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How does public agricultural research impact society? A characterization of various patterns

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ABSTRACT

This paper characterizes the various impact patterns generated by an agricultural public research organization (PRO), namely INRA (National Institute for Agronomic Research). We define an impact pattern as the combination of specific research outputs with specific actors that generates various types of impact. The analysis is based on information related to more than a thousand INRA innovations for which research outputs, beneficiaries, and impacts, have been codified. A classification based on the Partitioning Around Medoids (PAM) method is used to identify the seven main impact patterns.

There are two patterns that correspond to traditional INRA interventions to foster agricultural sector competitiveness; two that are related to innovations in health and economic issues; and two that have impacts on the conservation of natural resources. The seventh involves scientific advice related to public policy decisions. The research outputs and beneficiaries differ across these impact patterns. For example, those with economic impacts are more related to the agricultural sectors while impact patterns in the area of health affect industrial firms.

1. Introduction

Many countries aim at evaluating the societal impact of public research. This urge is explained by the shortages in public funds, the diffusion of New Public Management rules and by changes in the research system[1]. The public research system is increasingly governed by collaboration with industrial partners, interdisciplinarity, "context-driven" research targeted towards specific users and needs. Public Research Organizations (PROs) and researchers who formerly were evaluated only by their peers based on scientific excellence criteria, are being pushed by the different funding agencies and stakeholders to take a wider view of their performance that includes the societal utility of the knowledge produced. The PRO mission to achieve scientific progress has been extended to include the resolution of societal challenges through collaboration with and diffusion of knowledge towards socio-economic partners, and contribution to public policy decisions and scientific debate. In that context, PROs are required to adopt or develop methods that provide evidence of the societal returns from their research results. This pressure is especially strong for PROs involved in targeted research, e.g., in agriculture, to address stakeholders' issues. Evaluations of PROs have to show that the PROs' research results are generating various types of benefits for their various stakeholders and beneficiaries.

Such performance evaluations are made more complicated by the fact that: (i) the impacts are generally diversified, because PROs have multiple missions, (ii) the impacts generated result from the activities of multiple other actors than the PRO being evaluated, (iii) evaluation method needs to be standardized and applicable to various scientific domains and types of impact. Assessment of the broader impacts that take account of social, cultural, political, environmental, health, and economic returns, has been tackled by several studies and various evaluation exercises such as: the Research Excellence Framework in the UK (Martin, 2011); the NSF's broader impact criterion (Kamenetzky, 2013); the SIAMPI approach (Spaapen and Van Drooge, 2011); and the Payback Framework (Donovan and Hanney, 2011). These studies analyze the roles of multiple actors in the knowledge value and outcome generating processes. Many are based on case studies and combine qualitative

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[1] cf. 'Mode 2' knowledge production (Gibbons et al., 1994), 'Entrepreneurial University' model (Etzkowitz, 1998).

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data and quantitative metrics to assess the societal impacts of research. These analyses are interesting to understand the mechanisms that explain the impact generating processes, but are limited in their ability to aggregate individual stories to understand the different impact patterns generated by a PRO. Our paper tries to fill this gap by using an original clustering method on a large dataset of innovations.

The objective of our paper is to characterize the diversity in the impact patterns generated by the French PRO, INRA (National Institute for Agronomic Research). We define an impact pattern as the combination of specific research outputs with specific actors that generates various types of impact. INRA conducts targeted research in agriculture, food, and the environment. Its research generates economic, health, environmental, and political impacts, all of which are taken into account in our impact patterns. INRA was created just after WWII, and has a long tradition of partnerships with socio-economic actors. Due to the development of private research in agriculture and the emergence of new societal demands, INRA has been repositioning its objectives towards more basic research, and some of the areas that prioritize public value (Bozeman and Sarewitz, 2011). Agricultural innovations based on research results generated by INRA usually involve multiple actors (extension services, private companies, government bodies).

The analysis presented in this paper relies on a dataset that includes over a thousand events and records of research results expected to generate societal impacts. Records were collected for every year from 1996 to 2010 through a bottom–up process. For each record, we codified the elements of the impact pattern: the outputs, the beneficiaries, and the potential impacts. A statistical analysis based on the PAM (Partitioning Around Medoids) clustering method allowed us to characterize seven impact patterns. These patterns reflect regularities in the diverse effects on society. An understanding of these patterns should allow INRA to improve its knowledge transfer practices. The value of our analysis is that it is based on a large sample of research events that is representative of the multiple activities and missions of the PRO. To the best of our knowledge, very few analyses have been conducted on such a large sample of research events.

The paper is organized as follows. Section 2 reviews the literature on the evaluation of public research impacts. Section 3 introduces the data that is used for the PAM analysis in Section 4. Section 5 presents the results and describes the seven impact patterns generated. Section 6 discusses the results and concludes.

2. Evaluating public research impacts

We first review the literature on the economic impacts, and then work on the assessment of their broader impact. This body of work helps us to identify the impact pattern components (actors, research outputs) that need to be considered. Finally, we present our research approach.

2.1. Evaluating the economic impacts

Numerous economic analyses are based on econometric estimations of an aggregate production function, and evaluate the contribution of research and development (R&D) to productivity growth at the country or industry level. In general, they find a positive relationship between public and private R&D expenditure and economic growth and productivity. These methods include approaches that calculate rates of return to evaluate the social benefits associated with the R&D investment. There are several empirical studies, especially focused on the agricultural sector, that provide robust findings of very high (20–60%) social rates of return (see Alston et al., 2009; Evenson, 2001). At the aggregate level, the social rate of return exceeds the private rate of return. Jaffe (1998) develops this type of model at the level of the US Advanced Technology Program (ATP) and shows that the social return could be increased by combining the positive effects of knowledge, markets, and network spillovers. Such approaches have the advantage that they quantify the economic benefits, and are useful for justifying existing public R&D programs. However, they do not add to our understanding of the process of generating economic benefits.

A number of evaluation studies analyze the various economic impacts of specific public R&D programs. The US ATP has conducted various evaluation studies using different methodologies (Ruegg and Feller, 2003). Apart from the above-mentioned social returns approach, ATP has used survey methods that exploit information on the activities, relationships, accomplishments, and licensing results of multiple actors. Also, case studies have been used to understand how and why certain developments, such as the dynamics of collaboration between different participants, emerged. Some case study investigations include quantification of the costs and benefits of the project. Econometric and statistical analyses provide information on the functional relationships between economic and social phenomena, and forecasts of economic effects, such as crowding out effects between public and private funds. Social network analyses have added to our understanding of how the structure of a project could increase the diffusion of new knowledge. Bibliometric studies have been applied to evaluate the number of publications and patent citations that have been generated by the program. Historical tracing helps to identify the linkages between a research project and its subsequent economic impacts.

Some of these methodologies have also been used to assess the European Framework and other programs (Georghiou and Roesner, 2000; Policy Research in Engineering Science and Technology PREST, 2002). Overall, this set of studies estimates a wide range of economic impacts, such as cost savings, rate of adoption of technologies, the impact of increased product quality on sales, efficiency of alliances, networking effects, human capital effects, impacts on firm's productivity, etc. Each study analyzes a particular type of economic impact based on specific hypotheses and analytical backgrounds on how the impact occurs. They take account of elements, such as research outputs, networking, cooperation, and learning processes.

Another stream of work focuses more generally on the influence of public research on industry R&D (Cohen et al., 2002). Using survey data, Mansfield (1991) shows that, over a 10-year period, 11% of new products and 9% of new processes would have been delayed at least one year in the absence of the public research conducted in the previous 15 years. Mansfield (1998) estimates that the value of the innovations that could not have developed without scientific results, accounts for 5% of total firm sales. Based on patent citations, Narin et al. (1997) show that between 1987 and 1994, the knowledge flow between US science and industry tripled. Well-known surveys, such as the Yale and the Carnegie Mellon Surveys, evaluate how public research impacts on industry innovation. They show that, with the exception of medicine, some chemical products, and electronics, universities and PROs have few direct effects on industry R&D (Klevorick et al., 1995). Cohen et al. (2002) show that firms use the following research outputs (in the order of their importance): research findings, new instruments and techniques, and prototypes. The authors highlight that public research results are transferred to industry via publications, informal interactions, conferences, and consulting. Patents and licenses as technology transfer mechanisms are useful in only a few industries.

In the context of outputs, Salter and Martin (2001) consider that publicly-funded research contributes to economic growth in several ways: by increasing the stock of knowledge, training skilled graduates, new scientific instrumentation and methodologies, development of networks, stimulation of social interactions,