

The contribution of university research to the technological innovation of the German economy: Societal auto-dynamic and political guidance *

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In recent years a growing interest of firms in the transfer of technologically usable results from university research can be observed in the F.R.G. In the first part of the paper a short account of available empirical evidence for this is given. In the second part a general theoretical model is developed which tries to explain the intensification of transfer activities as the result of a specific auto-dynamical causality connecting firms and universities. In the third part the role of political guidance as a catalyzing force for this societal auto-dynamic is discussed.

1. Introduction

For more than a decade all Western capitalist countries have suffered from a severe economic decline. Meanwhile nobody believes that this is merely one of the many short-term fluctuations of capitalist economies. Some observers suggested very early that this crisis might initiate a period of far-reaching technological transformations of capitalist economies. In the F.R.G., for instance, Volker Hauff – then parliamentary state secretary, later minister of the Bundesministerium für Forschung und Technologie (BMFT: Federal Ministry for Research and Technology) – and Fritz Scharpf recognized in the mid-1970s the need for an extensive “modernization of the economy” [10].

Gerhard Mensch more generally concluded that the condition of the capitalist world economy was characterized by a “stalemate in technology” [15]. According to his interpretation, the growth potential of the key industries of post-war capitalist economies was cut down because the innovation potential of their established basic technologies was exhausted.

Diagnoses such as these maintain that technological progress is one of the central preconditions of economic prosperity. Technology, in turn, which for the most part of human history was only very loosely coupled with science, has gained an increasingly scientific character since the middle of the last century [2]. Technological innovation has become dependent upon scientific research efforts. Consequently, many firms have established their own R&D departments sooner or later. In all Western countries industrial R&D is by far the largest part of total research activities – in the F.R.G. more than 70 percent of the financial resources devoted to research in 1985 were consumed by industrial R&D (see [4, pp. 252–253]). But building up their own R&D departments does not make firms independent with respect to the scientific knowledge needed for the innovation of their products and production processes. Apart from their need of adequately qualified research personnel, firms must also use research results produced elsewhere. Empirical evidence in all capitalist countries during all periods of their development shows manifold contacts between firms and state-financed research institutes, among

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which universities are the most prominent ones.¹ There even seems to be a positive correlation between the magnitude of a firm's own research efforts and the intensity of its contacts with other research institutes. The more one researches, the more one has to rely upon other researchers' groundwork and cooperation.

Thus, there is a continuous flow of technologically relevant information from universities to firms. This technology transfer is likely to become a prominent topic of public discussion whenever major industries suffer from a lack of "innovativeness". In such times everybody looks for potential sources of technological innovations that might offer new directions of profit-making to the firms and thereby save the economy from its decline. One such source which might give rise to a hopeful perspective in future is university research.

The present situation in most Western capitalist countries clearly fits into this picture. During the last decade a massive normative re-evaluation of transfer activities between universities and firms has taken place in the F.R.G. For a long time such activities had been regarded as deviances from an ideal of pure, disinterested academic science. Nowadays transfer activities are proudly presented by the universities as manifestations of the societal use-value of their research results. This corresponds to a public opinion according to which university research is considered to be an increasingly expensive activity that may no longer serve just the intellectual passions of scientists but must pay a profit for society at large.

These changes of orientations are accompanied by social-structural changes. Since the end of the 1970s diverse new institutional forms of technology transfer between universities and firms have been developed, such as technology parks in the neighbourhood of universities, transfer bureaus in many universities, or jointly financed and directed research institutes of universities and firms. At present, no safe conclusions can be drawn about the effectiveness of these new institutions. But according to a common opinion among many observers such transfer institutions have to fulfil

intermediate functions which are crucial conditions of future economic growth in capitalist countries.²

Such an interpretation stressing the relevance of an increasing technology transfer between universities and firms for a surmounting of the present economic decline is shared by many actors in German science policy. Accordingly, the instalment of new transfer institutions has been the subject of political guidance. Various departments and levels of government participate in this transfer guidance: on the federal level the Bundesministerium für Wirtschaft (BMW: Federal Ministry of Economics), the Bundesministerium für Bildung und Wissenschaft (BMBW: Federal Ministry of Education and Science) and the BMFT; on the Länder level – the F.R.G. consists of 11 Länder – the respective ministries of economics and of science; and on the local level the offices for the promotion of local economic development. From the point of view of these political actors the decisive question is how and to what extent political guidance of the technology transfer between universities and firms is possible. What can political actors do to promote the realization and effectiveness of transfer interactions between university researchers and firms?

Obviously, there is no easy answer to this question. The subject is a new one for political guidance; political actors therefore do not have an accumulated stock of experience from which they can deduce feasible guidance strategies. Until now this subject area has not been sufficiently investigated by social scientists. Thus, no well-prepared empirical findings and ready-made theoretical models are available.³ Consequently, no one trying to make sense out of the fragmented, diffuse and uncertain information about the subject should claim to have found definite answers. This contribution should be seen as a conjecture, based upon preliminary empirical data and theoretical ideas. Hopefully, it may serve as an initial point of

¹ A recent survey of German firms has revealed that they engage in research cooperations and contract research most often with universities (see [24, pp. 27/28]). This is remarkable since in the F.R.G. a well-developed sector of other state-financed research institutes exists.

² See, for example, the speculations of Rolf Kreibich, who has been president of the Freie Universität Berlin for many years, about the emerging "science-technology-industry-paradigm" of societal development [14].

³ As documentations of conferences about these new forms of technology transfer in the F.R.G. see BMBW [3], Meyer and Friedrich [18] and Theis et al. [28]. A useful publication that presents international tendencies is OECD [21].

departure for a better understanding of the phenomena in question.

The argument shall proceed in three steps. Firstly, a short summary of empirical data shall be presented which might give an impression of the dissemination of various new forms of technology transfer from universities to firms in the F.R.G. Secondly, a general theoretical model shall be elaborated which tries to explain why such a sudden intensification of these transfer activities has occurred during the last ten years. This model stresses a particular causal connection between discontinuously changing technological needs of firms and the supply of universities with financial resources for research activities. Thirdly, possibilities for political guidance of the technology transfer between universities and firms shall be discussed within the perspective this model opens up.

2. The intensification of technology transfer ⁴

Activities of technology *transfer* are distinguished from a mere technology *diffusion* by intentional specifications of the user and of the use-value of the transmitted research results. University scientists are no longer indifferent to the potential technological usefulness of their research results in various industries. Research efforts are rather directed towards the solution of certain technological problems so that technological applications of research results are no longer at best accidental by-products of scientific ambition. Moreover, while diffusion processes leave open who will be reached when and in which ways by the transmitted research results transfer activities are directed towards a circumscribed target group – for instance, small and medium-sized firms of a certain industry in a certain region. Summed up, technology transfer tries to reach a higher degree of *intentionality* of the transmission of technologically useful research results.

Six new forms of technology transfer from universities to firms may be empirically distinguished within the F.R.G.: ⁵

- research catalogues and data banks,
- transfer offices,
- joint research programs,
- personnel transfer,
- transfer research institutes, and
- technology parks.

A short description of each of these forms will explain how they work and how they have spread in the F.R.G. during the last years.

2.1. Research catalogues and data banks

A few German universities document their research potential in research catalogues. These catalogues are often distributed by the local Chambers of Commerce and Trade. In this way the firms of the region are reached. They can find out which researchers are working in which fields of inquiry at the respective university; thereby they can identify the scientists whom they may approach with specific technological problems.

Research data banks contain information about specified fields of research. They help to find out who has worked on certain research questions, and where his results have been published. These data banks are not restricted to university research, but include research from all kinds of national and international research institutes. The primary function of research data banks is to make communication easier within the scientific communities. But the accumulated data are also available and useful to firms wanting to know whom they may contact in case of certain technological problems. In the F.R.G., at present 23 “Fachinformationszentren” (scientific information centers) exist, each of which is specialized in certain disciplines or groups of disciplines. In addition, there are many smaller and more specialized research data banks.

2.2. Transfer offices

Transfer offices aim to promote communication between university scientists and firms in several ways. To begin with, such offices work as public relations agencies of university research. They organize information meetings – often in collaboration with Chambers of Commerce and Trade – where the research potential and the possible services of the university are presented to

⁴ A more detailed presentation may be found in Schimank [23].

⁵ For useful general discussions of the different forms of technology transfer compare Baer [1], Stankiewicz [26].

representatives of firms. This is also achieved by university stands at trade fairs.

But the main function of transfer offices is to mediate between firms and university scientists. Most often firms with certain technological problems ask the office for help in finding a scientist who can assist them in their search for problem solutions. Such assistance can be a short-term consultation; it can also amount to a longer-term contract research. The other way round, university scientists may contact their transfer office when they have produced an invention that may be useful to firms. The transfer office then will assist the researchers in applying for a patent, as it will also look out for potentially interested firms. Moreover, the office can advise a researcher who wants to found his own firm to market his invention.

In the F.R.G. nearly all of the more than 50 "Fachhochschulen" (polytechnics) with a technical orientation have already established transfer offices. At the Fachhochschulen the institutionalization of this new transfer mechanism began very early in the 1970s. At the university level the first transfer office was opened in 1976; but a rush of foundations only began in 1983. Nevertheless, at present 25 of the 56 universities and technological universities have transfer offices. The "Arbeitsstelle Forschungs-Kontakte" of the Universität Tübingen may serve as an example of the effects of this transfer form. Founded in 1980, after a starting period of two years it had quickly reached its capacity: unit of about 100 mediations per employee – with three employees plus secretary. Between 1980 and 1985, the financial support of the university by firms rose from 0.5 percent to 6 percent of all separately budgeted research funds. This may still seem to be a small amount; but one has to consider that only a few disciplines of university research are involved in transfer activities. In these disciplines research funds from firms often cover about 25 percent of all separately budgeted research funds (see [30, p. 12]).

2.3. Joint research projects

Joint research projects of universities and firms have been initiated mainly in the context of a new kind of research promotion program of the BMFT: the "Verbundforschungsprogramme". Established in 1984, this program is designed to stimulate joint

research projects of a group of firms together with state-financed research institutes, including universities. Three "Verbundforschungsprogramme" in the areas of information technology, environmental technology, and production engineering are working at present. Taken together they cover 58 percent of the whole promotion of R&D projects in industry by the BMFT. Unfortunately, there are no data about the quantitative involvement of universities in these programs.

2.4. Personnel transfer

Compared with the consultation of university scientists by firms, contract research, and joint research programs, personnel transfer is a more intensive transfer form. University scientists work for a period of time in R&D departments of firms, or industrial scientists collaborate for some time in university research institutes. In both ways industrial scientists are encouraged to learn new methods and ways of thinking. By working closely together with university scientists, industrial scientists get to know the latest research questions, methods, and results in the respective field of science; in turn, university scientists become acquainted with the firms' current technological problems.

Since 1982 three Länder of the F.R.G. have established programs to promote personnel transfer between universities and firms. In addition, on the federal level the BMFT initiated a similar program in 1984 which provides financial support for sending 200–250 industrial scientists to state-financed research institutes for a maximum period of three years. Interestingly, two-thirds of the industrial scientists choose university institutes.

2.5. Transfer research institutes

In a preliminary stage of this transfer form, research institutes at universities are founded with the explicit goal of exploring fields of research that promise technologically useful results for certain industries. This goes clearly beyond single or occasional projects of contract research. A purposeful orientation of research activities according to technological problems of firms and an active search for interested firms is implied in this kind of transfer. Since 1982 several important institutes of this kind have been founded, for example, the

"Forschungszentrum für Informatik" (informatics research center) at the Technische Hochschule Karlsruhe, which is supposed to finance itself through contract research and which has already large research contracts with IBM.

Transfer research institutes in the proper sense are university institutes that are financed not via project funds but via institutional funds to a significant extent by one firm or a group of firms. Through this participation in the financing of the institutes the firms obtain certain rights concerning decisions about the institutes' programs and directors, the marketing of the institutes' research results, and the involvement of their own scientists in the institutes' research activities. The \$70 million investment of the German chemical firm Hoechst AG in a biochemical laboratory at Harvard University in 1981 was at that time a surprising, for some people shocking event. Since then, there have been a couple of similar contracts between German universities and firms.⁶ In 1984, for example, an "Institut für Biotechnologie" (institute for biotechnology) was founded at the Freie Universität Berlin; the Schering AG, a large pharmaceutical firm, will invest DM40 million in this institute until 1994, which amounts to 50 percent of the total costs. Another example is the "Institut für Laser-Technologien in der Medizin" (institute for laser technologies in medicine) founded in 1986 at the Universität Ulm, which is partly financed by several firms.

2.6. Technology parks

Technology parks are conceived as organizational contexts in which newly founded technology-based firms are given the opportunity to develop their technological innovations until they have gained a firm standing in their industry. Such parks offer diverse services such as rooms for conferences or secretary pools for these firms. The firms can consult the management of the park with financial or marketing problems. Rents for offices and laboratories are cheaper than elsewhere. Being in the vicinity of a university provides opportunities to get inspiration and advice from university scientists – especially since

many founders of such technology-based firms are recent graduates and still have many personal contacts with researchers in the university.

Technology parks have spread all over the F.R.G. within a very few years. The first one was founded in 1983; in 1986 at least 27 parks existed, and 34 more were in various stages of planning. The size of these parks varies considerably – between parks for half a dozen firms and others that offer premises for about 50 firms. The respective demand on the part of the firms varies as well. There are parks in which only 40 percent of their capacity is actually given to firms, while other parks are full and have long waiting lists of interested firms. Indicators of the economic effects of technology parks are available only in a few cases. In the "Technologiefabrik Karlsruhe", for instance, 10 firms made a turnover of DM8.6 million in 1984, whereas in 1986 the turnover had risen to DM20 million.

This preliminary information must suffice here to give an impression of the new forms of technology transfer which have been institutionalized during recent years in the F.R.G. A rather sudden intensification of transfer activities is evident from these data. Obviously, both universities and firms have become interested in one another *simultaneously*. The question is why this has happened, and to what extent this change has been brought about by measures of political guidance.

3. The cyclical auto-dynamic of technology transfer

Current discussions about the possibilities and limits of an intensified technology transfer between universities and firms have pointed out many diverse determinants. An impression of the complexity of possible restraining or facilitating factors may be gained from the following brief list:⁷

- legal and financial conditions: The institutionalization of transfer forms – for instance, the foundation of a technology park – has to be financed. With respect to legal rules, in the F.R.G. university scientists interested in trans-

⁶ In a survey of newspaper articles 13 larger projects of this kind between 1982 and 1986 have been identified.

⁷ A more detailed discussion of several of these factors may be found in Schimank [23].

- fer contacts with firms are restricted by strict Federal and Länder laws and statutes.
- conditions of general and specific legitimacy: Public opinion about transfer activities may be more or less approving or disapproving. Perhaps more important, there may be resistance against transfer activities from several groups within the firm or the university.
 - the condition of complementary orientations: The orientations of firms and university scientists towards transfer activities must fit together. Scientific and economic orientations are never identical; but a working consensus about such issues as time horizon, applicability and publication of research results must be achieved.
 - conditions of transfer management: Transfer managers, such as the staff of transfer offices, must have certain skills if they are to moderate the communications between university scientists and firms smoothly.
 - conditions of the university research potential: The universities must have the necessary personnel and laboratory capacities to be able to meet the expectations of the firms – a condition not fulfilled, for example, by many French or Italian universities.
 - conditions of the firms' innovation potential: The firms have to be capable of implementing the research results of the universities in more efficient or effective production processes and better or new products.

All these factors vary considerably across nations, within nations across regions and industrial branches, and during time. No survey of the present situation in the F.R.G. with respect to these factors, however, shall be presented in the following. Instead, a general theoretical model shall be elaborated which focusses analytically on a more basic determinant of transfer activities – namely, the *simultaneous transfer motivation of firms and university scientists*. If this motivation is absent on at least one side, no transfer occurs and the conditions listed above are irrelevant. Only if this motivation exists on both sides at the same time a further discussion, which cannot be accomplished within the limits of this paper, of restraining or facilitating factors does make sense.

The theoretical model put forward here views the present intensification of technology transfer between universities and firms basically as a result

of the innovation cycle of capitalist economies. This cycle is governed by an auto-dynamic that emerges from the specific rationality of firms as economic actors within capitalist markets. This intra-economic auto-dynamic produces a parallel cyclical auto-dynamic within the relationship between firms and universities.

The elaboration of this model can start from the observation that the intensification of transfer activities is not spread widely over diverse scientific disciplines but is generally limited to two research fields: information technology and biotechnology. Both fields are highly differentiated and have an interdisciplinary character. Their basic theories, microelectronics and biochemistry, have been worked out continually in scientific research communities throughout the last decades. Thus, both information technology and biotechnology rest on well-founded general theories. This is a precondition for the search for potential technological applications. The abstract, highly simplified models of the general theories must be specified to enable a design of technical artefacts and procedures that do not only work in the ideal-typical environment of laboratory experiments but also under the manifold concrete conditions of non-scientific environments.

In the fields of biotechnology as well as information technology this technological orientation has dominated research activities for some time. This is how the transfer suitability of both research fields is ensured. Many technologically innovative research results have been worked out already. Although many have been implemented as technological innovations there are still many others which are ready and waiting for implementation; and new research results are being produced all the time. This growth intensity of both fields corresponds to the width of potential technological applications in many industries and realms of society. Information technology has already penetrated most realms of society – from industrial production to services, from mass media to leisure activities. Biotechnology promises a similar variety of applications in the health system, in ecology, in agriculture, and in the food industry, not to mention the possible future combination of biotechnology and information technology in the development of organic chips.

But the transfer *suitability* of research results is only a necessary, not a sufficient condition for the

present intensification of transfer activities. The other condition is the *simultaneous transfer motivation* of the relevant actors: on the one hand the university scientists, on the other hand the firms. For a long time many technologically relevant research results have been neglected by the firms in both research fields. In turn the university scientists who have worked out these research results were not interested in the commercial potential of their work. The decisive question therefore is why this mutual lack of interest has swung to the other extreme.

When asked, the firms involved in transfer activities articulate their motives quite clearly. They perceive serious technological problems which endanger their present competitiveness or are expected to do so in the near future. According to the firms, these problems reach beyond the present horizon of their own R&D departments. Consequently, the firms are looking for other research institutes, such as universities, where they can find solutions for these problems.

Such answers often sound like apologies for past mistakes. A closer look at the specific actor constellations of firms in capitalist markets reveals that these firms did not make any mistakes which could have been avoided but that they were irresistibly bound to act in this way.⁸

The basic feature of actor constellations in capitalist economies is competition. Firms have to realize their profits against other firms which try to do the same. One strategy a firm can use to gain at least a temporary competitive advantage is to innovate the technology of its products or production processes and thereby to enhance the quality and/or reduce the price of its products. Consequently, the permanent search for and implementation of technological innovations is an essential precondition of the survival of a firm on a competitive market. But, as each firm is subject to this innovation pressure, an escalating auto-dy-

namic begins. Each firm has to innovate because at least one of the others innovates.

In general, two types of technological innovation must be sharply distinguished: basic innovations and improvement innovations. While basic innovations radically change the technological foundations of certain products or production processes, improvement innovations are just incremental modifications. For example, substituting tubes with transistors in radiotechnology was a basic innovation; increasing the transistors' efficiency was an improvement innovation.

Under normal conditions firms prefer improvement innovations to basic innovations. The competitive actor constellations in capitalist markets discourage firms from developing basic innovations because this is nearly always a very risky, longterm, and expensive procedure. Instead, the R&D departments of firms concentrate on marginal improvements within the framework of the given basic technology of the firm. As this preference for improvement innovations is a general one, all firms in a particular industry share the same basic technology and exhaust its possibilities for improvement sooner or later. With the continual reduction of these possibilities the search for improvement innovations becomes more and more complicated and expensive. But their mutual competition forces the firms to prefer improvement innovations even then. The intensification of competition causes the firms to act increasingly short-sighted and consequently to reinforce the priority of improvement innovations even though they become more and more aware that they are all running into a blind alley. It is a rational irrationality which leads the firms to act this way: Short-term success means the final crisis comes nearer and nearer; but short-term success is indispensable in capitalist markets – thus, this fatal course of events cannot be avoided.

Since industries inevitably slide into a technological crisis from time to time, only the implementation of a new basic technology promises a way out of stagnation and decline. Such crises thus change the preferences of firms radically in favour of basic innovations. The firms then recognize that they themselves have neglected the necessary research efforts especially in the last period before the crisis because they were obsessed with trying to wring out the last tiny improvement innovation out of their exhausted basic technol-

⁸ The following simplified model of the innovation cycle in capitalist economies is basically inspired by Schumpeter [25]. Recently many contributions to discussions about the "long waves" of economic development and the current economic situation work out similar perspectives. Compare Mensch [16], Graham and Senge [8], Freeman et al. [6]. Kenney [12;13] uses a Schumpeterian approach for a very interesting analysis of the relation of firms and universities in the field of biotechnology.

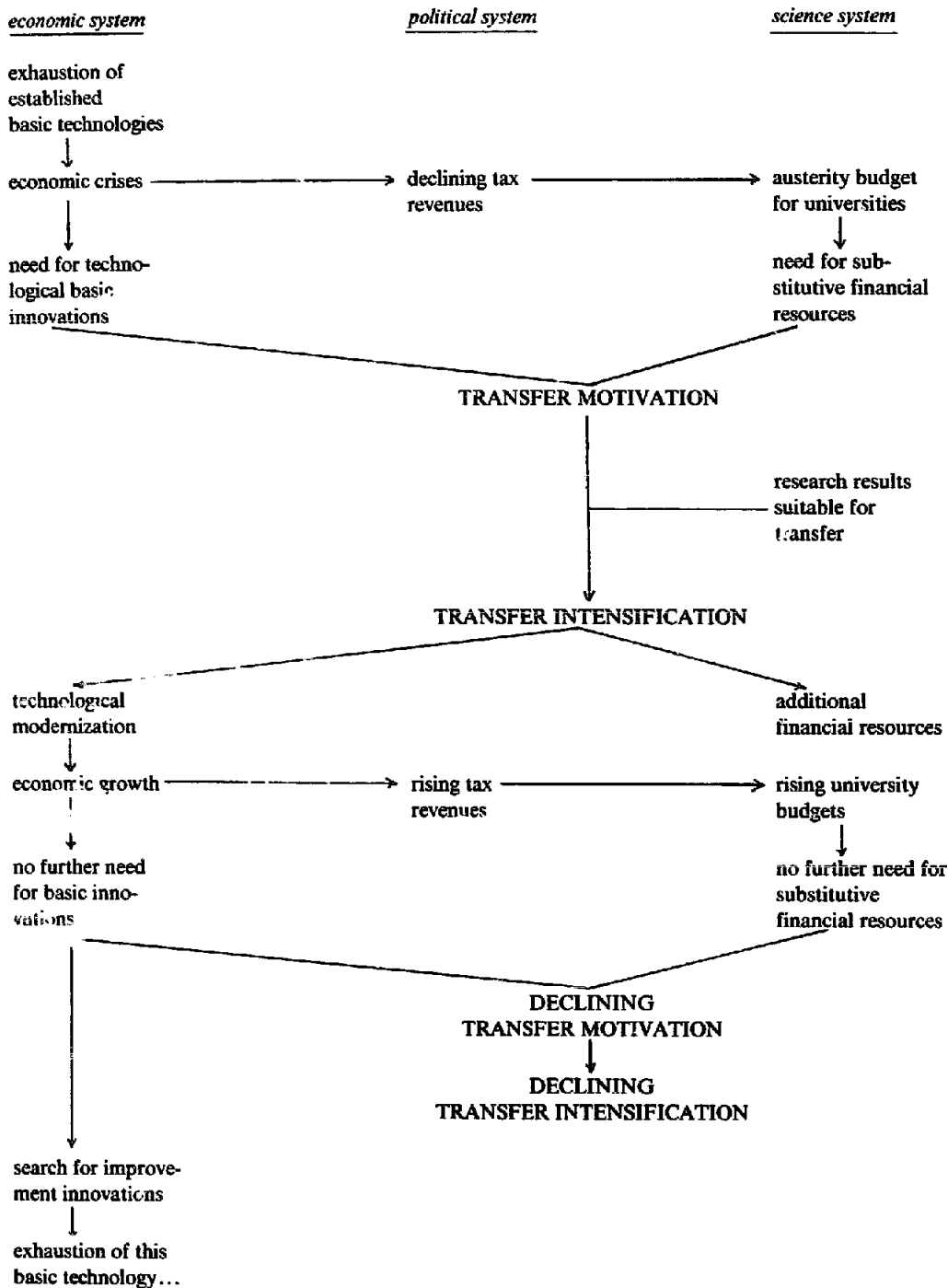


Fig. 1.

ogy. This situation forces the firms to consult state-financed research institutes, particularly universities.

Turning now to the universities, one can see at once that their most important motive for an intensification of transfer activities with firms is to compensate reductions of financial resources for

research. Since the mid-1970s the growth of these resources has lagged behind the inflation of research costs. In addition, many university scientists who had been preoccupied with teaching in the years before have now turned to research in view of declining numbers of students. Thus, the demand for financial resources has risen consider-

ably beyond the available resources; this is indicated, for example, by a rapidly growing number of research proposals not appropriated for financial grants by the Deutsche Forschungsgemeinschaft (DFG: German Research Society) (see [5, p. 17]). Moreover, since the beginning of the 1980s many permanent positions for research personnel have been cut at the universities as a consequence of an austerity policy of the Länder governments.

This reduction of their research capacities has motivated university scientists to turn to other potential sources of financial resources. Thus, firms interested in contacts with university scientists out of different but complementary motives are welcomed as partners for lucrative transfer activities. The interests of both sides meet. But what seems to many observers like a lucky chance really is an outcome of the structural interdependence between the economy and the university system. As universities are state-financed bodies and the financial potential of the state is dependent upon the prosperity of the economy, universities suffer from an economic crises as well. Consequently, the convergence of interests in an intensification of technology transfer from universities to firms is all but surprising.

Despite the claims of many current interpretations, this intensification will not last forever. As soon as the firms have gained the basic technologies needed from the universities, their interest in further intensive contacts will cease because then they will be able to resume their usual routines of improvement innovations again. Since this means that the economic crises will soon be over and the taxes will again flow amply, there will no longer be any need for austerity budgets for universities. Consequently, the universities will be well supported with financial resources from the state and will not need additional money from firms. Thus, they will also lose interest in transfer activities. Again, the interests of both sides meet – but this time in a reduction of transfer until the industries have used up the possibilities of their basic technologies for the next time.

In sum, the empirically discovered increase of transfer activities can be explained as a *cyclical auto-dynamic* caused by the specific actor constellations of firms in capitalist markets and the financial resource dependency of universities upon the state and, thereby mediated, upon the economy (for a summary see fig. 1). It must be stressed

once more that this is an ideal-type model which leaves out completely all the restraining or facilitating context variables of transfer activities mentioned above. Consequently, the aim of constructing this model cannot be to explain any real-life events of transfer intensification, or their absence. Only in combination with empirical knowledge about the context variables may this model work as an explanatory device. Thus, the model itself functions as a heuristic theoretical scheme for interpreting social reality.

4. Political guidance

A societal auto-dynamic like the cyclical intensification of transfer activities between universities and firms is unquestionable a product of intentional human action. A remarkable feature of such activities is that firms as well as universities deliberately change their way of acting. Nevertheless, the cyclical auto-dynamic is not an intended outcome of action but a non-intentional aggregation of many individual actions. The mechanism which sets this transfer cycle in motion is an endogenous one, namely the specific actor constellations of firms in a capitalist economy and of universities in relation to a capitalist economy. The auto-dynamic reproduces itself in a kind of pre stabilized harmony between the technological needs of the firms and the intensity of transfer activities.

But this does not mean that there is no need for political guidance of transfer activities. The many context variables important for the working of this auto-dynamic can become targets for political interventions in the process. Under these circumstances, the proper aim for political guidance is not the *creation* of transfer activities by building up transfer motivations on both sides. This is done by the auto-dynamic itself; political measures could only disturb that. But political guidance can *catalyze* transfer activities. Like a good catalyzer in chemical processes, political guidance can set in motion or accelerate transfer processes which would not begin or would drag on slowly without it.

To begin with, political actors are for at least two reasons unable to control transfer activities in a deterministic way. The first limitation of such a deterministic control are the realms of autonomy

which universities as well as firms possess. Firms in a capitalist economy are in the end autonomous with respect to investment and R&D decisions. University scientists have a similar autonomy concerning their research decisions. Thus, government agencies cannot order a firm and a university scientist to engage themselves in transfer activities of a certain magnitude and period of time in a certain research area. At best, political actors can try to induce firms and universities to do so by various kinds of gratification and persuasion.

Secondly, a deterministic political control of transfer activities is limited insofar as government agencies almost completely lack the necessary information to decide rationally who should transfer what to whom and when. Only firms know with adequate precision which kinds of research results they need, to solve their present technological problems. Government agencies trying to think ahead of the firms and to direct the research activities of firms and of state-financed research institutions according to expected future needs of the respective industry are almost doomed to fail, as experiences in many countries have shown again and again (see [9, pp. 145–156;19;20]). Further, only scientists can estimate which areas of research are already suitable for technological applications. Government agencies may, out of their ignorance of the specific state of the art in a given research field, try to transfer research results that are still not ready for a technological implementation. Consequently, since only firms and university scientists possess the relevant strategic information, government agencies cannot determine on their own which kinds of transfer activities should take place.

This lack of power as well as knowledge needed for a deterministic control forces political actors to acknowledge the primarily *decentralized self-organization* of the technology transfer between firms and universities. Nevertheless, measures of political guidance are in certain respects not only useful but sometimes even indispensable in preparing the context for effective transfer activities. Measures of political guidance can intervene into the complex structural context of transfer activities and try to manipulate at least some of these factors directly or indirectly. Three important measures of such a catalytic guidance are the mobilization of public legitimacy, the financial

support of self-organized institution building, and the removal of legal restrictions.

The *mobilization of public legitimacy* for an intensification of transfer activities between firms and universities has been very conspicuous in the F.R.G., especially since the change of government on the federal level in 1981. In the years before only some Länder governments – mostly where the Christlich-Demokratische Union (CDU: Christian-Democratic Union) was in office – propagated technology transfer as an important strategy to solve both the financial resource problem of the universities and the technological problems of firms.⁹ Especially the government of Baden-Württemberg never tired of advertising the urgent need and the already visible successes of such transfer activities. Since 1981 many programmatic statements from the BMFT show that the federal government headed by the CDU has taken up this issue and pushed it ahead as a prominent topic in its redirection of research policy.

This rhetorical political support of an intensified technology transfer furthers the societal auto-dynamic in several ways. First of all, the receptiveness of firms and university scientists for a reflection about the possibilities of transfer activities is enhanced. Technology transfer is diffused as a new and interesting idea in both groups. Moreover, these actors hope that the political rhetoric will soon be followed by more tangible proof of sympathy for transfer activities – especially financial support. This expectation accelerates the development of a positive public climate and the inclination of firms and universities to engage in technology transfer. Lastly, resistance against transfer activities by various actors in the firms as well as in the universities can be delegitimized by reference to the politically generated positive public opinion.

Governmental *financial support for the institutionalization of new transfer forms* has increased in correspondence to the mobilization of legitimacy. Since diverse chapters and titles of the budgets of local and Länder governments and the federal government can be sources of financial support,

⁹ To do justice to the Social Democrats, the first transfer offices at universities have been installed in Länder where they were in office. But such transfer activities remained a neglected issue in Social Democratic policy making.

no ready-made statistic is available to document this increase. To give just one example, several titles in the budget of the BMFT have sharply risen since 1981: For a new program of personnel transfer, in 1984 DM4 million, in 1985 DM7.7 million, and in 1986 and 1987 DM15 million for each year have been supplied; the venture capital provided for the foundation of technology-based firms has been increased from DM3.9 million in 1981 to DM70.8 million in 1986; and the financial support for several other forms of transfer has been enlarged from DM1.4 million in 1981 to DM18.2 million in 1986 (see [17; 4, p. 42]). These are comparatively small budget titles; but if one would add all the financial supports provided for founding the many transfer offices and technology parks during recent years this would amount to a rather large sum of public money.

Most new forms of technology transfer would not come into being without financial support from government. But although this support is existentially important to transfer institutions, government agencies do not interfere into the construction of these institutions. All matters of organization, goal-setting, work procedures, and personnel selection are left quite deliberately to the initiators, supporters, and managers of the transfer institutions. As a result, the self-organization of transfer interests "from below" is not stifled by political dirigism but fostered as the only reliable source of information about the specific local and situational needs and contexts of transfer activities.

A further measure of a catalytic political guidance of technology transfer is the *removal of legal restraints*. On the one hand, the "Arbeitnehmerfinder-Gesetz" (law about inventions made by employees) of the F.R.G. favours university scientists because it categorizes their inventions as "free" inventions from which the university as employer cannot reap any benefits. On the other hand, many political actors have begun to recognize that the present university law discourages university scientists from engaging in transfer activities. This demotivating effect of the university law is not only brought about by the restrictiveness of the regulations. In addition, the ambiguity of the regulations, and hence the unpredictability of an approval, as well as the complicated procedures of approval deter many scientists from even planning transfer activities. Indirectly such legal restrictions

demotivate the firms as well: If they anticipate that university scientists are entangled in red tape, the motivation to get involved with them is sharply reduced.¹⁰

Some Länder governments and the federal government have recently begun to relax certain statutes of the university law. University scientists shall become more flexible in financial and personnel matters and thereby shall be encouraged in their transfer motivation. It is as yet an open question whether these legal restrictions can be effectively removed without breaking up the unity of the public budget and personnel law by special administrative regulations for university scientists – a legally problematical matter. This shows how catalytical guidance faces increasing difficulties by moving from legitimation to financial support to legal changes. While the mobilization of legitimacy for transfer activities has to overcome the resistance of public opinion, which is comparatively easy, it becomes more difficult to support transfer activities financially because this means redistributing money and coming to grips with actors who are or perceive themselves to be at a disadvantage as a result of the changes. But the most difficult task is to amend the laws because, in addition to the resistance of actors, one has to surmount the inertia and the lack of transparency of institutions.¹¹

This short discussion of several measures of a catalytic guidance of transfer activities should have at least produced an awareness of the complex interplay between the societal auto-dynamic and political guidance. As many contributions to the current discussions about the possibilities and limitations of political guidance in complex contemporary societies maintain, political actors have to refrain more and more from temptations to deterministically control societal events and developments (see Kaufmann et al. [11]). Several alternative modes of political guidance are theoretically conceptualized and practically tested which all draw to a large extent on the self-organizing capacity of the actors to be guided (see [7;27;29]).

¹⁰ For example, when Hoechst AG in 1981 decided to cooperate with an American instead of a German university, this was heavily motivated by the anticipated bureaucratic restrictions for German university scientists.

¹¹ For the manifold difficulties of institutional reform see Scharpf [22].

Thus, their action potential is no longer warily viewed as resistant and dangerous to political guidance, but in contrast as helpful and even indispensable. In the same way, the auto-dynamic of the technology transfer between universities and firms has been portrayed here not as a barrier against effective political guidance but instead as a non-intentional creation of technological innovation opportunities that cannot be outdone, but must be promoted, by intentional innovation policies.

5. Conclusion

Surely the technology transfer from universities to firms is only one aspect of current efforts to overcome the decline of major industries in Western capitalist societies. But it is an aspect which deserves a thorough analysis. Here only preliminary empirical data and speculative theoretical ideas have been sketched mainly to stimulate further discussions and investigations of the subject matter.

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