This is a paper for the academic strand (A), targeting theme 4; Universities as interactive partners. This paper is the draft of the introductory chapter of a compilation thesis building on five papers (Jacobsson and Perez Vico, 2010; Perez Vico and Jacobsson, 2012; Jacobsson et al., 2013b; Perez Vico 2013; Hellsmark et al., 2013).

Capturing and explaining utilities stemming from academic research and development

Eugenia Perez Vico

Environmental Systems Analysis

Chalmers University of Technology, Gothenburg, Sweden

eugenia.perez@chalmers.se

Key words – impact of academic R&D; technological innovation system; research evaluation; utility of research

EXTENDED ABSTRACT

There is a growing interest in identifying and assessing utilities that stem from academic R&D. This calls for appropriate evaluation schemes founded on realistic representations of utilities. Although many have contributed with analyses of how research is made useful, the main focus has been on a selection of indicators in the form of firm creation, patenting, licensing and publishing within a rather short time scale (Jacobsson et al., 2013a).

However, this focus has substantial limitations since it (a) fails to capture less tangible and indirect utilities, (b) does not account for the influence from the surrounding context and (c) ignores the considerable time-lags involved when making science useful (Jacobsson and Perez Vico, 2010). There is, thus, a need for representations that include wider range of utilities, incorporate the contextual influence and allow for an appropriate time scale. Although some studies embracing several of these aspects have been conducted (e.g. Gibbons and Johnston, 1974; Mazzoleni, 2005; Meyer-Krahmer and Schmoch, 1998; Saxenian, 1994), an analytical approach that systematically takes all of them into account is lacking.

A framework that has proven suitable in understanding the role of academic R&D is the technological innovation systems approach (TIS) (e.g. Bergek et al., 2008a,b; Carlsson et al., 2002; Hekkert et al., 2007). Its use has lately been explored in the science policy domain (e.g. Hellsmark and Jacobsson, 2009; Mohamad, 2009). It is suitable since it enables a holistic analysis through a descriptive systems approach, and focuses on key innovation sub-processes and their interdependences through which long-term and indirect utilities stemming from academic R&D may be captured. Although this approach has been commonly used in studies of technical change, its potential for the understanding of how research is made useful has not been fully explored.

The purpose of this paper is, thus, to explore how utilities stemming from academic R&D can be captured and explained using the TIS approach. The research question is addressed by constructing a framework bringing together existing conceptualizations of how research creates utility and applying it empirically.

Drawing on the TIS approach and the research policy literature on academic utility, the framework of this paper is developed in four steps. First, a taxonomy of academic activities is compiled from a set of key references (see Jacobsson and Perez Vico, 2010). The activities are *conducting research*, *scientific publishing*, *educating*, *providing explicit guidance*, *commercialising*, *providing research infrastructure* and *networking*.

Second, to capture direct utilities, activities are linked to the list of key innovation sub-processes in the TIS approach. The key innovation sub-processes are *influence on the direction of search*, *legitimation*, *market formation*, *entrepreneurial experimentation*, *resource mobilisation*, *knowledge development and diffusion* and *social capital development*. This linking generates a 7x7 matrix where 37 out of 49 hypothetical utilities are recognized in an extensive literature review (see Jacobsson and Perez Vico, 2010). Third, long term and indirect utilities are captured in the form of *sequences of impact* – patterns that unfold as the impacts of activities are traced through interdependences between innovation sub-processes (Perez Vico, 2013). Fourth, individual patterns of impact of researchers/research groups emerge in previous steps. These patterns are explored in the form of different roles that researchers may take in making research useful, generating a taxonomy of seven roles; *researcher*, *teacher*, *advisor*, *debater*, *networker*, *infrastructure developer* and *entrepreneur*.

To test and illustrate the framework, three in-depth exploratory case studies are conducted on (i) Swedish nanotechnology research, (ii) energy research at a Swedish technical university and (iii) the research of a physics professor. Data comes mainly from semi-structured interviews with researchers, research managers, industry representatives and policy makers. These cases include (i) 35, (ii) 22 and (iii) 29 respectively. Also, extensive secondary data is collected from reports, books, research evaluations, documentations from events, news articles, on-line documentations, as well as analyses of patents and publications. The data is coded as activities and innovation sub-processes, and then analysed, searching for utilities, sequences of impact and roles. Hypotheses are checked in the data and through follow-ups with respondents.

The cases on nanotechnology research in Sweden and energy research at a university of technology explores and illustrates the first and second step in the development of the framework (Perez Vico and Jacobsson, 2012; Jacobsson et al., 2013b). A multidimensional picture of how different researchers work and create utilities is revealed. Impacts on expected sub-processes, such as *knowledge development* and *entrepreneurial experimentation*, are identified. However, utilities that previous literature has given less attention to are found to be very important, such as *influencing the direction of search* of actors, enhancing the *legitimation* of a field and *developing social capital*. In this case the framework also allows exploring how utilities are induced or obstructed by factors beyond academia's influence.

The case on the physics professor explores and illustrates the third step in developing the framework – the sequences of impact (Perez Vico, 2013). Long-term and multi-dimensional sequences appear, often within several decades. This reveals how utilities are deeply intertwined in, and enabled by, networks with competent and engaged partners. Impact on *knowledge development and diffusion* and *influence on the direction of search* are continuous and cumulative, and enable *legitimation*, *resource mobilisation* and *social capital development*. In turn, the latter two enable further impacts on the other innovation sub-processes, including, *entrepreneurial experimentation* and *market formation*.

The case of energy research at a technical university also illustrates fourth step of developing the framework – the roles (Hellsmark et al., 2013). The show how researchers differ in the types of utilities created. In particular, roles that previous research has given less attention to, such as *advisor*, *debater*, *networker* and *infrastructure developer*, appear to be important. The case also illustrates how the roles are interconnected as (a) taking on one role is a prerequisite for taking on another, (b) roles can be combined into "meta-roles" and (c) different researchers enacting different roles complement each other. The case also illustrates how the roles interact and depend on the context, that is, other system elements and exogenous factors.

In conclusion, this paper offers a framework for capturing and explaining academic R&D utilities. The framework is holistic since it applies a systems perspective on the generation of academic research utility, dynamic since it traces impact on sub-process dynamics as compared to solely structural change and it is context-dependent since it systematically accounts for contextual influence. Also, it draws the attention to a number of aspects that could easily be overlooked but which are essential in order to capture the full benefit of research. First, it accounts for multidimensional utilities that go much beyond those captured by conventional indicators such as spin-offs, patents and publications. This includes accounting for variations in how researchers create utilities through the role-based typology. Second, it draws particular attention to more subtle roles and utilities such as guiding beneficiaries through being a longstanding intelligent conversation partner, facilitating the development of social coherence through providing neutral meeting places or educating specialized human capital whose affinity drives collaboration, or educating the public through enriching societal debates. These utilities are largely related to significant, yet less tangible sub-processes such as *influence on the direction of search*, *legitimation* and *social capital development*. Third, this framework includes long-term indirect benefits that unfold in sequences of impact, mediated through students, firms or policy-makers. Thus, this framework explains how the generation of utilities is deeply intertwined in the actions of others. Fourth, the framework contributes to the understanding of how wider settings, beyond academia's influence, conditions the development of utilities. This pertains to other structural elements in the TIS as well as to the TIS external factors. Thus, the framework not only identifies the utilities but also contextual factors that condition their impact, guiding policy in systemically improving the impact. Fifth, the framework shows how utilities may unfold over a long period of time. It illustrates how it may take several decades for the substantial impact to emerge.

This paper has implications for research policy. First, policy should support the development of an informed view on how research is made useful that acknowledges multi-dimensional, indirect and long-term utilities. A strong view among many academics and policy makers is still that the utility of research equals direct commercialisation, which may lead to misguided expectations and efforts. Second, policy should offer support systems that induce the development of a wide set of utilities and move beyond those focusing exclusively on conventional commercialisation. Current support systems for making research useful at universities are still dominated by incubator programs and technology license offices that fail to support a wider set of utilities. Third, policy should apply research evaluation schemes that account for long-term multi-dimensional utilities and consider the influence from the setting. Solely focusing on quantifiable indicators, particularly narrowed down to spin-offs, patents and publications, is insufficient. Not only should indicators of a wider set of utilities be included, the indicators should be complemented with case stories. Many utilities cannot be captured in quantitative terms and are deeply intertwined with, and thus inseparable from, the influence from other factors.

References

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., Rickne, A., 2008a. Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. Research Policy 37, 407-429.

Bergek, A., Jacobsson, S., Sandén, B., 2008b. 'Legitimation' and 'Development of external economies': Two key processes in the formation phase of technological innovation systems. Technology Analysis & Strategic Management 20, 575-592.

Carlsson, B., Jacobsson, S., Holmén, M., Rickne, A., 2002. Innovation systems: analytical and methodological issues. Research Policy 31, 233-245.

Gibbons, M., Johnston, R., 1974. The roles of science in technological innovation. Research Policy 3, 220-242.

Hekkert, M.P., Suurs, R.A.A., Negro, S.O., Kuhlmann, S., Smits, R.E.H.M., 2007. Functions of innovation systems: A new approach for analysing technological change. Technological Forecasting and Social Change 74, 413-432.

Hellsmark, H., Jacob, M., Perez Vico, E., 2013. Enacting knowledge transfer: A context (in)-dependent and ”role-based” typology for capturing utility from University research Submitted to scientific journal.

Hellsmark, H., Jacobsson, S., 2009. Opportunities for and limits to Academics as System Builders - The case of realizing the potential of gasified biomass in Austria. Energy Policy 37, 5597-5611.

Jacobsson, S., Lindholm-Dahlstrand, Å., Elg, L., 2013a. Is the commercialization of European academic R&D weak?—A critical assessment of a dominant belief and associated policy responses. Research Policy 42, 874-885.

Jacobsson, S., Perez Vico, E., 2010. Towards a systemic framework for capturing and explaining the effects of academic R&D. Technology Analysis & Strategic Management 22, 765 - 787.

Jacobsson, S., Perez Vico, E., Hellsmark, H., 2013b. The many ways of academic researchers - how science is made useful. submitted to scientific journal.

Mazzoleni, R., 2005. The Contribution of the Escola de Minas to the Development of Brazil's Iron Industry (1876-1930), 2005 EBHS Conference, High Point, North Carolina.

Meyer-Krahmer, F., Schmoch, U., 1998. Science-based technologies: university–industry interactions in four fields. Research Policy 27, 835–851.

Mohamad, Z.F., 2009. The Role of Universities in national cartching-up strategies; fuel cell technology in Malaysia and Singapore, SPRU. University of Sussex, Sussex.

Perez Vico, E., 2013. Tracing sequences of impact from academic R&D: An in-depth study of a professor in physics Submitted to scientific journal.

Perez Vico, E., Jacobsson, S., 2012. Identifying, explaining and improving the effects of academic R&D: the case of nanotechnology in Sweden. Science and Public Policy 39, 513–529.

Saxenian, A., 1994. Regional Advantage, Culture and Competition in Silicon Valley and Route 128. Harvard University Press, Cambridge.