the impact to the mission.

Impact is usually hard to establish since both timing (it takes a long time in order to reach impact) and attribution (it is hard to define the specific contribution of a research group in a whole range of contributions) hamper impact assessment. Therefore the emphasis of the method is on output and outcome indicators. In order to limit administrative actions, assessment of societal value should be restricted to no more than 10-15 indicators in total.
To assess the societal relevance of a research group, the evaluation should also encompass an external questioning of a representative set of stakeholders in order to substantiate the value for these stakeholders. This exercise can complement the measurement of indicators. For questioning of stakeholders, different methods are available such as (web based) surveys, in-depth interviews or focused workshops. The choice of a method depends on the size and the nature of the interaction with society, but also on the complexity of the interactions and the available time. It is recommended to outsource the questioning of stakeholders to an independent external partner. Thus step 3 quantitatively and qualitatively measures the interaction with key users and stakeholders.

Step 4: Reflection and analysis of societal quality achievements
Finally, the data need to be analyzed and a score needs to be given to the indicators in the different domains. This last step is also to reflect on the societal quality a research group has achieved in view of its own mission and objectives. This reflection is important for the research group itself but also when an external evaluation committee has been appointed. It will be a qualitative decision, again based on the mission and objectives of the research programme or organization, how the different indicators should be weighed. Do the scores correspond with the objectives formulated during the programming process? Core of the reflection will be a strength/weakness analysis, based on the qualitative decision that will result in points to improve for the future. These points can be either adjustment of objectives, approaching other stakeholders, displaying other activities or no change at all.

Type of societal interactions, outputs and results
As described above, the number of theoretical approaches about how to measure societal relevance of research is not accompanied by simultaneously collected empirical data. This is due to, on the one hand, a limited idea of whom the stakeholders of a research group may be and what kind of interactions with these stakeholders can be considered productive. On the other hand, there is a lack of systematic recording of data to substantiate productive interactions, and therefore lack of sufficient datasets. Many interactions that do take place are still implicit, instead of explicit. This prevents more in-depth research into the value of the interactions, quantitative approaches and visualisation methods.

Productive interactions are guided by basically three types of how researchers communicate their results: written (in any type of publication, book, note, patent or report), orally (presentations, conferences, TV or radio, exchange or collaborations) and in person (PhD students or post docs, carrying their knowledge with them and sharing it with others). Whereas sophisticated bibliometric studies are used to study the scientific impact of research, there is a lot less empirical data on all sorts of indicators that are proposed to measure societal relevance. The indicators that have been proposed range from indicators measuring knowledge products, via knowledge exchange or knowledge transfer to knowledge use in the professional, private and general public domain. The table below (Figure 3) presents a comprehensive overview (Vullings 2008). It includes all types of indicators, written, oral and in person. However, it is not clear as yet to what extent these indicators are really indicative of societal relevance.

Figure 3 Overview of possible indicators for the assessment of socio-economic impacts of research

Interaction with / During	**Private professional sector**	**Public professional sector**	**General public**
Production of knowledge (inputs)	$ participation in research from this sector (national and international)	$ participation in research from this sector	$ participation in research from this sector
	# participants in research from this sector (national and international)	# participants in research from this sector	# participants in research from this sector
	# of graduates/ doctorates working (part-time) in this sector	# of graduates/ doctorates working (part-time) in this sector	
	# of representatives of the sector in user groups or other role	# of representatives of the sector in user groups or other role	# of representatives of the sector in user groups or other role
	Existence of plans to valorize results to this sector	Existence of plans to valorize results to this sector	Existence of plans to valorize results to this sector
Exchange of information (results)	# interviews and articles in business media	# interviews and articles in professional media	# interviews and articles in popular media
	# patents, # patent filings # licenses	# publications	# popular publications
	# performances in private sector conferences, forums et cetera	# performances in scientific and public sector conferences, forums et cetera	# performances to popular forums, such as national tv, radio
	# (part-time jobs) of participating researchers in this sector	# (part-time jobs) of participating researchers in this sector	
	# training and courses to this sector	# training and courses to this sector	# contributions to educational material
	# training and courses from this sector (entrepreneurship, IP, scouting)	# training and courses from this sector	
	# contributions to private professional websites	# contributions to public professional websites	# contributions to popular websites
	# products and services developed for the commercial market	# products and services developed for the public professional market	# products and services developed for the public market
	# spin-offs # start-ups		# of people reached directly and/or indirectly

			by products and services
Use of knowledge (effects)	$ products and services used by commercial market	$ products and services used by the public professional market	$ products and services used by the public market
	# consultations by this sector	# consultations by this sector	# consultations by this sector
	$ revenue from patents		
	$ revenue from licenses		
	$ revenues from spin-offs and start-ups		
	$ revenues from other services to this sector	$ revenues from other services to this sector	$ revenues from other services to this sector
	# citations in commercial publications	# citations in professional journals and publications	# citations in popular media
	# new job openings	# new job openings	

Adapted from Vullings 2008 and Mostert et al. 2010

Empirical data

Building on this pilot and conceptual framework, the next step is to further increase the amount of empirical data. In order to avoid perverse effects of collecting data in database systems without knowing the exact meaning, I've set up further experiments as case studies to assess the awareness among researchers and stakeholders, to investigate specific interactions and ways to describe these interactions, and the response of researchers once they are confronted with results of societal relevance measuring. The research focuses on medical research, because it has wide societal implications on health. The case studies were selected around one type of institution or stakeholder, and focuses on both professional, private and public domain, with an emphasis on productive interaction with the professional domain, in order to study social returns in more detail.

Case studies are:

1. The Dutch Heart Foundation (NHS): this charity foundation has funded research almost exclusively based on the excellence of the research plans. Till now, little attention was paid to stimulating the use of research results, or trying to speed up the translation process. They come to realize that they owe it to their donators to show what has come from their donations, therefore accountability and the need to – eventually – improve health care solutions are their main incentive to engage in a process to include end users (different stakeholders) already in a early phase of research project, and define indicators in consultation with both researchers and stakeholders to monitor research.
2. The Forum Biotechnology and Genetics (FBG): this government funded multi-stakeholder platform (researchers, intermediary organizations such as advisory councils, policy officers, industry branch organization representative, patient organizations) is instrumental in translating research into policy and even legal directives. They want to know what kinds of interactions are indicative for their relevance. This case study covers the range from knowledge products via knowledge exchange to knowledge use, and provides insight in the tracks along which these interactions take place.
3. The Dutch Journal of Medicine (NTVG): This is a medical journal in Dutch, which is highly valued by medical practitioners that are not active in research themselves. The Journal has no international Journal Impact factor, but it would like to know how, and to what extent their medical research papers are used in practice. They are interested in defining indicators that together may present a societal journal impact factor. This case study will be combined with the use of more traditional bibliometric indicators, and altmetrics.

4. The LUMC pilot continued (LUMC): The results of the pilot were published in a paper in 2010, but the results were never presented to the departments, discussed in detail and reflected on. The case study will focus on the reflection step, and find out whether there is a specific mission and objective of the departments connected to the data. In addition, the indicators in this paper, despite being developed bottom up, will be discussed by both the researchers and their stakeholders.

Figure 4 presents how the four case studies cover all aspects of the cycle presented in figure 2 in an overlapping fashion. The results will be mirrored and discussed with the extensive table of potential indicators for societal relevance in figure 3.

Figure 4 Case studies

Step	Step 1	Step 2	Step 3	Step 4
Case study	LUMC, NHS	NHS, FBG	FBG, NTVG	NTVG, LUMC

This case study methodology is deployed because it offers the opportunity to investigate on a small scale what is considered societal relevant by researchers and by stakeholders, instead of imposing a set of indicators that are not recognized as indicating relevance. Dialogue is important, to move societal relevance out of theory for those being evaluated and to discuss the context of research evaluation on scientific and societal grounds (including the value of more traditional bibliometrics) in more detail to raise awareness. Empirical data collection is starting now.

Discussion

The ambition to turn Europe into a knowledge intensive and innovative society is still suffering from the so-called European Paradox: While the level of scientific production (publications) and quality in Europe is fairly high, the concern still is that the research is not being converted into successful wealth-generating innovations, new businesses and societal impact (King 2004; Bonaccorsi 2007). To decrease the distance between producers and users of knowledge and to be able to produce relevant research and develop successful innovations, interaction with users is indispensable. The LUMC pilot shows that separate activities are needed to strengthen the societal relevance of research. This can be partly addressed by making research more demand driven. Demand driven research and evaluation contributes to societal relevance when the user is involved in the problem solving process; when he contributes to the development of a guideline, prototype, or process; uses it in another application or further distributes the knowledge to third parties. Demand also refers to the choices of stakeholders, their participation in and expression of interest for the research planning and evaluation process. In a way, it makes people aware, and research and valorization a personal responsibility rather than a policy measure, which hardly aligns with daily reality.
From a research evaluation point of view, the need for appropriate evaluation instruments is part of the wider need of professionalizing the process of socio-economic valorisation at large at universities and institutes for applied science (Martin 2007). Not only the evaluation instruments are lacking, also at the policy level this so-called 'third mission' of universities is little elaborated. Education and research are still at the core of university strategy and valorisation in its broadest sense mostly lacks strategic planning at the highest level. Even though the long-term mission is to make the Netherlands a knowledge economy, in general there is little attention from the central executives boards of how to plan, organise, execute and steer the processes of benefiting from research. Instead, only fragmented activities were initiated; such as raising a technology transfer office and making them responsible for economic benefits only.
In addition, the relevance of societal quality is counteracted by the emphasis of research groups (and university boards alike) on internationally highly rated peer reviewed publications and citations as a measure for scientific quality (Van Leeuwen et al. 2003).

This explains why research groups have little notion of defining a mission and objectives on societal benefits into activities and interactions with specific stakeholders. And this also explains why societal benefits of research are to some extent coincidental (Cassiman and Veugelers 2002). Implicit societal activities do take place, but usually the goals are undefined, inputs for societal activities and stakeholder outreach are not allocated and results of the interaction with society are not made explicit.
Moreover, different scientific disciplines will be different in the production and the reach of their research, which can be shown by the general importance and nature of publications or other expressions of knowledge, the characteristics of different measures and channels that pick up different type of organizations, and the channels through which it is communicated. This is also the reason to skip the individual level: it turns out that only few people (17% of all) are able to act at different levels at the same time (Nelson 2012).

So creating socio-economic benefit (and measuring the result) has to overcome several barriers at the policy and research management level. Thus, in the early phase, the case studies will mainly raise awareness, and teach how to define objectives, make current activities explicit and identify a broad spectrum of stakeholders to interact with that could benefit from the results. Eventually it may also result in a further professionalizing of research groups or research institutes in taking on a systematic approach on strategic planning of research and its benefits to science and society. In turn, the collective intellectual capital of universities and research institutes will become available to society at large.
Finally, we anticipate that integrating the evaluation of scientific impact and societal relevance at the same time is currently not acceptable, neither politically nor practically. Mixing an experienced process with a developing process is probably more frustrating than assessing both aspects separately. When in due time the assessment of societal relevance is accepted and understood at all levels, then the evaluation of scientific and societal quality might be integrated in one process.

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