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Public Policies Supporting Technology Appropriation

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1. Philosophies Underlying Public Policies

Public policies aimed at facilitating the industrial utilization of the public research base can be found in many industrialized countries. They differ, however, in terms of the conceptual framework applied, in their scope, form, and with respect to the actors involved.

A first conceptual destinction can be found in the nature of the knowledge to be transferred from academic institutions to industrial companies.

At the beginning of the seventies, public policies addressed the results emerging from public research centres, which were mainly manifested in the form of research documents (research reports, books and articles) and patents. In recent years, a shift has taken place towards the utilization of the technological capabilities of the researchers and engineers. Public policies, above all, have the following strategic orientations:

- to increase the transparency of available research results and the capabilities of researchers and to facilitate access to them,

- to transform and adapt available results and capabilities in order to improve their "applicability",

- to strengthen the capacity of potential users to specify, assess, and absorb available results and research capabilities

- to develop both non-commercial and profit-making services, acting at the interface between academic institutions and industry.

A second conceptual distinction relates to the "value" ascribed to the results of public R&D, especially with respect to their direct applicability in industry. An extreme interpretation, which can be found among the advocates of the French concept of "valorization", compares publicly funded R&D results to a gold mine, which can be exploited by "explorating", "digging", "transporting to the surface", "extracting" and "processing"; a process which is seen to be associated with high profit expectations. With this concept in mind, to "waste" something of high value by not realizing its price on the market should not be acceptable to society and the state, as all the cost have been borne by the taxpayer. As a consequence, the emphasis is on the identification, assessment, and marketing of "promising" research results, which would be a supply push concept.

Alternative approaches, which are more common in other countries, focus on demand pull or on the mobility of researchers and engineers. Examples of demand pull policies include incentive schemes that facilitate a firm's acquisition of knowledge and know-how from any suitable external source (e.g. not only research centres, but also engineering companies) and in any appropriate form (e.g. not only research results, but also through "people transfer" and competent go-between services). Different degrees of mobility reflect differences in career prospects and planning as well as differences in cultural attitudes to work.

Preference towards supply or demand-oriented concepts depend on

- the share of R&D carried out in the public domain, and especially the size of the funds spent on the development of large-scale technological systems (in the areas of nuclear power, aerospace, etc.) and on military research, and

- the level of mobility from public research establishments, to industrial companies.

A third conceptual distinction is of an "instrumental" nature. Policies to facilitate technology transfer between public research establishments and industry are often based on one of two organizational models. These can be labelled

- the model of "bridging" public research and industry and
- the model of building an "interface" between public research and industry.

According to the "bridge" model, an emphasis on technology transfer leads to the pursuit of common goals for basic and applied research in one organization. The second model is based on the assumption that research and industry are two social systems, characterized by different goals, award systems, orientations and constraints, and that it is not possible to develop a continuum between the two systems within one single organization, as suggested by the first model. It looks to me as if the first model has more support in France, whereas in Germany the second model is preferred.

As the academic research system and the industrial research system are two different social systems, the rationale for interface organizations is to integrate aspects of both systems in a consistent form. This applies above all to organizations offering research based services to industrial clients. Some of the major aspects of interface organizations are listed in the following table:

aspect	research institutes	interface organizations	industrial R&D
orientation	peer group in scientific community	industrial client	company goal
criteria for success	publications, awards	value of contracts, application of results	product on the market
access to results	wide publications	confidential reports	internal reports
organization	individualistic	ad-hoc-teams	units
substance	disciplinary orientation	integrating commercial aspects	development and engineering
constraints	bureaucracy	time and cost frame of contracts	achievement of mile stones is decisive for continuation

2. Interface organizations and units in Germany

In the Federal Republic of Germany, research based services for industrial clients (outside the State "regulated" aerospace sector) are offered by a variety of organizations which are competing in quite a few technological areas. Their relative share of the industrial contract R&D market (given in brackets) shows that typical interface organizations are not the dominant actors in this field

- specialized R&D units of manufacturing companies (30 - 40 p.c.)
- consulting engineers (10 - 15 p.c.)
- university institutes (20 - 25 p.c.)
- professors and lecturers at universities and technical colleges (Fachhochschulen) offering such services as free-lance experts or by working in a joint service company (10 p.c.)
- institutes of the Fraunhofer-Gesellschaft (FhG) (10 p.c.)

- institutes and industrial liaison units of the large-scale research establishments which are mainly performing mission-oriented R&D in the fields of nuclear energy, space, biotechnology etc. (3 p.c.)
- private R&D companies, above all the Battelle Institute (6 p.c.)
- collective research institutes which are mainly engaged in non-competitive sectorally-based collaborative R&D projects (3 p.c.)

The specific mechanisms through which interface organizations try to achieve their goals, may be quite different. There is not a single optimal organizational set-up. This can be illustrated by presenting two German cases
- the Steinbeis-Foundation, and
- the Fraunhofer-Society.

3. The Steinbeis Foundation

The Steinbeis Foundation, named after the promoter of technological and industrial infrastructures in the State of Württemberg in the 1850s, operates as a private organization in Baden-Württemberg: Steinbeis aims at assisting innovation in small and medium sized companies, mainly through technological consultancy.

The operations of Steinbeis rely on a dense network of technological specialists, most of them holding chairs at Technical Colleges (Fachhochschulen) in Baden-Württemberg, loosely coordinated by a central office, which also acts as a clearing house for requests from industry and as a general manager for more complex consultancy or development projects.

The majority of Steinbeis' operations are performed by:
- 16 Technical Advisory Units, attached to each of the

Technical Colleges, offering advice and consultancy on a small scale, carried out by individual specialists;
- more than 70 Transfer Centres, each spezializing in one single field of technological application.

The professional human resources of the Advisory Units and the Transfer Centres are:
- more than 700 Professors at Technical Colleges, who - under a framework contract with Steinbeis - may act as freelance consultants on a case-to-case-basis for consultancy, training and technological development projects;
- almost 170 young engineers, employed on a full time basis at the Transfer Centres, who often move to client firms;
- more than 700 students and scientists;
- about 30 professionals at the Central Office.

Steinbeis does not rely on public subsidies. It only provides the "seed money" to start a Transfer Centre. Contracts with clients, mainly from industry, account for about 90 % of its annual 50 mDM budget. Most contracts are with firms within thirty minutes driving distance. The average size of contract is about 5000 DM.

The main features can be summarized as follows:
- Steinbeis is an interface organization utilizing the competence and entrepreneurial abilities of the Professors (and students) of Technical Colleges. These Professors are highly motivated because working with Steinbeis provides the opportunity for a permanent updating of their technological competence, and also offers a noteworthy additional income.
- Steinbeis' Central Office provides joint marketing and management services.
- A close link between Steinbeis and the Government has contributed to the development of the "Steinbeis" name,
- Steinbeis is extremely flexible:

- o the large know-how pool allows it to take on board problems related to all fields of technology
- o the marginal time/marginal cost operating principle (with respect to the Professors) allows a flexible adjustment of human resources to changing needs - at almost no cost
- o most operations are performed on a decentralized basis by the 80 regional and technological subunits, on their own responsibility.

4. The Fraunhofer-Society

a) The main features

The Fraunhofer-Gesellschaft (FhG) is the only publicly sponsored research institution in Germany which has set as its primary objective the promotion of the application of new technologies in German industry and the investigation of areas of long-term public concern such as environmental protection, energy saving etc.

The primary mode of FhG's operations is that of contract research which covers about 85 per cent of its budget and personnel.

FhG operates in the following fields of research
- microelectronics,
- information technology,
- production automation,
- production technologies,
- materials and components,
- process engineering and biotechnology,
- environmental protection and health,
- energy and building technology,
- technological information exchange and studies.

In each of these nine research areas there are on average

between four and seven institutes, each employing between fifty and two hundred people.

The following tables provide a breakdown of the major figures on finances and human resources:

Personnel:	
employees	6,000
of which	
- are employed with a limited work contract	2,000
- hold a university degree	1,500
- are doctoral students or student assistants	1,200

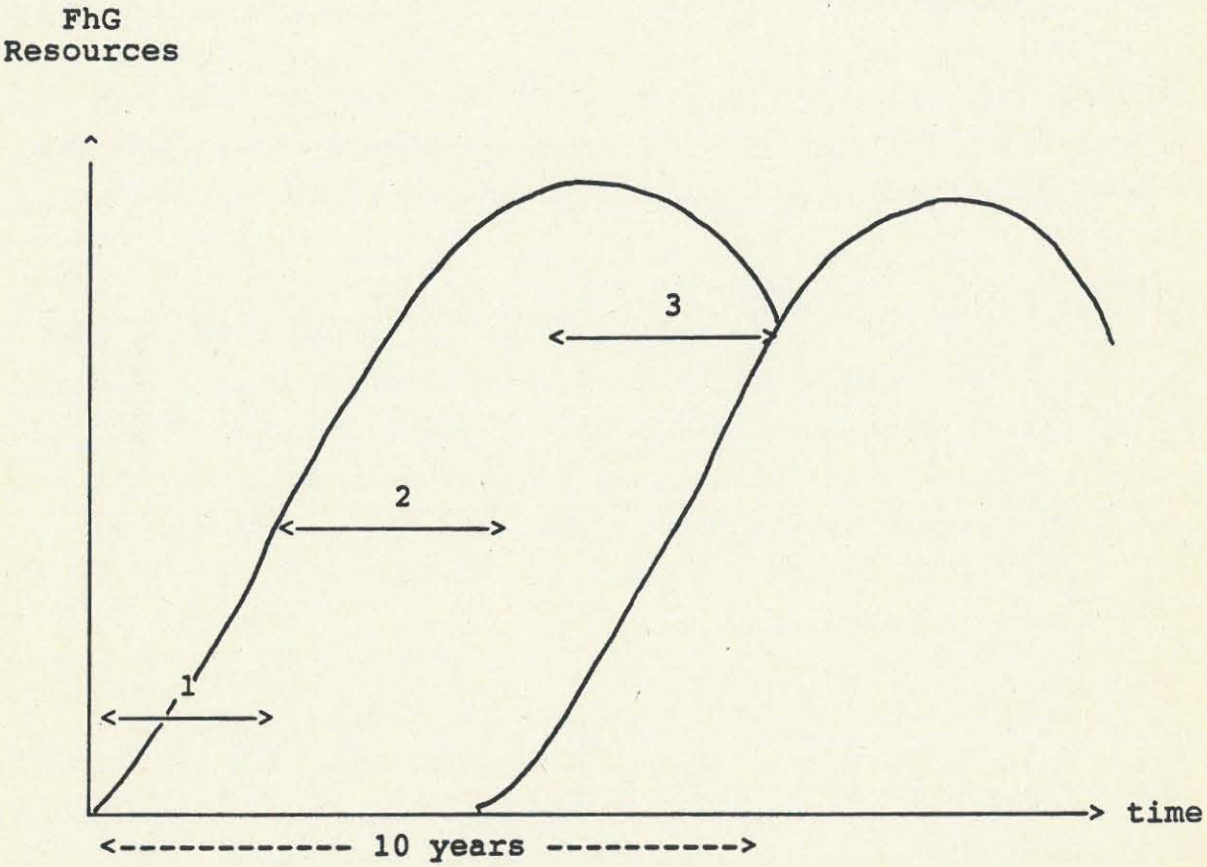
Finances (in mDM)	
Total budget	750
of which is spent on contract research	600
which is paid for	
- by basic funding from the government	180
- by contracts from industry	180
- by contracts from public bodies	200
- by public investment grants and other income	40

FhG is a fairly dynamic organization:

- There are high annual growth rates for its budget and personnel: between 10 and 20 per cent over the last 10 years.
- It is the springboard for an industrial career for many engineers: About 50 per cent of them leave after a couple of years to take over responsibilities in industry.
- The average fluctuation rate of researchers is 8 to 10 per cent p.a. As a consequence, two thirds of all researchers are under 40.

The following picture shows the position of a typical Fraunhofer-Institute (FhI) in the process of technological development. The type of work a FhI can engage in, its role

and its mode of financing changes during the different phases of a cycle of technological development, lasting on average ten years:



(1) exploratory R&D: basic funding
(2) know-how accumulation: publicly funded R&D projects
(3) know-how transfer: R&D contracts with industrial clients

(1) Once a new area of academic research seems to offer opportunities for industrial applications, the FhIs would pick up the state of knowledge and invest their own funds to assess the new technology's technical and commercial feasibility.
(2) This exploratory work is the basis for publicly funded R&D projects (some of which are performed as group projects with industrial partners), which will lead to an accumulation of knowledge and know-how in that field.

(3) At this stage, an FhI has become a centre of technological competence, and development contracts with industrial companies will lead to an intensive transfer of know-how to industry.

These major characteristics, which are the basis of the profile of FhG and which have been the main reason for its success in recent years, can be summarized as follows:

(1) FhG is an independent, private organization, and is not part of any public body. It has developed a corporate identity and a unique profile, different from the Max-Planck Gesellschaft (centre of excellence for basic research) and the large scale research establishments (mission oriented R&D in nuclear energy, aerospace, etc.); it is now regarded as a respectable member of the research community.

(2) FhG has set explicit research and commercial goals:
- to perform excellent applied research with the aim of serving (short-term) industrial and (long-term) public needs;
- to cover 70 per cent of its expenses by contracts with industrial and public clients.

(3) FhG receives an annual basic funding of about 30 per cent of its turnover from the government, paid as a reward for success on the market.

(4) A central allocation of gains and resources allows risk sharing amongst the FhIs and gives room to decide autonomously where to invest in research equipment and in which fields and sectors new operations or new capacities should be created.

(5) Most FhIs have developed institutional links to universities and to industry.

(6) The implementation of strategic goals and testable annual objectives for each FhI allows a continuous assessment of its performance in commercial and professional terms; it also provides a basis for decisions on closing or starting new institutes or research units.

(7) FhG headquarters provides tools and services for the professional management of the individual FhIs, especially in the areas of
- accounting,
- marketing,
- contract filing,
- strategic development and
- project management.

b) The cooperation of Fraunhofer-Institutes with universities

During recent years, FhG has developed a set of mechanisms for liaising with universities, the most important of which are:

(1) The appointment of a managing director of an FhI is organized in accordance with a university, and the managing director holds a full chair at a university.

(2) An FhI is located on campus.

(3) An FhI and its complementary university institute share a common infrastructure (measurement and testing equipment, workshops etc.).

(4) An FhI employs students as research assistants, who often take the opportunity to write their diploma thesis under the guidance of the FhI.

(5) The university's faculty appoints FhI researchers to complement their teaching programme by lecturing on their experience in applied research and in new industrial applications.

(6) University institutes and an FhI perform joint research projects.

(7) An FhI engages university staff members as consultants for its research projects.

As successful FhIs use the full range of cooperation mechanisms, they are able to develop a symbiotic pattern of cooperation with one or even more universities in the course of time:

- the FhI becomes the contract research arm of the university institute,
- or the university institute is regarded as the basic research extension of an FhI.

c) The links of Fraunhofer-Institutes with industrial partners

According to the FhG's understanding of its own role, applied research aims at industrial application. As a consequence, the degree to which an FhI covers its costs by revenues from industrial contracts is regarded as the main indicator of its success. In order to stimulate and facilitate the industrial orientation and cooperation of the individual FhIs, a number of mechanisms have been developed and implemented over the last few years:

(1) Annual negotiations between the individual FhIs and the FhG's presidency result in the determination of commercial targets, especially of the volume of contracts with industry to be achieved and of the share of income from industry of the FhI's budget respectively. If an FhI does not achieve the agreed objectives, less (centrally

controlled) resources will be awarded in the year following (e.g. basic funding, financial premiums for researchers, replacement of vacant positions, investments, etc.).

(2) FhIs act as partners in an R&D consortium with industry. Their opportunities have increased in recent years, as public R&D promotion has shifted from funding R&D projects in individual companies to the funding of collaborative R&D projects.

(3) Industrial companies detach researchers to FhIs, not only with the financial support of a corresponding federal programme, but also at their own cost.

(4) Each FhI has a supervisory board, which annually monitors its work and results. Representatives from industry play the major role on these boards.

(5) Researchers at an FhI often view their employment at FhG as being transitory, their next phase being planned as a career in industry. Compared with other research organizations in Germany, FhIs contribute a respectable number of spin-off companies to manufacturing industry.

5. Comparison

The two organizations presented try to develop links to academic institutions and to industry, partly in similar, partly in different ways:

- The "individualistic" approach of Steinbeis develops and supports a market for small scale know-how transfer projects, performed mainly by or under the responsibility of individual Professors. Public Services, which would be performed anyway, are "valorized". E.g., an additional value is created, which can be "appropriated" by the "valorizors", and this contributes also to regional development and to

the quality of academic teaching. Conflicts with commercial consultants are avoided if project size can be kept small.

- The "institutional" approach of Fraunhofer develops and supports a market for contract R&D, performed by institutes attached to Technical Universities. These institutes rely to a much lesser degree (than Steinbeis) on university resources, at least in financial terms. Links to Universities are essential.
- Both organizations transfer the knowledge and know-how accumulated not only via joint projects, but also intensively via mobility to industrial users.
- Neither Steinbeis nor Fraunhofer place emphasis on the general transfer via technical documents, either as an input from the academic institutions, or as an output of their own work. However, both see the development and selling of technological competence as a crucial element of their respective organizations.

Neither interface organization has all the characteristics of private organizations, but their commercial orientation and their business like structures and procedures have been continuously developed. Both are performing certain roles in the formulation and implementation of public innovation policies, which gives them the image of public organizations.

The description of their internal mechanisms and structures, as they appear today, would be incomplete without mentioning that the historical development of the two organizations was mainly a trial-and-error-process, combined with the taking up of occasional (political) chances.