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Technology transfer between basic research and industry

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Abstract

Pure science-driven incentives and applied industrial and technology policy have seldom produced significant synergy. The demarcation between basic and applied research is still valid, yet from the industrial and macro-economic point of view this classification has become obsolete and the pursuit towards common welfare should be prioritized.

This paper studies what steps should be taken in a large-scale basic research centre to produce, in a more efficient way, both the epistemic utilities required by the scientific community and the practical utilities demanded by industrial and national institutions. The aim is to develop an approach that enables industrial companies to consolidate themselves with the technologies and other services needed to accomplish major basic research experiments. The paper provides an overview of the concepts describing the technology transfer, diffusion and innovation functions in an organization and how they should be implemented into the strategy and operational activities of a basic research centre.

The paper concludes that without organized and well focused interaction with industry the gains from basic research are not exploited. It presents various scenarios of cooperation and practical suggestions to accomplish fertile communication between academic community and industry. The key factor in collaboration is in learning by interacting; thus, being part of the knowledge creation process, the prospects for both scientific inventions and industrial innovations are established. The underlying case is that of CERN and especially the 10-year accelerator project at its commencement.

1. INTRODUCTION—TECHNOLOGY DIFFUSION AND TRANSFER

Technology transfer and related topics such as technology diffusion and dissemination have established themselves as essential parts of the prevailing research and technology development policy on both the national and the European level. Visible evidence of this is, for example, the Commission's agreement to accept most of the European basic research centres to participate directly in the various Community research and technology development programmes. One clear objective of this kind of collaboration is to promote scientific and technological development in a stringent economic situation and in ever more resource-demanding research. Yet it is argued that pure collaboration is not enough, the industrial and economic impact of the research should also be exploited, and the yield of the money invested in fundamental research should be realized in shorter cycle times. The issue of industrial and academic collaboration has been valid for some time, yet it has been shadowed significantly with political debate and the practical standpoint has been ignored. The paper strives to promote the operational and practical issues to establish means for fertile collaboration between market forces and academic research.

As the topic is of current interest there is a clear need to define some of the key concepts used. The word 'diffusion' originates from the Latin verb *diffundere*, which means the spread of something in an environment or a space. Thus, technological diffusion means the passive spreading of technological knowledge, related to an innovation, around technological society. Technology transfer is an active and intentional process (licensing, foreign investments, buying) to disseminate or acquire knowledge, experience and the related artifacts. Hawthorne [1 (p. 65)] points out that transfer presupposes agreement and therefore involves payment, as diffusion is the money-free process of the spread of knowledge from person to person and from firm to firm. Diffusion concerns the knowledge itself, while transfer involves both the replication of the knowledge and the physical things related to an innovation. In this respect technological transfer can be seen as a special case of diffusion. This also means that diffusion and transfer create possibilities for further innovations, not by means of imitation but as a normal development process. Diffusion process is a vital element in the origins of technical change.

The rest of the paper focuses on the various ways and scenarios to create technical change from collaboration between industry and fundamental research. First, we will examine the various motivations of this kind of collaboration; this is followed with a schematic study of structural alternatives to perform such collaboration. Then the strategy implications of industrial and academic interaction are viewed both from the applied technology and from the fundamental research point of view. After this the metrics to assess this kind of collaboration are studied and some preliminary suggestions are put forward. Finally, conclusions are drawn.

2. MOTIVES AND OPPORTUNITIES FOR COLLABORATION

Every change, whether on the economic, academic or technological side, produces favourable circumstances for action, i.e. opportunities to be grasped at. To be successful, the exploitation of opportunities presupposes enough accumulation of all the aspects involved with the respective technological knowledge. A firm pursuing a technological opportunity is taking its chance to make profit out of the moment by aiming at an innovation. The speed of reaction to a technological opportunity is a critical factor in the success of industrial economics. To put this in evolutionary terms, the empty niches of the techno-economic system provide opportunities for change, but there is no certainty that mutations will take place which will take advantage of these opportunities. Yet, by playing and operating continuously around technical changes, the prospects for prominent innovations are set. The sources of new ideas stem from random occurrences which tend to have more meaning to active rather than to absent minds.

The experiments performed by fundamental research, almost without exception, push the achieved and prevailing technological advancements to the extreme. These are exactly the circumstances in which technological development takes place and where the economic potential of new inventions is significant. Several innovation studies [2–7] which focus on technology-intensive new products show that connections to the academic world are vital at certain points of the innovation process. This aspect becomes even more important when completely new technologies and methods are being developed. Thus, collaboration with fundamental research bears the possibility for radical innovations and not only for incremental innovations.

Dosi [8 (pp. 1135–1136)] divides the sources of opportunities into scientific-related and other sources. The former has played a central role in the building of this century's major new technological paradigms (synthetic chemistry, the transistor, bioengineering), while during the 19th century new paradigms were typically introduced by imaginative craftsmen. The economic growth of the 20th century could be explained by the increasing number of opportunities initiated by the mutual links between science and technology. Advances in science play a major direct role, especially at an early phase of the development of new technological paradigms. In this respect the opportunities are bound to paradigms and they take place in technological trajectories.

The opportunity for new products and innovations is not the only motivation for collaboration. To ease the speed of diffusion, concepts such as 'new industrial districts' and 'new industrial spaces' have emerged in everyday technology policy discussions, and in reality technology villages, manufacturing areas, science parks and other convenient arrangements for manufacturing and R&D have been established. As Andersen and Lundvall [9 (pp. 11–12)] have pointed out, 'learning by interacting' through technological networks has become as important as the traditional 'learning by doing and using' as the source for new innovations. Yet these interactive networks tend to be bound either to scientific or to industrial work. Apart from the important face-to-face contacts, together with today's technical possibilities, these distinct networking realms could be brought together to provide true means for continuous interaction with no significant barriers of physical distance. This would produce efficient and well focused diffusion channels for the technological information produced, which could also be governed and controlled by restrictive authorization and access policy.

The following things may be listed to summarize the main sources of motivation for collaboration between science and industry:

- in most cases major technological advances and innovations originate from interaction between industry and the scientific community, thus this kind of activity should be encouraged;
- several studies provide inductive evidence that so-called 'non-mission oriented' research, i.e. activities with no direct links to customer requirements and money making but to objectives bound to pure technological performance, constitutes a fertile source of new innovations;
- technological breakthroughs require nowadays significant investments and the resources directed to fundamental research should also contribute to industrial competence; thus collaboration is justified and in compliance with rational technology policy;
- a well proven fact is that increased interaction and collaboration between diverse partners provide leverage to the creation of new ideas, i.e. the cross-

fertilization of various problems and approaches to solve them is justified and appreciated;
- the transfer of technological knowledge is not a one-sided phenomenon, from fundamental research to industry, but a two-fold process where the interference and cumulative effect of information from both parties provides solutions and new insight with both an epistemic and an economic impact.

An example of a massive technology transfer and development project which aims to promote academic and industrial interaction is the German state biotechnology programme. The systematic collaboration started as early as 1968, yet still in 1988 its share of the total funds for academic science accounted for 56% [10 (pp. 98–100)]. This shows that technology transfer in a new branch of research requires both industrial and public impact to integrate fundamental research with the innovation processes. The programme has resulted in several product and process innovations.

3. COLLABORATION STRUCTURES

There are very few cases of systematically organized collaboration between fundamental research and industry; even scarcer are the follow-up reports of these kinds of venture. The German state biotechnology programme resembles the one the Japanese have been practising very successfully. Perhaps the best known governmental institution to coordinate and promote a nation's industrial competence is the Ministry of International Trade and Industry (MITI) in Japan. MITI has, or at least used to have, the power to pull together and subsidize groups of firms and research institutions to do cooperative research. By concentrating on certain key industries (computers, automobiles, consumer durable goods) MITI has orchestrated the R&D attacks, using the knowledge of the main firms in order to achieve commercial success (see, e.g., Freeman [11, 12]). In the US a similar organization is the Department of Defense (DoD), whose activities in military development have spun off several new technologies and companies. These cases already show that the focus of concrete actions in the field of technology transfer has been more on a national level. On the international level, rather well documented technology transfer operations are carried out between industrialized and Third World countries, e.g. in solar technologies. But what about the multinational and publicly funded basic research centres, such as CERN,[1] where one nation's interests are intermingled with international policy making and the common good is not so easily defined?

There are various ways of organizing technological collaboration between industry and the basic research centres. One way is to promote interaction through direct contracts between companies and specific development projects within the research centre. These contacts would focus more on problem solving and new technology development efforts, whereas service and pure material delivery based bids and operations could be conveyed through special front-end companies. These front-end companies could act more as representatives of the industries of each participating nation and provide the research centre with quality assurance and follow-up services. Thus, the level of technological skills determines the level of collaboration. Fig. 1 aims to depict transactions on the low technological level of interaction.

The main idea of this kind of collaboration is to partially out-source the purchasing operations of the research centre towards the front-end companies. Front-end companies mediate the invitations to tender to the industry they represent and perform preliminary preselection of the potential vendors. The final screening process is carried out by the research centre. Collaboration according to this structure already exists at CERN, yet the operational level varies significantly between member countries. This concept works well when the content of the collaboration is on a simple technological level, e.g. most of the civil engineering projects, bulk material deliveries, maintenance work, out-sourcing of the service functions such as health care, surveillance etc. These transactions may not be regarded as technology transfer, and the next step is to promote interaction on higher technological levels with the emphasis on problem solving and new technological advances.

Technology transfer, as defined earlier, is an active and intentional process, where the collaboration takes place in a preplanned manner. Therefore the objective is not to close as many deals as possible and to make profit directly, but to focus on the content and the possible gains of the interaction, which are, hopefully, rewarded in the future. To some extent we are broadening the concept of transfer as an activity with one direction to comprise two-fold interaction. In its purest form technology transfer is seen as an errand with no clear understanding of the outcome, yet the collaborating parties bring in their special and diverse skills to promote the results. Laamanen and Autio [13] and, with quantitative data, Autio [14] have classified and studied numerous—more than 30—mechanisms and channels of technology transfer. One of their conclusions is that technology transfer based on several months' face-to-face interaction provides good prospects for successful innovation. This approach of putting forward diverse skills with partial overlapping as a possible solution of a problem is also valued by the Commission when it evaluates R&D project proposals.

From the research centre's point of view, the whole technology transfer schema converts into R&D projects with industrial enterprises. As a transfer channel these projects may utilize several media to propagate their results, especially to disseminate the academic results. Close R&D projects are already being processed intensively between the industrial and academic partners, and the results have been manifold. The underlying problem seems to be that the projects

[1] CERN, the European Laboratory for Particle Physics, has its headquarters in Geneva. At present, its Member States are Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland and the United Kingdom. Israel, the Russian Federation, Turkey, Yugoslavia (status suspended after the UN embargo, June 1992), the European Commission and UNESCO have observer status.

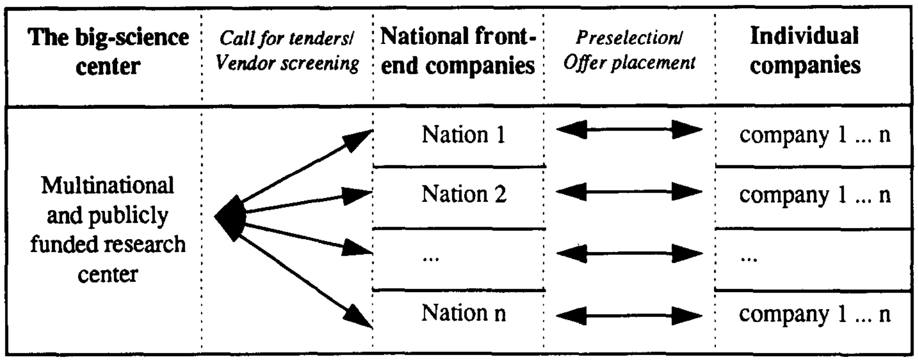


Fig. 1. The use of national front-end companies as mediators between industry and the research centre on low technological interaction.

are not actually R&D projects, but merely ordinary purchasing and installation projects. Thus, often these projects do not contribute to the technological skills of the participating partners. One reason for this must be the lack of organizational power to develop such a forum and infrastructure where the mutual needs and objectives are integrated into an R&D project. The key is to establish visible control of various technological trajectories which are valid in the research centre. This means that problems and research items are divided into clearly distinguishable development paths with detailed analysis of possible input of different technological branches to solve the issues. Fig. 2 displays schematically how collaboration on technological bases may be structured.

In technology studies, a technological trajectory is defined as the development path of normal technology [15]. The notion of normal technology has an analogy with Kuhnian normal science, in which there is one leading paradigm ruling the scientific research. Technological trajectory manifests itself as the activity of technological process along the economic and technological tradeoffs defined by a technological paradigm. Once a new technological trajectory is established, it is likely to dominate the old one in the sense that it is economically and technologically superior. Trajectories have their own structure, meaning that inside a firm or an industry other trajectories may be distinguished. For example, in the computer industry the development and research on computational speed, monitors, software and networks form their own trajectories, with possible subtrajectories. Activities inside the trajectories determine the direction of technical change. Within accelerating technologies the changes and shifts in paradigms and technological trajectories are very visible; e.g., magnet technology has faced considerable technological changes due to applications of superconductivity, which in turn has boosted research on cryogenics and vacuum technology.

The research centre should establish the infrastructure needed for industrial collaboration. This would include well defined information dissemination channels, procedures to link smoothly both the industrial and the research centre's technological trajectories and, of course, to agree on the project-related economic issues. This calls for a detailed technology interaction protocol or manual, which describes the technological trajectories in terms of research topics, responsible people, legal terms, economic contributions etc. Perhaps the World-Wide Web might provide a partial solution to establish dialogue between the possible collaborators. Following up R&D projects can also go along these lines.

4. STRATEGY

Before describing the strategy implications of systematic technological interaction, we have to study the different behaviours and innovation procedures of the firms, i.e. what kind of collaborators are interested in participating in R&D projects with a fundamental research centre. Freeman [3 (pp. 170–183)] has outlined the following six innovation strategies for a firm, with the following characteristics:

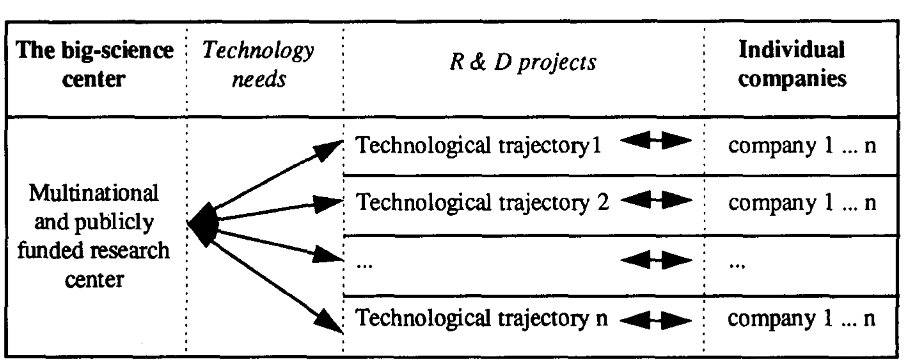


Fig. 2. Collaboration structure for a higher technological level between science centre and industry.

- *Offensive strategy* is adapted by firms aiming to achieve market and technical leadership with high profits (i.e. a temporary monopoly situation); they are highly research intensive, usually with strong in-house R&D, or they have connections to other science–technology systems such as universities; they practise active patenting policy and have a vast experience in the field.
- Firms with *defensive strategy* try to avoid the heavy risks of being the first in the market, and they hope to profit from others' mistakes by improving the design and probably establishing their independent patent position; in order to do this they must have the required knowledge and experience to catch up with the new innovations in a short time; often they lack connections with fundamental research and usually they emphasize the education of their staff and customers.
- Companies applying the *imitative strategy* are ready to buy a licence to use the innovation in their particular market position; they follow way behind the market leaders and compete with the others by having lower production costs (modest R&D and technical service).
- Satellite and sub-contractor companies usually apply a *dependent strategy* by doing what the 'big brother' says; they concentrate on being cost efficient, reliable (delivery times) and flexible (product modifications and changes) in their production.
- *Traditional strategy*, i.e. a traditional firm sees no reason to change its product because the market does not demand a change, and product innovations are usually of the 'same-product-in-different-wrapping' type.
- *Opportunist strategy* seeks for opportunities to prosper in an important 'niche', which does not require any in-house R&D or complex design but satisfies consumer need.

This classification is only an instructive one, for in practice firms may use several strategies at the same time on different products. Also, the market situation affects the choice of strategy. Some strategies are used more in certain industries than others; also, the nature and scope of the innovations differ among industries. Yet the message is clear for a research centre: companies with an offensive innovation strategy provide the best opportunities for collaboration. These companies already possess advanced technological skills and do not hesitate to participate in ventures with some risks and investments. These companies may be spotted by following Pavitt's [16] results. After studying about 2000 significant innovations in the post-war period in the UK, he depicts certain sectoral patterns of innovations among different industries. According to their motivations, size and aims in their search for innovations, one clearly distinguishable category of industries was the *science-based* (electronics, chemicals, biotechnologies, drugs) sectors, where innovations are usually directly connected with new advances in science, requiring strong inhouse R&D, usually cooperating with universities and other research institutes, and the innovations concern both processes and products. However, in some cases, for reasons of secrecy and privacy, companies may feel reluctant to collaborate with other parties.

These and other similar studies sum up the profile of successful innovations: understanding of the user needs, integration of R&D with production and marketing functions, links with an external science and technology network, concentrated high-quality R&D and a powerful, experienced, senior business innovator. This clearly indicates also that companies with an offensive innovation strategy seek actively scientific partners to collaborate with. Thus, technology transfer and interaction are basically concerned with finding the interested partners to work together.

It should be mentioned that CERN is not starting from scratch. There are, continuously, several major R&D projects in progress and without them most of the scientific accomplishments would be nonexistent. Yet the organization lacks a systematic approach to perform technology transfer and interaction. Most of the current collaborations are of random origin and, thus, the potential hidden in this kind of activity is not fully exploited. To develop a strategy of technological collaboration with industry, the fundamental research centre should first perform the following tasks:

- Identify the prevailing and most probable future technological trajectories in the research centre.
- Classify the technological trajectories which overlap industrial interests, focusing especially on companies showing the characteristics of an offensive innovation strategy.
- Collect and analyse historical data on previous R& D projects with the industry and reflect on this information as motivation and learning for future industrial–scientific collaboration.
- Establish systematic procedures and means to integrate industrial partners with fundamental research; this includes solving the practical formalities (finance, intellectual property rights, infrastructure etc.) of the collaboration.

5. INVESTMENT AND MEASUREMENT METRICS

The risks of investing in R&D are known to be high. The uncertainty of the technical solution is not the only factor that can ruin the innovation; market and general business uncertainty may also wreck the novel product or process. To avoid failure, several methods have been developed to ease the investment and project evaluation decisions, and to measure the return of R&D investments. As an ideal method for project selection, Freeman [3 (pp. 157–159)] suggests a combination of a quantitative cost–benefit approach with a qualitative check-list approach. Few attempts have been made to develop such a methodology that combines both quantitative and qualitative aspects of the decision problem (e.g. [17]). Depending on the nature of the research (basic, applied, product or process development), the applicability of these methods varies. For example, strict quantitative methods are insufficient to evaluate basic research and usually the opinions of experts are sought, while simple product improvements can be measured by quantitative means. In practice, the use of quantitative measures has seldom been used. Yet in science and industrial based collaboration the evaluation dimensions should comprise scientific, commercial and technological aspects. Among these factors a balance should be found which, from the empirical point of view, might be a tricky problem, because they tend to contradict each other.

Methods to measure the output of an R&D project differ from each other, depending on what is measured, at what phase of the innovation process and with what criteria. Macroeconomic models study the effects of R&D expenditure on productivity growth at the industrial, national or global level, business models calculate revenues from R&D investment, and scientometric or 'technometric' models aim to evaluate the results from the epistemological point of view by analysing the documents (bibliometrics, e.g. counting the citations) and other achievements of the project (prizes, patents etc.). Mansfield [18] (see also Pavitt [19]) has studied the connection between academic research and industrial innovation by choosing randomly 76 major American firms in various industries, and concludes that 10% of the new products and processes commercialized during 1975–1985 could not have been developed without substantial delay were it not for recent academic research (gestation time was about 7 years). The reasons for Japan's innovativeness in engineering technologies have been studied closely. A recent study by Wakasugi [20] shows that independence of the R&D division from other divisions of the company, together with flexible financing, are the key elements of Japanese success. He also points out that, especially in the electric and electronics industries, for the last few years Japanese firms have been seeking new organizational and managerial patterns to connect applied research and product development more closely with basic research.

In multinational research centres and other similar institutions the traditional way of assessing the return on investment, i.e. member state fees, is based on pure transactions. Under the policy of fair returns this criterion provides a biased view of the true gains of collaboration. A division should be made on what kinds of transaction are involved. As said earlier under 'Collaboration structures', simple transactions, concerning materials, services and other goods, may be handled in terms of fair return through the national front-end companies. Although this way of measuring may not provide cost efficiency in the organization, it still provides politically justified results. Where technological collaboration through R&D projects is concerned the traditional metrics do not suffice. The success of technology transfer and interaction, i.e. the outcome of scientific–industry R&D projects (for more subtle assessment see, e.g., Geisler and Rubenstein [21], Phillmore [22]), should be measured in terms of:

- new product, processes, and services produced;
- patents and licenses produced;
- scientific publications, doctoral theses and other academic outputs accomplished;
- congresses, workshops, seminars, briefings and other information dissemination occasions held;
- spin-off companies, joint ventures and other business units founded;
- mobility of people from industry to research and the other way round.

Old wisdom in the tradition of measurement is that one gets what one measures. This is also valid with technology transfer and interaction. If the focus is only on return on investment and the money involved in various transactions, the control and follow-up, not to mention the development aspects, are lost.

6. CONCLUSIONS

The capitalist system fuels itself from new products, processes and services. An economy loses its competitiveness without continuous upgrading and innovation processes [23]. Thus, technology transfer and the related functions in an economy play a crucial role and are a significant source of new innovations. When properly implemented, collaboration between fundamental research and industry produces significant technological leverage in the form of new products, processes and services. This article has focused on promoting means and structures to establish functional and flexible links from a basic research centre to industry. Instead of one-sided technological transfer, the aim is to promote technological interaction along well-defined technological trajectories with multiple synergy to the collaborators. The paper has outlined the motivations for collaboration, how it should be structured and what strategy implications the interaction generates. The key assessment criteria are also listed, in order to control and adjust the collaboration.

The development and construction of the Large Hadron Collider system is a project similar in size to a huge offshore oil drilling platform; yet, different from the oil rig, the new accelerator requires several new technological skills and thus its size in technological terms is much greater. When two or several different approaches with similar technological incentives meet, the clash will most probably be a fertile one. It is the collaboration which triggers new ideas and ways of doing even better collaboration. Thus, it is not only the prime goal of an R&D project that is important but also the way it is achieved. After all, in technology transfer the process matters more than the ultimate outcome.

REFERENCES

1 E.P. Hawthorne. *The Management of Technology.* McGraw-Hill, Maidenhead, 1978.

2 SAPPHO. *Project Sappho: Success and Failure in Industrial Innovation.* Science Policy Research Unit, University of Sussex, 1971.

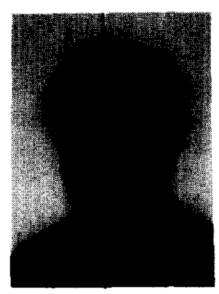
3 C. Freeman. *The Economics of Industrial Innovation.* Frances Pinter, London, 2nd edition, 1982.

4 R. Lovio. *21 innovations in Finnish electronics industry: Backgrounds, success factors and problems.* Technical Research Centre of Finland, Espoo, 1988 (in Finnish).

5 M. Lindell. Developing new products—an action, interaction and contextual approach. *Scandinavian Journal of Management,* 7(3) (1991) 173–189.

6 A.-P. Hameri. *Technical change, innovations and technological causality—an empirical and philosophical enquiry.* Acta Polytechnica Scandinavica,

Mathematics and Computer Science Series, Doctoral Dissertation No. 61, Helsinki, 1993.
7 E. Autio. *Technology transfer effects of new, technology-based companies—An empirical study*. Institute of Industrial Management, Helsinki University of Technology, Espoo, 1993.
8 G. Dosi. Sources, procedures, and microeconomic effects of innovation. *Journal of Economic Literature*. 26 (September 1988) 1120–1171.
9 E.S. Andersen and B.Å. Lundvall. Small national systems of innovation facing technological revolutions: An analytical framework. In: C. Freeman and B.Å. Lundvall (eds.). *Small Countries Facing the Technological Revolution*. Frances Pinter, London, 1989, pp. 9–36.
10 U. Hilpert. Economic adjustment by techno-industrial innovation and the role of the state—Solar technology and biotechnology in France and West Germany. In: U. Hilpert (ed.). *State Policies and Techno-Industrial Innovation*. Routledge, London, 1991, pp. 85–108.
11 C. Freeman. *Technology Policy and Economic Performance: Lessons from Japan*. Frances Pinter, London, 1987.
12 C. Freeman. Japan: a new national system of innovation? In: G. Dosi et al. (eds.). *Technical Change and Economic Theory*. Frances Pinter, London, 1988, pp. 330–348.
13 T. Laamanen and E. Autio. *Technology transfer between research laboratories and industry—Measurement and evaluation*. VTT Research Notes, No. 1507, Technical Research Centre of Finland, Espoo, 1993.
14 E. Autio. *Spin-off companies as agents of technology transfer: an empirical study of the spin-off companies of the Technical Research Centre of Finland*. VTT Research Publications, No. 151, Technical Research Centre of Finland, Espoo, 1993.
15 G. Dosi. Technological paradigms and technological trajectories. A suggested interpretation of the determinants and directions of technical change. *Research Policy*, 11 (1982) 147–162.
16 K. Pavitt. Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy*, 13 (1984) 343–373.
17 B.K. Eres and B. Raz. A methodology for reducing technological risk. *R&D Management*, 18(2) (1988) 159–167.
18 E. Mansfield. Academic research and industrial innovation. *Research Policy*, 20 (1991) 1–12.
19 K. Pavitt. What makes basic research economically useful? *Research Policy*, 20 (1991) 109–119.
20 R. Wakasugi. Why are Japanese firms so innovative in engineering technology? *Research Policy*, 21 (1992) 1–12.
21 E. Geisler and A.H. Rubenstein. University–industry relations: A review of major issues. In: A. Link and G. Tassey (eds.). *Cooperative Research and Development: The Industry–University–Government Relationship*. Kluwer Academic Publishers, USA, 1989, pp. 43–62.
22 A.J. Phillmore. University research performance indicators in practice: the University Grants Committee's evaluation of British Universities. *Research Policy*, 18(5) (1989) 255–271.
23 M.E. Porter. *The Competitive Advantage of Nations*. MacMillan, New York, 1990.



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Transferts de technologie entre la recherche fondamentale et l'industrie

Résumé

La synergie de pures motivations scientifiques et de politiques industrielles et technologiques appliquées a rarement eu des résultats significatifs. La démarcation entre recherche fondamentale et recherche appliquée est toujours valides, pourtant d'un point de vue industriel et macro-économique, cette classification est devenue obsolète et la recherche du bien-être général doit devenir une priorité. Ce papier examine les mesures qui devraient être prises dans un centre de recherche fondamentale à grande échelle, afin de produire d'une manière plus efficace à la fois les outils de connaissance dont la communauté scientifique à besoin et les outils de connaissance pratiques que les institutions nationales et industrielles réclament. Notre but est de développer une approche qui permette aux industries de se consolider grâce aux technologies et autre services indispensables pour accomplir des expériences majeures de recherche fondamentale. Dans ce papier nous offrons une vue d'ensemble des concepts qui décrivent le transfert de technologie, la diffusion et les fonctions d'innovation au sein d'une organisation et comment ils doivent être intégrés à la stratégie et les activités opérationnelles d'un centre de recherche fondamentale. Notre papier conclue que sans une interaction bien focalisée et bien organisée avec l'industrie, les bénéfices de la recherche fondamentale ne sont pas exploités. Ce papier présente plusieurs scénarios de coopération ainsi que quelques suggestions pratiques afin d'accomplir une communication fertile entre la communauté scientifique et l'industrie. Le facteur clé dans la collaboration étant l'apprentissage interactif, il fait donc partie du processus de création de connaissance et la perspective d'inventions scientifiques et d'innovations industrielles est établie. Le cas typique est celui du CERN et particulièrement le projet décennal d'accélérateur à son commencement.

Technologietransfer zwischen Grundlagenforschung und Industrie

Abriss

Rein wissenschaftliche Anreize und die angewandte industrielle und technologische Politik haben selten bedeutende Zusammenwirkung produziert. Die Abgrenzung zwischen Grundlagenforschung and angewandter Forschung ist noch immer gültig, doch vom industriellen und makro-ökonomischen Gesichtspunkt her ist diese Klassifizierung hinfällig geworden, und dem Streben nach gemeinsamen Wohlergehen solte Vorrang gegeben werden. In dieser Arbeit wird untersucht, welche Schritte in einem groβ angelegten Forschungszentrum unternommen werden sollten, um auf effektivere Weise sowohl die epistemologischen Einrichtungen, welche die wissenschaftliche Gemeinschaft benötigt, als auch die von industriellen und nationalen Institutionen verlangten praktischen Einrichtungen zu produzieren. Das Ziel besteht darin, einen Ansatz zu entwickeln, der es industriellen Unternehmen ermöglicht, sich mit den Technologien und und anderen Dienstleistungen, die zur Schaffung wesentlicher Experimente in Grundlagenforschung nötig sind, zusammenzuschlieβen und zu festigen. Diese Arbeit bietet einen Überblick über die Konzepte, beschreibt Technologietransfer, Ausbreitung und Innovationsfunktionen in einer Organisation und wie sie in der Strategie und den Arbeitsabläufen eines Zentrums für Grundlagenforschung ausgeführt werden sollten. Die Arbeit schluβfolgert, daβ der Vorsprung und die Gewinne der Grundlagenforschung ohne organisierte und gut konzentrierte Interaktion mit der Industrie nicht ausgenutzt werden. Wir präsentieren in dieser Arbeit verschiedene Szenarien zur Zusammenarbeit sowie praktische Vorschläge zum Erreichen fruchtbarer Kommunikation zwischen Gemeinschaft und Industrie. Der Schlüsselfaktor bei der Zusammenarbeit ist Lernen durch Interaktion, und durch diese Teilnahme am Entstehungsprozeβ des Wissens und der Kenntnisse werden die Aussichten für wissenschaftliche Erfindungen und industrielle Innovationen hergestellt. Der zugrundeliegende Fall hierfür ist CERN (European Organization for Nuclear Research) und insbesondere der Anfang des 10jährigen Beschleunigerprojekts.

Las transferencias de la tecnología entre la investigación básica y la industria

Resumen

Los incentivos que son únicamente empujados por la ciencia y las políticas aplicadas industriales y de la tecnología pocas veces han producido una sinergia importante. La delimitación entre la investigación básica y la investigación aplicada sigue teniendo validez, aunque desde un punto de vista industrial y macro-económico esta clasificación se ha vuelto obsoleto y se debe prioritizar la búsqueda del bienestar común. En este documento se estudian los pasos a tomar en un centro de investigación básica a gran escala para producir de una forma más eficaz tanto las utilidades epistémicas necesarias para la comunidad científica como las utilidades prácticas requeridas por las instituciones industriales y nacionales. Se propone desarrollar un enfoque que permite a las empresas industriales consolidarse con las tecnologías y demás servicios necesarios para poder llevar a cabo los experimentos principales de la investigación básica. Este documento ofrece una vista general de los distintos conceptos y describe las funciones de transferencia, de difusión y de innovación de la tecnología en una organización y cómo deben implementarse dentro de la estrategia y las actividades operacionales de un centro de investigación básica. Se llega a la conclusión de que cuando no existe una interacción organizada y bien enfocada con la industria, los beneficios de la investigación básica no se aprovechan. Se documentan varios ejemplos de cooperación y se hacen varias sugerencias prácticas para lograr la comunicación rentable entre la comunidad académica y la industria. El factor clave de la colaboración se encuentra en aprender de la interacción y entonces, ya que forma parte del proceso de la creación del conocimiento, se crean posibilidades para ambas invenciones científicas y innovaciones industriales. El caso de fondo es el de CERN y especialmente el proyecto de 10 años de aceleración en sus primeros momentos.

Government support for R&D: The Spanish case

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Résumé

Cette étude a pour but d'identifier les caractéristiques industrielles et sectorielles de l'ampleur de l'aide publique reçue par les entreprises espagnoles dans la pour suite de leurs activités I+D. A cette fin, nous avons conçu un modèle de régression multiple qui permet d'analyser la dépendance à l'aide publique reçue par les entreprises espagnoles par rapport à un ensemble de variantes spécifiques aux entreprises et aux secteurs où elles fonctionnent. Les résultats de cette recherche nous démontrent que les différences sectorielles sont minimes par rapport à l'importance des aides publiques correspondantes. En outre, le pourcentage de capital étranger et la taille de l'entreprise influencent la variante qui s'y rapporte, mais pas de manière importante. Seule l'analyse permet de démontrer une corrélation déterminante avec l'aide publique reçues par les entreprises pour ces activités.

Abriss

Gegenstand dieser Arbeit ist es, die bestimmenden Unternehmens -und Bereichseigenschaften zu identifizieren für die Höhe der öffentlichen Unterstützung, die die spanischen Industrieunternehmen erhalten, um ihre F+E (Forschung und Entwicklung) Aktivitäten durchzuführen. Dazu wurde ein Mödell der mehrfachen Regression eingeführt, das die Abhängigkeit der öffentlichen Unterstützung untersucht, die die spanischen Industrieunternehmen erhalten in Bezug auf ein Satz eigener Variablen der Firmen und der Bereiche, wo sie im Wettbewerb stehen. Die Ergebnisse der Untersuchung zeigen uns, wie äußerst klein die Unterschiede sind in Bezug auf die Bedeutung der bezogenen öffentlichen Unterstützungen. Darüberhinaus beeinflussen der Prozentsatz des ausländischen Kapitals und die Größe der Firmen bei den abhängigen Variablen, wenn auch nicht in wesentlicher Form. Nur allein die Stärke bei der Forschung zeigt eine wesentliche Wechselbeziehung mit der öffentlichen Unterstützung, die die Firmen für diese Aktivitäten erhalten.

Resumen

El objetivo de este trabajo es identificar las características empresariales y sectoriales determinantes de la magnitud del apoyo público que reciben las empresas industriales españolas para realizar sus actividades de I+D. Para ello, se planteó un modelo de regresión múltiple cuyos resultados muestran cómo las diferencias sectoriales son mínimas en cuanto a la importancia de las ayudas públicas referidas. Además, el porcentaje de capital extranjero y el tamaño de la empresa influyen en la variable dependiente, aunque no de forma importante. Sólo el esfuerzo investigador muestra una interrelación determinante con el apoyo público que reciben las empresas para esas actividades.

Artificial neural networks for supporting production planning and control

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Technovation, 16(2) (1996), 67–76