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Understanding societal impact through studying productive interactions

ICT research in the UK and the Netherlands

Stefan de Jong , Katharine Barker, Deborah Cox, Thordis Sveinsdottir, Peter Van den Besselaar

Abstract

Universities are increasingly expected to complement their traditional research and training missions with that of a third mission to reflect the engagement of universities with society, through the application and exploitation of knowledge. Previous research has resulted in limited knowledge on how field specific interactions between academic researchers and societal actors relate to the societal impact of academic research. This paper seeks to assess the impact on society of the work of university research, by examining in detail several case studies taken from the field of ICT research and to address what patterns of productive interactions result in societal impact within 'fragmented adhocracy fields' and what implications these patterns have for societal impact assessment of these fields. Our approach proves it is possible to identify how and what researchers have contributed to social impacts. Shifting focus to interactions allows short term knowledge transfer efforts contributing to societal impacts to be assessed.

Introduction

Beyond education and research, universities are increasingly expected to realise their 'third mission'. These 'third mission' activities of universities are meant to stimulate the application and exploitation of knowledge for the benefit of the social, cultural and economic development of society. They shape the interaction between universities and academic research with the wider society (Pålsson et al. 2009; Tran 2009). Several concepts have been suggested for this interaction in the academic literature, such as 'Mode 2 knowledge production' and the 'Triple Helix of university-industry-government relations' (Gibbons et al. 1994; Etzkowitz and Leydesdorff 1998; Hessels and Van Lente 2008). However, these remain at a rather general level and do not help to *assess* societal impact at the level of individual research projects and programs. For this, a range of methods have been proposed, developed, and sometimes tested (Davies, et al. 2005; De Jong et al 2011; Spaapen & Van Drooge 2011; Donovan & Hanney, 2011; Bozeman & Sarewitz, 2011). Inspired by these concepts and methods, science policy makers and funding agencies have introduced a variety of instruments to stimulate relationships between science and society, including European Framework Programmes, the Dutch Bsik-FES programme, and the UK Economic and Social Research Council's Science in Society Programme.

Simultaneously, (experimental) indicators for societal impact are increasingly included in national research evaluation exercises. The swift conversion of societal impact assessment from craftsmanship to standard and routinised activity in research evaluation and by funding agencies leads Ben Martin (2011) to fear that *'…we may be in danger of creating a Frankenstein monster*' as it remains unclear what impact exactly is and how it can be stringently and soundly evaluated. A rather wide range of definitions exists of the concept of societal impact. Bornmann (2013) identifies three main strands of defining societal impact in research evaluations since the 1990s. These strands seem to represent three subsequent stages in the process of research having impact:

- Societal impact as *a product*: Knowledge with a potential societal value is embodied in a product that may or may not be used by societal audiences (Boekholt, Meijer and Vullings 2007). Among these products, one may distinguish between information, products, tools and instruments, methods, models. An example is the summary for policy makers of the report 'Managing the risks of extreme events and disasters to advance climate change adaption' issued by the IPCC (2012);
- Societal impact as knowledge *use*: Interaction processes between researchers and societal stakeholders may result in the adoption of knowledge by the latter (Moffat et al. 2000; Roessner et al. 2006; Castro Martinez et al., 2008). Knowledge use may be facilitated by a product (the use of a policy report by civil servants) or a person (researchers as consultants);
- Societal impact as societal *benefits*: Effects of the use of research results. Within this category, many notions of societal impact can be found. Focus can be on policy, professional practice, economy, or on wider impacts, such as the impact on culture, media and community. Impact can have the form of jobs and education (Library House

2006), or network building, trust, and community formation (Walter, Helgenberger, Wiek and Scholz 2007).

There is no clear one answer of how to evaluate social impact. In research evaluation, differences between fields create challenges for comparison (Donovan 2007; Martin et al., 2010, Lane 2010). The same holds true for societal impact evaluations (De Jong et al., 2011). Furthermore, most of the proposed societal impact indicators focus on economic impact (for example, Health Economics Research Group, Office of Health Economics and RAND Europe 2008) or health impact (Bensing et al., 2004), which suggests that other fields require additional indicators for measuring their societal impact. In addition, many of these indicators are output or outcome indicators, whereas process indicators are less represented. The latter are needed when the time lag between research results and societal outcomes is large. In those cases, the type and intensity of interactions may be a reliable predictor of societal outcomes in the long run. Societal impact process indicators should be based on an improved understanding of the complex interactions between academic researchers and societal stakeholders. Which interactions are important, or even required, for research to have impact? Two types of interactions can be distinguished in the literature.

- First are *direct* interactions by academic researchers with stakeholders during and after the research process. These interactions may generate relevant research questions, may improve access to financial and material resources, and may support knowledge diffusion (Bozeman and Coker 1992; Molas-Gallart et al., 1999; Cowan and Patel 2002; Molas-Gallart and Tang 2007; Academy of Finland 2009). In the process of stakeholder involvement, personal interaction between researchers and stakeholders may accelerate research uptake (Meagher et al. 2008; Brousselle, Contandriopoulos and Lemire 2009). The involvement of key persons, such as high level civil servants, have been found to increase success chances even more (Molas-Gallart and Tang 2007; Kennedy, Seymour, Almack and Cox 2009; Krücken, Meier and Müller 2009). Alternatively, malfunctioning personal interaction hampers research having societal impact (Kingsley, Bozeman and Coker 1996).
- Second are *indirect* interactions mediated through information carriers. For instance, this can be in the form of texts (Molas-Gallart, Tang et al. 1999; Molas-Gallart and Tang 2007; Health Economics Research Group, Office of Health Economics et al. 2008; Prins 2008) and of technological artefacts (Kingsley, Bozeman et al. 1996; Kingsley and Farmer 1997).

Earlier works show these interactions take place in often complex networks. The network configuration, the actors (researchers, intermediaries and stakeholders), research fields, and societal sectors involved may all influence societal impact and the way it is, or isn't, generated (Molas-Gallart, Tang et al. 1999; Krücken, Meier et al. 2009). There is an urgent need for further studies on these interaction processes. Cozzens et al (2002) suggest the challenge in measuring societal impact is due to a paucity of well-developed models explaining the processes leading from innovation to impact. In a report about the value of medical research, the Health Economics Research Group *et al.,* (2008) stated that there is consensus in the academic literature about the existence of societal impact of academic research, but that it is less clear how different processes of knowledge transfer contribute to it. In their study of the impact of a German university on its geographic region, Krücken *et al*., (2009) argue that there is a need for additional studies to completely grasp the fundamental dynamics of knowledge transfer. Jensen, et al. (2008) pleaded for more qualitative research on the interaction mechanisms deployed by academic researchers.

These interaction processes with stakeholders are subject to field specific dynamics. As Whitley (2000) argues, different fields are characterized by different research dynamics, based on internal factors as well as on contextual factors. Research dynamics are fundamentally related to the organizational characteristics of a field. For example, if in a certain field researchers depend less on peer recognition for careers and funding, they have more freedom to address a large variety of audiences. If there is no clear hierarchy between these audiences and these audiences also have different objectives, dependence of scientists upon any single audience is lower than in the case of a strict hierarchy between audiences. In cancer research, for instance, patients have different objectives than peers. This offers other practices and aims than purely scientific ones, such as funding by patient organizations next to funding councils (Whitley 2000). Verbree *et al.* (2011) indeed found that medical research groups have a wide variety of funding sources, indicating a wider variety of audiences.

To summarise, previous research has resulted in limited knowledge on how field specific interactions between academic researchers and societal actors relate to the societal impact of academic research. Furthermore, evaluation methods for societal impact mostly have neglected these interactions so far. In a European FP7 project *Social Impact Assessment Methods for research and funding instruments through the study of 'Productive Interactions'* (SIAMPI) we aimed to overcome this gap by *studying interaction processes between academic researchers and their stakeholders* in four different research fields. Interviews were used to trace interactions between researchers and their stakeholders to identify societal impact. [1] Molas-Gallart and Tang (2011) tested the method in the social sciences and humanities. Their conclusion is that it offers a way to deal with attribution problems that are widespread in the evaluation of these fields. In these domains, research dynamics are intertwined with social and political developments. Moreover, mapping productive interactions helped researchers to reflect on their engagement with users and society. However, the value of the method has not been determined for other research fields yet.

The aim of this paper is twofold. First we aim to extend the scope of our SIAMPI approach by empirically testing the concept of productive interactions in other research fields than social sciences and humanities as done by Molas & Tang (2011) and De Jong et al (2011). In this

[1] Spaapen, J. and L. Van Drooge (2011). "Introducing 'productive interactions' in social impact assessment." *Research Evaluation* **20**(3): 211-218.

way we hope to contribute to a better theoretical understanding of how societal impact is produced in a variety of research fields. Secondly, we aim to contribute to improving the evaluation of these fields. We focus on the class of fields labeled ‘professional adhocracies’ by Whitley, which includes engineering, artificial intelligence and bio-medical sciences. These fields are unique in combining standardized research methods with a wide variety of audiences. Other fields, either have highly varied audiences, but low standardization of research procedures, for example the social sciences (fragmented adhocracies) and humanities (polycentric oligarchies), or have highly standardized research procedures, but a small variation in audiences (technologically integrated bureaucracies), such as chemistry.

Nevertheless, in professional adhocracies performance-standards are mainly set by scientific peers. Other audiences have less influence on evaluation criteria (Whitley 2000). Consequently on the one hand serving highly varied audiences is intrinsic to these fields, while in evaluations, emphasis is on the academic audience. This creates a tension in adhering to standards set by the peer community on the one hand and being relevant to varied audiences on the other hand. Furthermore, professional adhocracies display a high variation of research topics within each field. If commercial applications exist, the variety increases even more (Whitley 2000). Mapping productive interactions in one of these fields has to take into account a wide variety of research dynamics and thereby serves as a serious test for the method.

The main questions we will answer in this paper are (a) What patterns of productive interactions result in societal impact within ‘fragmented adhocracy’ fields, which are characterized by standardized research procedures on the one hand and a highly varied audience on the other hand? (b) What implications do these patterns have for societal impact assessment of these fields?

The following section explains the method of our study (the SIAMPI approach), and discusses the selection of fields and cases. The subsequent section describes four cases in terms of the observed productive interactions and the societal impact. The fourth section presents the comparative analysis of the cases, leading to the impact indicators presented in section five. The concluding section reflects on the value of the SIAMPI approach for the evaluation of societal impact of fields that can be characterized as professional adhocracies’.

To answer our research questions, we co-developed the SIAMPI approach (Spaapen and Van Drooge 2011), based on the earlier ERiC project (De Jong et al 2011). At the core of the approach is the notion of productive interactions. Productive interactions are defined as encounters between researchers and stakeholders in which both academically sound and socially valuable knowledge is developed and used. The method distinguishes direct interactions and indirect interactions. Within these interactions, different carriers may be distinguished, including and amongst others, that of funding. Products and knowledge transfer are considered interactions and not impact. Interactions are also characterized by their duration and the resources involved. Examples of resources are IPR agreements, financial contributions and use of research equipment. Impact is regarded as the consequences of knowledge applications: research has impact if stakeholders changed their thoughts and behaviour based on the research outcomes. Stakeholders are broadly defined as all the actors involved in the process that leads to societal impact. This includes societal actors such as governments, NGOs, industry and consultancy firms but also researchers from other fields that take up knowledge and further develop it.

Method and cases

To trace productive interactions, the SIAMPI approach includes interview protocols. Separate protocols are available for researchers and stakeholders. The researcher protocol includes the following item categories: interviewee profile; research context in terms of users; mechanisms of interaction and outcomes/impacts. The stakeholder interview includes items on: interviewee profile; knowledge context in terms of use of academic knowledge; mechanisms of interaction with the academic researchers on the one hand and their own stakeholders on the other hand and outcomes/impacts for/on their organisation.

From the fields that can be characterised as *professional adhocracies* we have selected ICT research because we expect to find a large variety of productive interactions in this field. It has a wide range of applications everywhere in society: in the commercial sector, as well as applications within government and for example, in research and education. To study productive interactions between ICT researchers and their stakeholders, we have selected two contexts; a society-oriented multi-university research programme with multiple stakeholders involved from the outset and a more traditional setting of a single university research department with no pre-determined stakeholder audiences. These different settings are chosen to explore a variety of research dynamics within the field.

We have focused on the UK digital economies research[2] programme, which is funded by four UK Research Councils, with a broad societal aim: to bring about the transformational impact of ICT for all aspects of business, society and government. Within the programme, we selected a project in which two universities cooperate with a variety of societal stakeholders. These are multinationals in the ICT and electronics sector; local organisations including patient and government organizations and some 3000 volunteers from the region, including people from a range of age groups and with a variety of disabilities. Under these circumstances, we expected to find many productive interactions between ICT researchers and their stakeholders.

The selected academic university department is located in the Netherlands. It has an excellent scientific reputation, including a broad range of both theoretical and applied computer science. Research of the group is heavily funded through EU and national research programs. In addition there was evidence of interdisciplinary collaboration by computer science staff with economists and social science researchers. Within the department we have selected one fundamental and two applied research groups.

[2] http://www.rcuk.ac.uk/research/xrcprogrammes/Digital/Pages/home.aspx

Data were primarily obtained through one to two hour semi-structured interviews, following the SIAMPI interview protocols, which we adapted to the ICT field. In total we have conducted 22 researcher interviews and 8 stakeholder[3] interviews. The interviews were recorded, fully transcribed and checked by the second interviewer. The interviews were analysed to identify the various types of productive interactions, as well as the outcomes and social impacts. Alongside the interviews, texts such as websites, annual reports, policy documents and evaluation reports were used to obtain contextual information.

Results

This section presents a selection of four cases, which are representative of our findings. For each case, productive interactions and impacts are described, together with factors that influenced the interactions and impacts of the research.

Case 1: A fundamental project with societal benefits: Forensic software

A professor of a Dutch research group in knowledge representation and reasoning was involved in a ten year research effort during the 1990s that resulted in a standard language for ontologies for the World Wide Web. The language developed facilitates software applications *'that need to process the content of information instead of just presenting information to humans'*[4]. The research undertaken resulted in new standards for the semantic web and in one of the best-cited papers in the field[5]. The impact on the development of the semantic web is also an obvious societal outcome of the research.

Furthermore, the research resulted in a spin-off company, which is the focus of the first case. Over the years the company employed many former Masters and Doctoral students of the group. In 2009 after ten years of research and development, the company launched a software product for forensic research, which allows intelligent investigation of large numbers of e-mails and data files. The product became a success. Four phases of interactions can be distinguished in the process from academic research to product launch.

(i) Between 1998 and 2001 academic knowledge was being *developed into technology*. The leader of the academic research project took part-time leave from the university in order to be involved in the new spin-off company, which was founded by a former classmate and personal friend of his. In this phase, his most important role was demonstrating the *potential value* of the technology. The professor and the company signed an IPR agreement stating

[3] In this study, stakeholders are broadly defined as beneficiaries of the ICT researchers that have been interviewed. NGO's, funding agencies, governments and private companies, other scientific researchers, such as biologists and medical scientists are included.

[4] http://www.w3.org/TR/owl-features/

[5] The paper received an award for the highest impact over the past 10 years at the 2012 at the International Semantic Web Conference. Impact is based both on citations and on impact on the community. This award is one of the most prestigious in the field.

that all IPR will rest with the company. In this phase, the professor and employees of the company co-authored a number of scientific papers, which were presented at academic conferences.

(ii) From 2001 to 2005 the company was involved in projects to demonstrate the *viability* of the technology. The goal was to translate the academically developed technology into a practical tool for use outside the university. The owner of the company financed the R&D. Pilot projects were undertaken in the building industry and in the education sector amongst others. The company also participated in EC funded projects with various academic institutes and large firms, large telecom and insurance companies. Every three months meetings were held with the professor, in which he had two main roles. He firstly served as the company's antenna in academia, for example by highlighting upcoming new standards and formats to take into account. He secondly brought in his network. The university based research group provided the company with skilled employees and interns, who served as an additional interaction mechanism between himself and the company.

(iii) The phase of *product development* began in 2006 and ended in 2008. In this phase the goal was to slim down the tool to its essential core. The role of novel academic knowledge became less prominent and meetings with the professor were held only twice a year. His role shifted towards providing complementary knowledge rather than providing state of the art advice. The company shifted its focus towards the market.

> *'We* [the company] *said: 'we will make it a success', so we could not stay in our ivory development tower, we had to go into the field and talk to police departments, we had to give presentations…'*

In this phase, the need for knowledge on marketing and software engineering grew and external investors were recruited for financial support. Knowledge on licensing was obtained externally and engineers were hired from a polytechnic where the owner of the company had been employed.

(iv) From 2009 onwards the focus has been completely on *marketing*. The relation between the university and the company now ismaintained through the scientific board of the company, of which the professor became a member. A joint venture with a software vendor with market knowledge was created to enter the market. Within nine months a worldwide sales organisation was established to distribute the software. The product is sold in combination with training on how to use it and has already been sold to police departments in the Netherlands, China and the USA, and to international accountancy companies. It is used to investigate digital information in the fight against crime and fraud.

In terms of the three approaches to impact, this case is an example of impact as a *societal benefit.* More specific, the research resulted in economic and safety impacts.

Case 2: A fundamental project with limited societal benefits so far: Investigating medical protocols

When asked for his best recent paper, a researcher in knowledge representation and reasoning mentioned a paper in which he and his colleagues showed that medical knowledge could be represented using reasoning tools based on mathematical logics. They were the first researchers that had achieved this. The project was funded by the European Commission through a FET-open grant; a grant for blue-sky research in future and emerging technologies in ICT[6]. The test case in this project was a medical protocol for breast cancer treatment. Initially, medical researchers thought that it would be impossible to capture medical knowledge into logics because it would be too complicated. Experts from logics, on the other hand, thought that it would be impossible because medical knowledge would not be precise enough to do so. After a few years of research in an international consortium, the approach was successfully applied on the case of a protocol for the treatment of breast cancer. The stakeholder involved in this project is an institute responsible for improvement of quality in health care, including medical protocols. The researchers collaborated intensively with the institute but not with medical researchers themselves. One of the results of the project was that existing treatment recommendations proved to be inconsistent.

Regardless of the success of the method and its obvious potential value for medical practice, the societal impact of this research has remained only limited to present date. The researcher explained that apart from financial investments outweighing quality improvement, the method was too far ahead of its time to be incorporated into medical practice at the time. Applying the method requires skills, which are hardly available and the deployment of formal reasoning in medical practice would require substantial changes in existing routines and in existing culture. Absorptive capacity to deploy the method is lacking at the level of the every-day medical practice. Therefore, IPR agreements have never been made, since from the beginning it was clear the project would not result in a marketable tool. Nevertheless, because of the study, an institute responsible for improvement of quality in health care realized it should improve its internal quality procedures.

Unlike the previous case, the principle investigator is not putting any additional effort into stimulating societal application for the method since he does not consider it to be his responsibility and there is a lack of incentive to be involved in third mission activities. *'Do we try to keep it in the spotlight so…no…that is unrealistic. Knowledge transfer…to say it bluntly…I'm neither paid nor rewarded for knowledge transfer or directed towards it...to be honest…I did not become a scientist to do those things.'*

This does not mean the efforts put into developing the method were not of any use. The research is taken further in a new project that aims to integrate static data in personal health records into the dynamic data of the protocols. Integrating static and dynamic data is a scientific challenge in computer sciences, with potential societal benefits. Knowledge on

[6] http://cordis.europa.eu/fp7/ict/programme/fet_en.html

formalizing dynamic data gathered in the previous project is used in this project. In terms of the interaction types, the uptake of the method by other societal relevant projects may lead to *indirect* societal impact.

Summarizing, in terms of the impact concepts distinguished in the introduction, the knowledge developed in the project described here clearly was *used* by societal stakeholders. However, the sectors' absorptive capacity is simply not large enough to adopt this type of innovation at this moment and turn it into a societal benefit, as it is not compatible with existing practice and skills. The approach developed in this project may turn out to be a necessary contribution to changes in practice, but in isolation it is not sufficient for change.

Case 3: A fundamental project contributing to societal benefits: Medical imaging technology

In 2003 the Dutch government funded nearly 40 new research programmes at a total cost of 802 million euro. The goal of these four to eight year programmes was to strengthen the future national knowledge base[7]. One of the aims of the programmes was the translation of fundamental knowledge into new products, processes or societal concepts. Consequently, the programme leaders also have a responsibility for knowledge transfer and dissemination.

Among the programs was the Virtual Laboratory e-science programme (VL-e). It aimed to improve e-sciences by developing facilities and methodologies. Within the Medical Sub Programme, the Medical Diagnosis and Imaging Project focussed on recognition of digital images. This project resulted in a software tool that is now widely used within a university hospital. The tool is expected to contribute to finding a cure for Alzheimer's disease at a much faster rate than had the tool not been developed.

The software tool is based upon the work of a (fundamental) theoretical computer science group and an (applied) research group on high performance distributed computing. Both belong to the same university department. The groups cooperated on developing methods for the recognition of digital images. The fundamental group develops protocols that are used by the applied group in developing software for distributed data processing. One of the results is a generic software platform for distributed computing.

The software platform was further developed within the VL-e programme. There, collaboration emerged between researchers from the applied research group and a post-Doctoral researcher in medical technology at a university hospital. The goal of the latter researcher was to improve the ICT environment within the hospital. After a few meetings, the post-doc started to adapt the generic software to the environment of the hospital.

The post-doc needed a test case for further development of the software. At the hospital he approached a radiologist who was studying brain images to identify biomarkers of

[7] http://www.agentschapnl.nl/programmas-regelingen/besluit-subsidies-investeringen-kennisinfrastructuur-bsik (6-12-2011)

Alzheimer's disease. Pharmaceutical companies used these markers in clinical trials. The software he used to study the images was rather inefficient; it took half a year to analyse the thousands of images resulting from his research. The radiologist, however, was reluctant to use the newly developed software tool, since he was not able to see its value. By coincidence, the radiologist happened to play field hockey with an employee of an ICT support organization, who had supported the post-doc in his research.

> *'But also it turns out that the medical doctor, the radiologist, who doesn't know much about computers but is a very good radiologist, understands shrinking brains, happens to play field hockey with the ICT support person at […] that I was dealing with. So they talked.'*

The ICT support person convinced the radiologist to give it a try. From that moment on, the radiologist and the post-doc had many conversations about what ICT had to offer and about the radiologists' needs.

Despite the fact that the distributed computing researchers had to continue working at the forefront of their own field, they remained involved in the development of the software. The medical post-doc served as a translator between the distributed computing group and the radiologist. The computer researchers preferred to provide academic support through e-mail; over 700 e-mails in total were sent back and forth. Ultimately, a software tool was developed to study brain images 300 times faster than before. An analysis that used to take half a year now could be done overnight. In terms of impact definition, in this case there is a clear change in practice because of knowledge use by stakeholders. The change in practice has resulted in a *societal benefit,* if medical researchers are considered stakeholders of ICT researchers.

In spite of the cooperation in the project, no joint publications of the computer scientists and the medical researchers were produced, because of disciplinary boundaries. What is frontier research in the medical imaging field is a case in applied ICT research.

Case 4: An applied project on its way to societal benefits: Ambient Kitchen

The Digital Economy Programme[8] is a nationally focused cross-research council programme from the UK. It is aimed at providing capability in the early adoption of information technologies by business, government and society and focuses on the transformational effect that these technologies can have. One of three UK research hubs funded through the Digital Economy programme is the Social Inclusion through Digital Economy (SiDE) hub, a collaboration between two universities that have worked together on previous projects within ageing, assisted living and technologies. The hub addresses some key strategic and applied research questions, which aim to yield innovations across the fields of technology, social science, business and user engagement in research.

[8] http://www.rcuk.ac.uk/research/xrcprogrammes/Digital/Pages/home.aspx

One of the projects in the hub is the Ambient Kitchen. This is a lab-based project through which the research team are exploring the use of pervasive computing for assisted living. In brief, The Ambient Kitchen embeds sensors in the kitchen environment, for example in the floor, cupboards, kettles and food containers that allow the kitchen to be aware of how food and utensils are being used. Tags integrated in food items and appliances, together with sensors integrated into the bench and cupboards, allow the location, and changes in location, of objects to be monitored; and a pressure sensitive floor allows people in the kitchen to be tracked.[9] The project team are particularly interested in supporting the elderly and those with dementia.

The Ambient Kitchen is a research platform and the software is in a constant stage of development and re-development. The Ambient Kitchen is a collaborative university led research project involving significant numbers of users in several different 'groups'. Interactions between researchers, volunteers and stakeholders are structured from the outset into the Digital Hub project. It includes regular demonstrations for a variety of groups such as university students, representatives from other universities, members of the public, city council members, company visitors and the media by researchers of the technologies developed from The Ambient Kitchen work being undertaken. The concept of delivering demonstrations to a variety of groups was planned but the type of audience is subject to opportunities emerging during the timescale of the project.

The project aims to work with volunteers, including people from a range of age groups and with a variety of disabilities. Recruiting to the volunteer pool has been carried out through local governmental departments and local charities including Years Ahead, the Regional Forum on Ageing and The Alzheimer Society. The panel of volunteers is contributing to the formulation of research strategy and the evaluation of the research outputs, as well as being engaged in participatory design, co-design and evaluation activities to ensure that the outputs of the research programme are both meaningful and usable.

Other interactions factored into the planning of the project included membership by the Digital Hub researchers of various charities which were engaged in the research to help recruit users. Being involved with the charities helps the research teams to maintain strong links with the user community and to develop the applications. The involvement of the research may be personal but is a link that can be exploited and has benefits for the research activity and in principal for the charity's community.

The aim is to set up 20 to 30 ambient kitchen installations in real private homes, within the next five years, and do further field tests before considering commercialization. As the project is ongoing, the full impact has not been realized yet. It is however clear that work on the ambient kitchen includes many different productive interactions between scientists and societal actors in the form of publications, awareness raising and liaising with stakeholder

[9] http://culturelab.ncl.ac.uk/ambientkitchen/

groups. The latter will help in articulating user needs and in generating feedback on new products and services.

In terms of the types of impact, and the interaction types, this case is an example of societal impact as knowledge *use*: Interaction processes between researchers and societal stakeholders results in adoption of knowledge by the latter

Comparative analysis

The previous section described four different cases of research projects/programmes with their specific audiences, productive interactions, and types of impacts. This section aims to analyse the cases and collect the building blocks for indicators to assess professional adhocracies based on an understanding of their research dynamics.

Table 1: Overview of the findings

	Impact		Stakeholders of researcher		Productive interaction types		Interactions caracteristics	
case	**Scholarly**	**Societal**	**Direct**	**Indirect**	**Direct**	**Indirect**	**Resources (Human, Financial, Technical, Legal)**	**Duration**
1 Basic	Highly cited paper	SOCIETAL BENEFIT* Spinoff-company. Successful product. New standards for the semantic web.	Spin-off company	Building industry. Education sector. Police departments. Accountancy firms.	Professor participated in company in different roles over time. Co-authoring papers. Presentations at scientific conferences. Advice by professor. Hiring employees with additional skills.	Internships. Graduates of involved group. Scientific papers.	IPR Agreement. Company funding. EC funding. Joint venture. Sales contracts.	Long, from knowledge development to product introduction
2 Basic	Proof that representing knowledge in logics is possible	USE OF KNOWLEDGE* Demonstrating inconsistency of treatment recommendations. Realization quality	Organization for improvement of quality in health care	Health care sector (medical doctors, nurses, hospitals) and patients	Face to face working meetings with stakeholder. Formal project meetings with research consortium.	Take up of results by other research project – which may have societal	EC funding through FET-open; medical protocols	Medium: during knowledge development and use in one case

case	Impact		Stakeholders of researcher		Productive interaction types		Interactions caracteristics	
	Scholarly	**Societal**	**Direct**	**Indirect**	**Direct**	**Indirect**	**Resources (Human, Financial, Technical, Legal)**	**Duration**
		procedures should be improved.				impact.		
3 Basic	Generic software tool for distributed computing	SOCIETAL BENEFITS* Software tool for medical imaging resulting in 300 times faster image analyses	Post-doc medical technology	Radiologist and other medical researchers the university medical hospital	Formal meetings Informal meetings	Software tool E-mail Intermediary person	Government funding through VL-e	Long period of knowledge development, development of tool
4 Applied	Academic conference articles and position papers	USE OF KNOWLEDGE * Ambient kitchen incorporating prototype system	Charities, City Council Volunteers in user groups People with Dementia Carers, University Students Representatives from Other Universities Members of the Public, Company Visitors, Media.	Broader Community. This project promotes Community Cohesion	Volunteer panel Conference disseminations Demonstrations Membership of Charities	On-line forums Prototypes feedback forms newsletters, project website newspaper/ magazine articles	Commercial company Council and Charity representatives working within the project	Duration of the project

* Type of impact as distinguished in the introduction

ICT research, as expected, has a *wide variety of stakeholder* audiences (table 1). In some cases, such as The Ambient Kitchen, contact with stakeholders, including charities and city council members is directly between researcher and stakeholder. In many cases, of which we have only presented one, ICT research is translated by multiple other researchers, before societal stakeholders benefit from research results. This is exemplified in the medical imaging case.

We have found a *variety of productive interactions* between ICT researchers and their stakeholders (table 1). There are direct interactions, including demonstrations in The Ambient Kitchen, indirect interactions such as the software in the medical imaging case, and financial interactions, for example the investments in the forensic software case. There does not seem to be a distinction between interactions that are more likely to lead to impact and interactions that are less likely to do so.

What does seem to be important for the creation of (or occurrence of) social impact are interactions that take place after the research has been completed, as a comparison between the forensic software case with impact and the medical protocol case without impact demonstrate. Both technologies were promising and in the medical protocol case stakeholders acknowledged the value of the research. In the first case the professor was committed to further development of the knowledge, since the owner of the company was a personal friend and many employees were former Masters students and Doctoral students of the professor. It is not the incentives of the research system, but the social network of the involved researcher that seems to be the decisive factor. In the latter case the researcher was not committed to further development of the technology. In addition, strong links with the large and complex user community did not exist.

Comparing the cases, there does not seem to be a difference between societal relevance and impact of fundamental and of applied research. There does, however, seem to be an important difference in the research configuration. In fundamental projects, it is not clear from the outset, which end-users might benefit from the research. That makes it difficult to include them directly. As a result research is conducted in 'knowledge development chains' with many interactions in each link. A stakeholder in one link can be the researcher in the next. This type of configuration seems to yield generic results with a wide range of potential applications. The knowledge development chain can have different branches resulting in different applications of the same generic research results. Examples are the forensic software project that emerged long after the research project had been finalised, and the medical imaging project.

In applied projects the end-user is more likely to be known and therefore can be included in the project from the outset, as we have seen in the Ambient Kitchen case. In that case, research is conducted in a 'beehive' configuration, where researchers from multiple fields and stakeholders from different backgrounds can interact simultaneously to achieve a common goal. This type of configuration seems to result in outcomes with a specific application.

Apart from the issue of not (yet) known end-users there is also the issue of the complexity of the user network. In the case of the medical protocols, the potential users were well known (the doctors in the field) and therefore, this is a basic research project with known users. However, the development from the prototype into usable and used tools requires many different types of additional innovations and changes in order to have the technology implemented. Additionally, the researcher together with the medical doctors involved did not have the position or instruments to influence this larger use-system. In the image analysis case, the users were not yet known and potentially there are many. Nevertheless, a relatively simple chain of actors enabled the development into a specific application for a specific user type.

In basic research we often see one (essential) innovation and the development into an innovation then requires a follow up trajectory that depends on the complexity of the context.

In case 2, the context was much more complex than in case 3 (and case 1). Furthermore, the involved researchers and the organization for quality improvement in health care were not connected to the main players. This may explain the different outcomes in terms of use: To have a tool adopted by a group of medical researchers is much easier and requires less socio-technical systems innovations than to have a tool used by the medical profession, which is strongly institutionalized, regulated, and dominated by huge interests. Applied research, in contrast, often includes from the onset an analysis and development of the whole socio-technical system in which innovations would be used, and not only one (albeit crucial) component.

Table 2: Type of research, complexity and obtained impact

Research type	Case	Complexity	Impact
Basic (without innovation strategy)	2	High	Use of Knowledge
Basic (plus innovation strategy as follow up)	1 3	Low Low	Societal Benefits
Applied	4	High	Use of Knowledge

The following images show in brief the interaction networks. Where the researcher collaborates with a stakeholder who is well integrated in the use environment and has a significant interest in ‘selling the product’, societal relevance changes into deployment of the innovation in society.

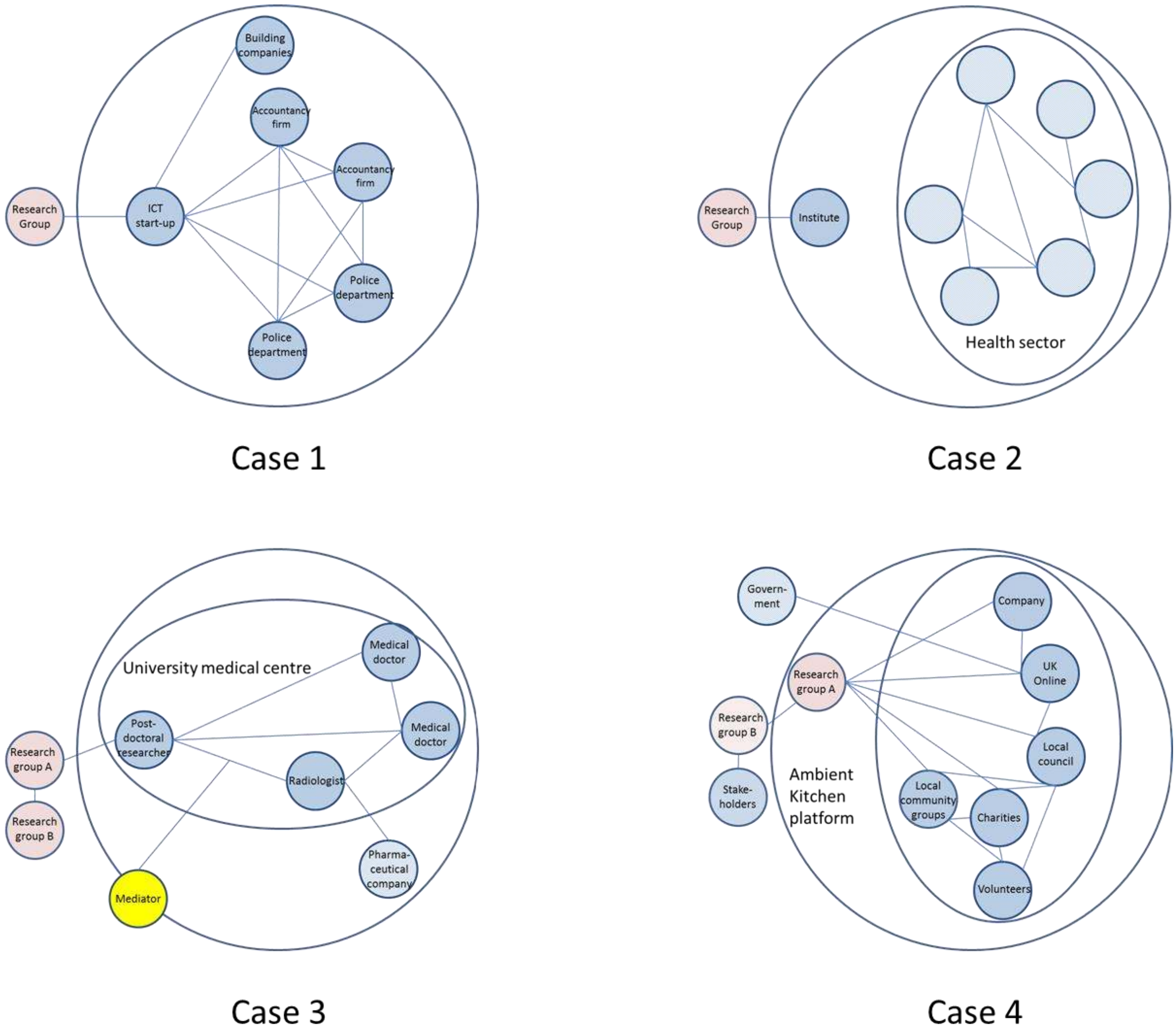

Figure 1: Network diagrams of the cases

Tracing these productive interactions, we found *a number of impact types* of ICT research (table 1). It can have safety impacts, exemplified by the potential improvement of medical protocols. It can have commercial impacts, such as the forensic software (which could also be considered a safety impact). It can have an impact on the quality of life, as the Ambient Kitchen and medical imaging cases show. In all cases, ICT research was one of the contributors to the impact. The knowledge it produced had to be further developed, as in the forensic software case, or it facilitates the advancement and impact of other disciplines. ICT research contributed to the resulting impacts, rather than bringing them about by itself. Two consequences of this facilitating role can be seen in the cases. First, it takes time for ICT research to have impact; it took ten years from an academic web language to a commercial forensic software tool. Second, impact also depends on the stakeholder. If a stakeholder acknowledges societal relevance of research outcomes, but lacks, for example, resources or absorptive capacity, there will be no societal impact. The medical protocol case is a clear example of such a situation.

Discussion

Our study served two aims. The first aim was to extend the scope of the SIAMPI approach by empirically testing the value of the concept of productive interactions in ICT research as a representative case of professional adhocracies. Investigating processes and interaction, rather than results or products helped to construct a more complete picture of the societal impacts of this type of research. Two classical problems in research evaluation can be overcome with this more complete picture. The first is the problem of attribution. Attributing impacts to individual researchers or single research groups is problematic because usually more parties, also from society, are involved in knowledge production. Using the SIAMPI approach it proved possible to identify how and what researchers have *contributed* to societal impacts. The second is the problem of temporality. It is well known, as some of our cases also demonstrate, that there is a considerable time lag between research and impact. By shifting focus to interactions short-term knowledge transfer efforts contributing to societal impacts can also be assessed.

On first sight, the approach might seem to have two disadvantages. First, the approach may appear to be labour intensive because of the collection of data through interviews. We believe this is not necessarily the case. Data collection can be guided by two questions: 1) who - and how - do you interact with in your research and who do they interact with about your research results – now and in the past? and 2) what has your contribution been to their opinions and activities? Answering these questions facilitates self-reflection and preparing research evaluations. The SIAMPI approach not only helped us to identify stakeholders, audiences and impacts of research, it also actually revealed audiences that the researchers were previously unaware of when assessing societal impact.

Second, the approach of tracing productive interactions might be mistaken for adopting a linear point of view. Due to a setting of accountability and evaluation, it is about the impact of research on society and not about the impact of society on research. Nonetheless, before knowledge is transferred from the academic domain to the societal domain, there are many two-way interactions between the research community and societal stakeholders. For instance, research questions are fine-tuned with stakeholders and findings are tested in societal environments after which stakeholders provide feedback. It is exactly these interactive processes that are captured by the SIAMPI approach.

The second aim of the paper was to contribute to improving the evaluation of ‘professional adhocracy’ fields. From the comparative analysis of the four cases in the previous section, we may derive indicators and implications for the evaluation of ICT research. Four lessons can be formulated.

First, our cases show that it is insufficient to focus only on direct contacts that researchers have with societal stakeholders when assessing their societal impact. ICT research contributes to societal impact of other research fields, as well as to its more direct societal impacts. In other words, when assessing ICT research’s societal impact, other research fields are important stakeholders. Output indicators to assess this function of ICT research can be software tools and data tools. Use of these tools is an indicator of quality. In some cases evidence of use will be co-authorships, citations or acknowledgements. In other cases evidence has to be collected qualitatively.

Second, one should be careful appreciating certain types of output, activities or types of research more than others. Our cases do not provide evidence that some of them lead to more impact than others. This also implies social impact assessments should be careful in evaluating basic research with limited societal stakeholder involvement. As basic research by definition is less direct in leading to impact than applied projects with a wide range of stakeholders, one should always look at the position of the research in the larger interaction network between research and audiences.

Third, post-research support - ranging from support through e-mail conversations to being (part time) employed by a spin-off company - to stakeholders seems to promote societal impact. This leads to an additional societal impact indicator for evaluating research institutes or programmes: are incentives present for post-research support to societal stakeholders?

Finally, when it comes to assessing actual impacts emphasis should be on (i) *contributions* of research to societal impact instead of *attributing* societal impact to specific research and (ii) *efforts* instead of *results* (which does not exclude acknowledging results), as successful innovation is not the standard outcome. Furthermore, (iii) appropriate time frames should be used if the aim is to show concrete societal impacts.

As explained above, this paper tests the Siampi approach for *professional adhocracies*. Molas-Gallart and Tang (2011) have shown the value of the approach in *fragmented adhocracies*, taking the social sciences as a test case. In both cases the method could be fruitfully applied and our findings are in line with those of Molas-Gallart and Tang: focusing on the process rather than focusing on the impact itself helped to identify impacts previously unknown (case 3) and interactions are crucial for impact to occur (case 2). In further research we will investigate the production and evaluation of societal impact in other fields, such as climate science. This may lead to a more complete picture of how societal impact is generated and should be evaluated in different ways in different fields. Through this we may avoid the creation of the Frankenstein's monster (Martin 2011) that may do more harm than good to the science system and to societal benefits it brings.

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