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Reflexive Stimulation or Disjointed Incrementalism?

Readjustments of National Technology and Innovation Policy

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Abstract

Are national technology and innovation policies becoming obsolete under the conditions of an increasing internationalization of science, technologies and industry? The paper supports the argument that despite globalization and Europeanization, national technology and innovation policies remain the most important and effective level of governance in this area of policy. The argument will be elaborated in four steps: firstly, the paper presents a brief overview of the discussions and controversy concerning the future governance of technology and innovation policies. Secondly, the effects of changing general conditions on national policies are discussed, especially the policy implications of the development of new technologies, of the internationalization of industry and of the growing importance of public discourses. Thirdly, the relations between the national and the European level of governance are analyzed and an answer is given to the question why there has not been a significant shift of competencies and resources from the national to the European level until now. Against this background and with a special view regarding the German case, the paper finally analyses strategic reorientations, new elements and instruments of the national technology and innovation policy and discusses their impact on science, industry, and society.

1 Discussions and controversies: Globalization, multi-level governance and the remaining role of national policies

For a long time major objectives of national technology and innovation policies have included strengthening technological competitiveness, supporting technologies and promoting innovation activities on the territory that is controlled. And they are still at work. In Germany as well as in other leading countries, national policy efforts are strongly focused on the aim "to enable Germany to hold its own against the competition of other leading technology regions of the world." (BMBF 2000: 14-15) However, are national policies still able to call the tune? What remains of national political capabilities to stimulate or shape technologies, innovation activities, infrastructures and institutions under conditions of an increasing internationalization of knowledge, technologies and industries?

In Germany, since the early 1990s these questions have been discussed mainly in the field of political science (see Grimmer et al. 1992; Martinsen/Simonis 1995; Gerybadze et al. 1997; Grimmer et al. 1999; Simonis et al. 2001; Grande 2001). The debate began with a paradigm shift. The conception of a coherent and intervening state with regard to economy and society and with this the idea that the state could shape or steer technological progress (Hauff/Scharpf 1975) was empirically proven wrong (Simonis 1992; Meyer-Krahmer 1999). Instead since then three different arguments have been widely acknowledged:

Firstly, it has been recognized that the state is only one player in the technology and innovation process among other relevant actors. Moreover, it has been shown that political decision-making systematically depends on external expertise and negotiations with powerful private actors especially from industry and science. Therefore the idea of an autonomous and directing state was replaced by various concepts of a cooperative, interactive, learning or negotiating state.

Secondly, it has been emphasized that political authorities are not able to plan or steer technologies or innovation activities but instead at best are able to provide general conditions and 'soft' incentives for multiple self-organized and self-interested groups of actors. Therefore the idea of an active and intervening technology and innovation policy was rejected in favor of new modes and instruments concerning a more indirect stimulation of innovation activities, infrastructural and institutional change.

Thirdly, it has been stressed that the complexity of policy-making itself has increased significantly over the past two decades. Because of Europeanization (and regionalization too) national technology and innovation policies have lost their exclusiveness in the policy-making system in favor of an emerging multi-level system of governance. Therefore the focus of analysis has shifted from national policies to the patterns of Europeanization and the multi-layer structure of this policy field.

However, behind these stylized facts there are still controversial points. This concerns especially the two related questions which will be discussed in this paper.

The first one deals with the distribution of resources and competencies within the scope of the multi-level system of governance. Is the gradual Europeanization of innovation and regulatory policy activities undermining or replacing policies carried out at the national level? Or does the nation state remain the indispensable and dominant arena of policy activities? (see the discussions in Kuhlmann 2001; Edler et al. 2003; Edler/Kuhlmann 2005) Or, to put it into a normative question: is a "much stronger, more focused and

integrated policy for industry and technology" in the European Union necessary to fulfill the conditions of globalization and to consolidate Europe's competitiveness in the global technology race? (Chesnais et al. 2000: 249; see also EU-Commission 2000) Or is the technological competitiveness of Europe even today mainly based on the national capabilities, infrastructures and institutions of their leading countries?

If this last question is answered in the affirmative a second tier of questions arises concerning the remaining leeways and capabilities of policy-making at the national level itself. Does the internationalization of knowledge, technologies, markets and industrial activities lead to a convergence or dissolution of national innovation systems and to a substantial decline or erosion of nation states' capacities in technology and innovation policy? (Willke 2001; Grande 1994, 2001b; Ohmae 1990; Cairncross 1997) Or do there remain variations across countries in innovation, production and political systems as well as in national innovation policies indispensable in providing opportunities, infrastructures and institutions rendering the country attractive for science and industry? (Porter 1989; Nelson 1993; Mowery/Nelson 1999, Archibugi/Iammarino 1999)

The main argument of this paper is that national technology and innovation policy is not becoming obsolete. National systems of innovation with significant differences in technological specialization, markets, infrastructures and institutions remain the most important level of innovation activities even in the era of globalization. Moreover, national policies especially of the large European member states (and the US as well) aim at strengthening their own technological and economic competitiveness in rivalry with other countries. This sets limits both to the emergence of a European system of innovation and the European integration process in this area. Of course, to face the challenges of internationalization and to remain functioning, new adjustments of national technology and innovation policies are necessary. They have to open up, learn from and adapt to other countries and develop new systemic concepts and instruments of policy-making.

The paper argues along these lines in three steps. The following chapter discusses the effects of changing general conditions on the leeways and capabilities of national policies, especially the policy implications of the development of a new set of core technologies, of the internationalization of industry and of the growing importance of a watchful and headstrong public. In the third chapter the division of competencies between the national and the European level of governance will be analyzed and the question will be answered, whether there is a significant shift of competencies and resources from the national to the European level or not. Against this background and with a special look at the German case, the paper will finally sketch strategic reorientations, new concepts and instruments of national technology and innovation policy and discuss their capability to influence and stimulate innovation activities as well as infrastructural and institutional change.

2 Contexts: Fluid technologies, international economy, watchful public and changing governance

To get an impression of the challenges technology and innovation policies are being faced with, it seems above all necessary to work out major changes in technology, economy, public perception and governance during the last two decades and to sketch their repercussions on policy-making.

2.1 Fluid technologies

The portfolio of core technologies has changed fundamentally. Since the

1980s new information and communication technologies have transformed the entire economy and ultimately the rest of society as well. Moreover, genetic engineering, life sciences and nanotechnologies are gaining in importance.

The characteristics of these new cross-sectoral core technologies, which at present dominate the dynamics of innovation and sociotechnical change, differ from those of established large technologies or large technological systems (such as nuclear energy, aircraft and space technologies, and electricity systems) in many respects. Typical features of these technologies are (Dolata 1992, 2003)

- their dynamic and fluid state: they develop fast, have wide-ranging and cross-sectoral potential applications but are often extremely uncertain concerning the direction they are going;
- their often decentralized and fragmentary character: different from large technologies they emerge in countless areas and places, are promoted by a large number of different actors and can be used in numerous contexts;
- their science-based and multidisciplinary profile: they are often knowledge-based and interdisciplinary and call for intensive collaborations both within industry and between industry and academia;
- the absence of state intervention: they are promoted mainly by enterprises, scientific institutions, industrial networks and through cooperations between industry and academia – self-organized patterns of development without direct participation of state authorities are the rule;
- their international performance: the patterns of innovation, cooperation and competition are internationally interwoven.

These characteristics of new core technologies have considerable consequences for policy-making. The direct influence of the state on the dizzy dynamics and further pathways of these complex and small-sized new technologies is low. They are different from large technologies, because the state is not necessary as an indispensable investor, guarantor or customer. Moreover, the state is no longer only faced with a small number of well-known industrial or scientific actors. Instead it has to deal with multiple heterogeneous actors and numerous self-organized and -governed networks of innovators (Freeman 1991; Rammert 1997).

Under these conditions of private self-organization and uncertainty all kinds of innovation policy activities – ranging from public research programs, institutional restructuring of public research and incentives to support the innovation efforts of firms to regional initiatives and regulatory policy – cannot be developed by an autonomous and implemented by a directing state. Instead, policy-making of state authorities is more than ever systematically dependent on the external expertise and competencies of private actors which are at the head of the innovation process. A major new challenge in this respect is how the competencies and resources of new actors (e.g. start-up companies) can be integrated into the already existing patterns of private-public consultation and corporatist decision-making between state authorities, industry and science.

2.2 International economy

Moreover, technology and innovation policies are faced with considerable changes in the patterns of industrial innovation activities. In monetary terms, an average of 70% of the overall research and development in the OECD countries is carried out by industry (BMBF 2004: 489). Three new trends are particularly remarkable and have significant repercussions on pol-

icy-making: the step-by-step internationalization of industrial innovation activities, the growing importance of technology-based cooperations and the rise of new start-up companies as catalysts of the innovation process.

Above all the internationalization of companies' innovation activities has significantly increased during the past two decades. This trend is most remarkable in new high-technologies (like biotechnology and pharmacy, computer, semiconductor and information technologies). By now, German companies, for instance, spend more than a fourth of their overall research and development (R&D) budgets abroad. Actually, the exceptionally internationalized German chemicals and pharmaceuticals industry invests nearly half of their R&D-budget in foreign countries. Other large-scale enterprises like Siemens or Daimler Chrysler do so too (Belitz 2004: 18-25; BMBF 2002a: 123-138) What is typical of these companies is that they no longer carry out only subordinate development activities in foreign countries. Instead they have begun to realize leading-edge research in company-owned R&D-centers abroad – research activities that formerly were highly concentrated in their home country (Gerybadze et al. 1997; Hack 1998; Dolata 1996). However, internationalization doesn't mean indiscriminate globalization, as Ohmae (1990), Cairncross (1997) or Willke (2001) have suggested. Companies don't allocate their R&D-activities evenly and everywhere but concentrate them worldwide in a few leading regions or districts which are close to scientific excellence and (future) lead markets (Feldman 1994; Patel 1995; Heng/Schaaf 2002; Carlsson/Mudambi 2003). Instead of a locationless globalization very selective and a regionally concentrated patterns of internationalization are characteristic of industrial R&D and innovation activities.

A second remarkable trend of the 1990s is the rapid increase of collaborations both within industry and between industry and academia – especially in new high technologies. At the top of the trend is the pharmaceuticals industry. Today the large companies of this industrial sector spend between 25 and 30% of their research budgets on the support of external cooperations, whereas until the 1980s the same companies realized their research activities nearly exclusively in-house (Dolata 2003: 175-243). The systematic constraint towards cooperation results from the extraordinary dynamics of the generation of knowledge, the fast rate of technological change and the multidisciplinarity of research and development projects. These complex patterns of innovation are, even in large enterprises, impossible to handle purely by in-house capacities (Hagedoorn 1996; Hagedoorn et al. 2000; OECD 2000). Besides the expansion of company-owned capacities and capabilities (Pavitt/Patel 1999), they require the simultaneous recourse to company-external knowledge, know-how and competencies. Therefore today "the locus of innovation will be found in networks of learning, rather than in individual firms." (Powell et al. 1996: 116; also Freeman 1991)

A third new trend has to be added. Besides large enterprises small and research-intensive start-up companies have been established as pioneers, brain trusts and driving forces of the innovation process and the early commercialization of new technologies – not only in the U.S., but during the 1990s also in Western Europe. The personal computer and its operating systems, the early commercialization of genetic engineering, and the internet, for instance, all got under way not by saturated large enterprises but by new entrants (Ichbiah/Knepper 1991; Dolata 1996; Mowery/Nelson 1999; BRIE-IGCC E-conomy Project 2001). As venturesome, research-intensive and unconventional operating units they stimulate not only the innovation process itself, but at the same time

have become important external resources and cooperators for big industry, even though the bulk of the entire industrial R&D expenses still falls to large enterprises – in Germany approximately 80% (Legler et al. 2004: 15-24) – and only very few start-up companies conduct leading-edge research and turn out to be commercially successful innovators (Parker 1999).

Altogether these trends – internationalization, collaboration and the emergence of new industrial actors – have considerable impact on the outline of technology and innovation policies.

The formerly close connection between domestic enterprises, the national development of technologies and national policies has opened up. The addressees of national policy initiatives are no longer exclusively the well-known national champions and the medium-sized enterprises at home. Instead the state has to provide general conditions and incentives that are attractive for increasingly internationally operating domestic companies as well as for foreign enterprises which intend to invest in the respective country. Moreover, it has to develop new incentives that aim at supporting the emergence and stabilization of new start-up firms. And finally, it has to recognize that today the locus of innovation will be found "in the interstices between firms, universities, research laboratories, suppliers, and customers" (Powell et al. 1996: 118) and therefore has to promote initiatives designed to stimulate cooperative arrangements and networking as well as technology transfer from academia to industry.

The pattern of a highly selective and regionally clustered internationalization of companies' research and innovation activities not only interweaves national (and regional) locations closer than ever before but at the same time places them into fierce competition and rivalry. Under these conditions, nation states are under pressure to compete with each other and struggle for locational decisions and investments of both domestic and foreign enterprises and scientists, too (Jessop 2002). For this purpose above all, they have to offer excellent research conditions, sophisticated innovation infrastructures and prosperous lead markets to companies.

2.3 Sensitive public

During the last two decades the public perception and use of new technologies has changed too. Starting with the fierce protest against nuclear energy, almost every new technology has been perceived ambivalently and has been widely discussed in public. Moreover, the end user make use of the opportunities of new technologies often in a headstrong and unexpected way (Bauer 1995; Bauer/Gaskell 2002).

In contrast to the 1970s and 1980s, today public unease concerning new technologies is not only spurred on by well-organized protest movements, non-governmental organizations and environmental and consumer associations but is increasingly expressed by collective actors which are non-organized and hardly ever institutionalized, such as citizens, voters and consumers. They remain unimportant as long as they do not develop shared user preferences or problem perceptions concerning new technologies. But if so, they are no longer only passive addressees of new technological supplies but instead can exercise considerable influence on the design and portfolio of new products as well as on public policy (Dolata 2003: 31-33).

On the one hand collective actors do appear as headstrong users and selective consumers. This is the case with many new everyday applications of media, information and communication technologies. Often final customers and users exert an influence on new technological supplies by using them very selectively or contrary to all expectations. This can lead both to

failure or (sometimes unexpected) success of new products (Kubicek 1997).

On the other hand, collective actors can also be skeptical, watchful citizens and discerning consumers, the majority of which may not accept new technologies or specific applications. This is for instance partially the case with genetic engineering, especially with new applications in agriculture and the food industry (Hampel/Renn 1999).

These opportunities of public intervention do not only have repercussions on the strategies of certain industries, they can also put political authorities under pressure. Public policy is not only forced to create initiatives and incentives which aim at strengthening countries' economic and technological competitiveness, it is at the same time faced with an enlightened public which no longer accepts technological progress in general but discusses and sometimes refuses new technologies. Therefore, policy has also to develop new modes of mediation of social controversies concerning new technologies. It has to ensure transparency, safety, consumer protection and participation as well.

2.4 Multi-level governance

Finally, the architecture of innovation policy-making itself has also changed. Since the early 1980s the most remarkable new development in this respect has been the gradual formation of an original European technology, innovation and regulatory policy. Since then, national policy initiatives have been increasingly supplemented by and partly intertwined with corresponding activities of the European Union. The formerly unchallenged dominance and exclusiveness of national authorities and policies has been restricted in favor of a co-evolution and co-existence of different levels of innovation policy making.

What does co-evolution and co-existence mean? Are we witnessing an intensified European integration and a significant shift of governance and policy-making from the national to the European level? Or can we observe only loose combinations of fragmented levels of governance in which national policies and arenas still play the dominant role? To answer this first tier of questions I will now analyze the dynamics, scope and breadth of European integration in the field of innovation and regulatory policy and give reasons for the argument that the national level of policy-making still remains the most important one.

3 Architectures: European Integration, National Systems of Innovation and International Rivalries

3.1 European Integration?

Without doubt the European Community has reached a new level of governance and the Commission of the European Communities has been established as a new and important actor in technology, innovation and regulatory policy during the past two decades. This has happened mainly in two areas: in the development of legal frameworks for research, production and commercialization of new technologies, and in the implementation of European programs for research and technological development. Moreover, with the recent approach "Towards a European research area" launched in 2000, the Commission started a new attempt to coordinate European, national and regional innovation policies in a better way (European Commission 2000).

Responsibilities for the set up of legal frameworks and regulations of technologies have shifted heavily from the national to the European level since the late 1980s. Meanwhile, the decisions concerning legal and regulatory aspects take place mainly at the European level – and are reflected in a whole string of relevant initiatives, guidelines and directives that are un-

der way or have been enacted by the European Union (for instance in biotechnology and chemicals regulation or in patent protection). As a result, the negotiations dealing with legal and regulation aspects have also shifted from the national to the European governance level – with the European Commission and the European Parliament, the governments and responsible ministries of the Member states as well as the relevant pressure groups of the European lobbying process as influential negotiating parties. However, this significant Europeanization of legal activities and regulations has not led to a dramatic loss of influence of national authorities, actors and controversies up to now. As for instance the development of regulations for biotechnological research, production and marketing or the discussions about a renewed European chemicals regulation show, national actors and interests are closely involved in European negotiations, are often able to set the tone, to initiate and to speed up as well as to protract or to block the European decision-making process (Dolata 2003a; Hampel 2005; Jacob/Volkery 2005).

Table 1: Budget of the EU Framework Programs for research and technological development (FPs) in comparison with the public R&D funds of the Member states

		Budget FPs (billion Euro)	Share of FPs on total EU budget (in %)	Public R&D funds of the EU Member states (billion Euro)	Share of RP-budget on public R&D funds of the Member states (in %)
1. FP	1984 – 1987	3.75	2.41	110.5	3.4
2. FP	1987 – 1990	5.37	3.15	128.1	4.2
3. FP	1990 – 1994	6.60	4.04	198.9	3.3
4. FP	1994 – 1998	12.30	4.02	220.1	5.6
5. FP	1998 – 2002	14.96	4.15	251.7	5.9
6. FP	2002 - 2006	17.50	-	-	-

Source: Rammer et al. 2004: 170

However, in the field of European technology and innovation policy such a comprehensive shift is scarcely to be identified up to the present – not even as an outcome of the recent European research area initiative.

Of course, the European Union has become a serious player in technology and innovation policy, too. Since the early 1980s the EU has established ever increasing Framework Programs (FPs) for research and technological development that are targeted at a number of advanced technologies, particularly including sectoral programs to support research in information and communication technologies and the life sciences. Furthermore, FPs are aiming to stimulate scientific cooperation within Europe and to strengthen the transnational networking between the actors, institutions and regions involved (Peterson/Sharp 1998; Borrás 2003; Prange 2003).

Even though the total amount of the European Union's spending on research and technological development has increased substantially through to the present, it cannot keep up with the public funds for research and development (R&D) in the Member states: as table 1 shows, the 17.5 billion Euro budget of the latest framework program meets with only approximately

6% of the total public funds for R&D in the Member states, of which about 75% are spent in Germany, France, the UK and Italy (BMBF 2002: 338). The European funds have gained in importance in supporting research and infrastructures in the smaller and weaker Member states, but have only a minor impact on the national innovation systems of the leading ones (Pavitt 1998).

More important is the fact that European policy has not yet been able to integrate the fragmented national research infrastructures, to coordinate the various regional, national and European policy activities effectively and to develop a coherent European technology and innovation policy which would be mandatory on the Member states (Kuhlmann 2001; Grande 2001a). In 2000 the European Commission itself stressed this negative record by stating that "it cannot be said that there is today a European policy on research. National research policies and Union policy overlap without forming a coherent whole." Furthermore: "Above the European research effort as it stands today is no more than the simple addition of the efforts of the 15 Member States and the Union." (EU-Commission 2000: 7)

It seems that the European research area initiative launched in 2000 will not be able to change this situation fundamentally. The suggestions made with this new approach were not far-reaching. Although the Commission was aware of the lack of coherence and coordination of national and European technology and innovation policies, the only suggestions made in this respect were to develop a benchmarking system of national research policies, to improve science and technology foresight, statistics and indicators, and to strengthen and intensify the European networking of existing national research centers as well as public-private partnerships. In contrast to the past, the Commission did not claim once again far-reaching new competencies in technology policy but instead emphasized its role as a catalyst and soft coordinator of activities which (should) take place mainly on the national and sub-national level (EU-Commission 2000, 2002, 2003; see also Edler et al. 2003; Edler/Kuhlmann 2005). This is an remarkable restraint which recognizes the persistent dominance of national resources within the EU as well as the fact that even though the industrial innovation activities are highly internationalized, the national and sub-national innovation infrastructures remain the most important ones concerning the production of new knowledge and technologies.

To sum up, the future role of the European Union as a player in technology and innovation policy seems to be confined to the forecasting of technological developments and the benchmarking of national policies as well as to the stimulation of European networking in science and technological development. Paradoxically, concentrating on this restrained scope of duties may turn out to be a successful strategy for further European integration – not only because it takes into account national self-centeredness but particularly because it acknowledges the necessity of distinct national and sub-national policies. Therefore one can hardly expect the emergence of a European technology and innovation policy which could replace or compete with the national policies at eye level. It seems that the recent initiatives undertaken will not remove the existing balance between the European and national responsibilities and competencies in this policy field.

3.2 National systems of innovation and international rivalries

There are two complementary explanations for this restrained scope of European integration and the persisting dominance of national policies in this arena.

Firstly, international as well as regional patterns of innovation are chiefly structured and formatively in-

fluenced by the distinct peculiarities of national systems of production, innovation and policy-making. Despite increasing interweaving and penetration there is little empirical evidence for a strong convergence of national systems or for the emergence of a coherent European system of innovation.

Secondly, the leading countries – among others especially the U.S., Germany, France, the U.K and Japan – clearly compete with each other. Against the background of a very selective and regionally concentrated internationalization of industries' innovation activities, national policies are forced to compete for technological leadership as well as for the most excellent and attractive innovation-oriented infrastructures as major prerequisites for their competitive advantage.

Especially the research on national systems of innovation (Nelson 1993; Edquist 1997; Mowery/Nelson 1999; Balzat/Hanusch 2004) and the varieties of capitalism (Soskice 1999; Hollingsworth 2000; Hage/Hollingsworth 2002) has shown convincingly, that major differences still exist between national systems of production, innovation and policy-making. These differences range from distinct national research and education systems, unique structures of industry and inter-firm collaborations through to the financial systems, the demand and market structures or the patterns of negotiation, public perception and political moderation of controversies about new technologies. Of course, the national systems are closely intertwined in the age of internationalization and national policies try to learn form and adapt to each other. But they do so in their own unique way and against the background of very different national innovation cultures, patterns of technological specialization, institutional contexts and political systems. And they try to sharpen unmistakably national or rather regional innovation profiles and strengths which enable the country to stand the test of international rivalry and competition (Diederen et al. 1999; Kuhlmann 1999, 2001; Borrás 2004; Senker/van Zwanenberg 2001).

All in all there is little evidence so far of advanced tendencies towards a uniformity of national systems or towards the emergence of a coherent European system of innovation. Instead, the territories of the great nation states remain the most relevant areas of innovation with diverse and unique profiles. Otherwise the highly selective and regionally concentrated locational decisions and investments of industry would make no sense: enterprises do not go anywhere but instead put out feelers and make very specific locational choices.

Against this background it should be comprehensible why core elements of technology and innovation policies still remain nationally-based – even within the European Union. If national areas of innovation with distinct infrastructures, patterns of specialization, institutions and cultures are still the most important ones, their modernization and readjustment right at the front has to be pushed forward by national political authorities. And if the internationalization of industrial research, development and innovation activities is not viewed as a process of locationless globalization but instead is identified as a highly selective process restricted to a few top regions and lead markets worldwide, the great Member states of the European Union are not only competing with their non-European rivals (like the U.S. or Japan) but also with their European ones – and therefore pay careful attention not to reduce the remaining leeways of national policies by delegating core competencies to the European Union (Banchoff 2002).[1]

[1] In two interim balance sheets of the European Research Area Initiative the EU-Commission had to admit that „the initiative in its current form seems to be hampered, however, by insufficient participa-

4 National leeways and profiles: Readjustments of technology and innovation policy in Germany

If strategies and policies that aim at getting competitive advantage are still the domain of national initiatives, negotiations and decisions, the second tier of questions concerning the remaining leeways and capabilities of national technology and innovation policies has to be answered. Are the competencies and capacities of national policies being eroded, regarding the background of the indisputable internationalization of markets, firms and technologies? Or do national policies remain a relevant factor in stimulating and shaping technologies, infrastructures and institutions?

4.1 Limits and new challenges of innovation policy-making

The findings so far should have supported to idea that the capacities of innovation policy-making are limited to the provision of general conditions for strongly self-organized actors and private contexts of research, development, production and use of new technologies. In contrast to this, political authorities cannot steer or influence the dynamics of technological development itself, of industrial innovation activities or of scientific research in a formative way. Moreover, the regionally clustered internationalization of the innovation activities of industry has strong repercussions on the leeways and the focus of national policies: above all they have to develop new concepts and instruments which aim at providing infrastructural, institutional and regulatory conditions that are attractive for both domestic and foreign enterprises.

Therefore, the former alignment of national research and technology policies on the funding of specific technology programs, the support of national champions and the concentration on large technologies (Meyer-Krahmer/Kuntze 1992) has become too limited in several respects.

The rise of new core technologies such as information and communication technologies, biotechnology or nanotechnologies has qualified the importance of large technologies as cornerstones of national technological competitiveness and as major forces of technological change. Accordingly, policy is not only forced to readjust the portfolio of supported technologies but also has to develop new concepts and instruments to support this new set of core technologies which are developing in a more decentralized way and are being encouraged by numerous private actors and fluid networks of innovators (Rammer et al. 2004).

However, today the attractiveness and competitive advantage of a country no longer depends mainly on the direct public support of new technologies. Unmistakable national innovation landscapes with competitive regional and sectoral technology clusters, excellent research conditions, effective systems of technology transfer and future lead markets have become crucial factors for the competitiveness of countries as well as for locational decisions and investments of industry (Meyer-Krahmer 2005). Accordingly, technology and innovation policy activities have to open up and to concentrate their efforts more strongly on the stimulation and restructuring of technology-related infrastructures and institutions.

The former concentration of policies on the support and protection of national champions has also become too limited. Against the background of the described patterns of internationaliza-

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tion of the Member States. This is reducing the impact of the activities being undertaken, thereby jeopardizing the chances of the project achieving its objectives: the creation of a genuine ‚Internal market in research' and the establishment of genuine coordination of national research policies." (EU-Commission 2002: 3; see also EU-Commission 2003)

tion, national policy has also to woo foreign enterprises which intend to reinforce their own position through investments in the host country. Moreover, besides the support of large enterprises, national policy is forced to develop specific initiatives and incentives to support the emergence of technology-based start-up firms which are gaining in importance as locational factors. And finally, the strong state-protection of national champions or industries in the past has widely proved to be counterproductive in stimulating innovations as well as in strengthening the national economic and technological competitiveness of industry. This applies especially to new core technologies which are best developed in the environment of fierce competition. "Successful national industries tend to be ones where intensely competitive domestic rivalries push each other to excel." (Lawton 1999: 42; see also Monopolkommission 2004).[2]

4.2 New adjustments of national technology and innovation policy

Since the mid 1990s, the governments of the leading states have reacted to these limits and new challenges with remarkable readjustments of their technology and innovation policies. Despite all variability in the points of departure, featured concepts and instruments, they aim at strengthening unmistakable national and regional innovation landscapes by stimulating competition as well as networking between the actors involved and by restructuring the infrastructures and institutions relevant for innovation (Larédo/Mustar 2001; Rammer et al. 2004).

In Germany this new set up of priorities in technology and innovation policy can be observed in particular in four related areas.[3]

Firstly, the political support of structural change in the national patterns of technological specialization towards new research- and knowledge-intensive technologies and branches of industry has been strengthened. However, the featured initiatives and instruments are not new or spectacular. They concentrate on the implementation of research programs which feature new core technologies, especially information and communication technologies, biotechnology and life sciences, nanotechnologies, new materials and environmental technologies. In 2004 in Germany 20.1% (in 1993: 17.1%) of the total (civil and military) federal funding on science, research and technology was spent to support these new clusters of technology. In contrast the federal funding of large technologies (especially nuclear energy and nuclear fusion, aviation and space technologies, military projects) has gradually decreased (from 29% in 1993 to 20.1% in 2004), even though these sectors are still of importance in the profiles of federal support (data calculated on the basis of BMBF 2004: 616-621 [table 8a]).

Secondly, the public support of research, development and innovation in industry has changed significantly. In general, the federal state has withdrawn from financing industrial R&D

[2] Timothy Bresnahan and Franco Malerba argue similarly with respect to the protectionist policy of individual European governments concerning the computer industry in the 1970s and 1980s: „The effect of protection by individual European governments was to keep an uncompetitive European computer industry alive and sheltered from destruction by IBM. These barriers to exit, however, did not lead European firms to launch major policies and investments able to increase their innovativeness and competitiveness internationally." (1999: 102)

[3] For more detailed empirical findings and statistics see the annual reports on the technological specialization and competitive advantage of Germany: BMBF 2000a, BMBF 2003; BMBF 2004 and Grupp et al. 2004. A comparative analysis of recent trends in technology and innovation policy including Germany, the U.S., the U.K., France, Japan and Finland can be found in Rammer et al. 2004.

directly in a remarkable way. While at the end of the 1970s the public share of total industrial R&D expenses amounted to 14%, at the beginning of the new millennium in Germany the federal state financed not more than 3.5% of the total R&D-expenses of industry (Legler et al. 2004: 32f.). Moreover, compared with the public support of large enterprises, the public support and stimulation of small and medium sized enterprises, especially of new technology-based start-up firms, has gained in importance. Although even today with approximately 80% the bulk of the remaining public support of industrial R&D falls to large enterprises, especially to the aviation and space industry, in relative terms since the mid 1990s small enterprises have benefited more and more from public financial support. At present, public money amounts to 8.5% of the total R&D-expenses of small firms, whereas on average only 2.5% of the R&D of large enterprises (i.e. companies with more than 5000 employees) is financed by the state (Legler 2004: 32f.). This is completed by specific programs of gaining importance which support the founding and financing of new start-up firms (BMBF 2002b: 16f.; BMBF 2004: 200-2003). All things considered, innovation policy initiatives have realized that small enterprises and especially technology-based start-up firms play an important part as catalysts of innovation, as locational factors and as potential external resources and partners for big industry.

Thirdly, since the mid 1990s, national policy has begun to take regions as important elements of national innovation systems seriously and therefore has developed new concepts and instruments of a region-oriented technology and innovation policy which makes use of the regional level in order to pursue national goals. It focuses on three targets: generating new regional high-technology clusters, stimulating inter-regional competition for science, technology and innovation, and improving regional networks of innovators as well as the functioning of regional innovation systems (Braczyk et al. 1998; Dohse 2003, 2005). In Germany, the successful prototype of this new area of technology and innovation policy was the so-called BioRegio Contest which started in the mid 1990s and was as subsequent initiatives, too, designed to transform a dormant sector into one intended to be globally competitive by stimulating biotech firm start-ups, the growth of existing companies, the provision of venture capital and the networking of regional actors and institutions. The instrument, which was then new but is meanwhile widely applied, was the invitation to a contest which aimed at stimulating new high-technology clusters and regional centers of excellence by putting the participating regions in an inter-regional competition for additional federal funding.

Finally, since the late 1990s political measures have been initiated to stimulate structural changes of the public science and research infrastructures and institutions. They aim at a stronger competition within the public research system and between their institutions as well as at a faster rate and more efficient system of knowledge and technology transfer from science to industry (Etzkowitz 2003). Among the public initiatives are the introduction of periodical evaluations and the hierarchical reorganization of universities and other public research institutions as well as the intensification of competition for financial resources. Moreover, especially the new instrument of public competitions is widely used to stimulate the clustering of first-class research in a few national lead projects (so-called "Leitprojekte") and centers of excellence (so-called "Kompetenzzentren"). Additionally, the public support of research projects has been strongly focused on applied research and on the intensification of collaborations between public re-

search institutions and enterprises (BMBF 2004: V-XVI). As a result the pressures on universities and other public research institutions to compete with each other, to bundle their resources in lead projects and centers of excellence, to legitimate scientific research by their economic relevance and to contribute to economic development have increased significantly (Rammer et al. 2004: 132-142).

4.3 Reflexive stimulation or disjointed incrementalism?

These new adjustments of national technology and innovation policy are towering above the former concentration on the political shaping of technologies and national industries, the financing of large technologies and the protection of national champions. Instead, the renewed approach appears to be more indirect and context-oriented: above all, it aims at restructuring national (and regional) infrastructures, institutions and innovation landscapes which are attractive both for scientists and enterprises from wherever. The featured new instruments for that purpose are contests which stimulate competition between research institutions or regions as well as initiatives which support the clustering of research in national (or regional) centers of excellence and the networking between scientific and industrial actors. The addressees of these initiatives are no longer mainly domestic large enterprises but also their foreign counterparts, new start-up firms and (regional, industrial or academic-industrial) networks of innovators which often develop only after the implementation of corresponding public initiatives.

Within the inevitable limits of innovation policy-making described above, the readjusted policy is definitely able to cause structural effects. In Germany (as well as in other European countries) it has stimulated the emergence of visible sectors of start-up firms (Dolata 2003). Moreover, it has formatively contributed to the emergence of new regional high-technology clusters and the regional networking of actors (Dohse 2003). And finally, it has forged a far-reaching restructuring of the public research and science system towards increasing competition and clustering, academic-industrial cooperation and technology transfer (BMBF 2004: 473-525). What at first sight appears as a decline of policy-making capacities turns out to be a truly indirect but none the less active and effective contribution to the readjustment of general conditions concerning the technology and innovation process. Therefore, instead of an erosion we are facing a transformation of state capacities in technology and innovation policy.

However, in the end one has to roughen up this far too pretty picture in at least two respects.

The new concepts and instruments cannot be analyzed as a radical new beginning or a clear break with former patterns of research and technology policy but instead are incrementally and sometimes inconsistently fit into existing and persisting ones. The persistence of classical patterns of innovation policy-making is blatant especially in the case of large technologies (in Germany for instance this is seen in the public support of Transrapid, space technologies or traffic telematics) which still remain an important focal point of technology policy. Johannes Weyer has rightly stressed that in these cases even today the state operates "with the classical repertoire of direct intervention, direct project promotion, market foreclosure, promotion of public champions and the exercise of buyers' and buying power (2004: 293; 2005)".

Moreover, the new adjustments of technology and innovation policy can cause new problems, that might arise as a result thereof. A regional-oriented technology policy which aims at picking winners may foster the develop-

ment of some selected regions but at the same time suppresses the development of other regions or innovative enterprises that are located outside the target region (Dohse 2005). The currently strong orientations of technology and innovation programs and public initiatives to restructure the public research and science system by intensifying networking between academia and industry, stimulating technology transfer and the short-term benefits of scientific research for economic development, may cause similar problems. They tend to underestimate that the further development – especially of new science-based and knowledge-intensive technologies – will depend exceedingly on the contributions of pure basic research for a long period (Meyer-Krahmer 2000). Finally, all the readjustments of technology and innovation policy so far have hardly made a contribution to really integrating and institutionalizing the resources and actors of public protest and controversy regarding new technologies into the patterns of political negotiations and decision-making. Of course, policymakers are strongly dependent on external expertise and consultations with private actors. However, at the top the negotiating state still remains a corporatist state. Decisions of general importance are usually negotiated with large enterprises, the federations of industries and the federations of science in closed sessions (Saretzki 1997; Dolata 2003: 265-303).

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