A Developmental German State? Explaining Growth in German Biotechnology and Venture Capital[1]

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Introduction

Since the 1970s, the German Federal Ministry of Research[2] had been interested in biotechnology. Long before the German pharmaceutical companies, which were comfortable with their strong performance as "pharmacy to the world," the Research Ministry identified biotechnology as a growth sector and began spending money to develop it. By the 1980s, after spectacular successes in the US, German industry had become interested in biotechnology but remained moribund or off-shored research to the United States due to German regulatory hurdles and strong anti-biotechnology pressure mobilized by the Greens. Although the Research Ministry doubled its spending on biotechnology through the end of the 1980s, the sector fell farther behind the US, Japan, and even Britain. By the early 1990s, biotechnology outside Germany had clearly become a "future industry" with predicted growth rates of up to 25 per cent in certain sectors, and the German government determined, not the least with an eye to unemployment, to make Germany number one in biotechnology in Europe. The Research Ministry defined its technical strategy by looking to the United States. The approach has been surprisingly successful: regions throughout Germany have mobilized organizations supporting small startups and linking industry and universities, banks have become involved in providing pools of venture capital, and the number of small biotech startups has doubled twice in the past three years. Prominent industry analysts conclude that Germany has entered a biotech boom (Schitag, Ernst, and Young, 1998). This paper explains the success by highlighting the leadership of the federal government – leadership that poses a puzzle for scholars of comparative politics who regard the German state as semi-sovereign, or incapable of autonomous leadership.

Containing left and Green party opposition to biotechnology is not the only story, despite the publicity it has received. Anti-technology sentiment, at its zenith in the late 1980s, has been contained by national regulations and muted by party leadership. Indeed, the current Social Democratic (SPD)-Green government approved a lukewarm embrace of the sector. The SPD, the party closest to the trade unions, modified its stance after realizing the biotechnology sector is creating hundreds of new highly paid jobs. The Greens, born in opposition to nuclear power, decided that biotechnology opposition need not be a holy cow. Their 1998 agreement with the SPD to form Germany's government aimed to phase out nuclear power, but to support

[2] The ministry has been variously named in the past three decades. It is currently called the Federal Ministry of Education, Science, Research and Technology (*Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie)*. For ease of reading, I refer simply to the Research Ministry.

pharmaceutical biotechnology (humans' health) and bioremediation (environment's health); to preserve freedom of research despite a reiteration of the programmatic opposition to genetic engineering; and to accept the existing EU and national regulations. Nods to the fundamentalist position included only long-term monitoring of transgenics, and additional spending for research on the social and ethical consequences of genetic engineering. Left and Green opposition has become less determining of biotechnology's trajectory than the Research Ministry's promotion policies. This paper's main focus is on the latter – the activist state policies that have jumpstarted biotechnology.

The Research Ministry's success in promoting biotechnology presents a puzzle for comparative political economists since it contradicts received wisdom about the German federal government's capacity to make policy. The German state is generally portrayed as sharply constrained in its ability to play a leadership role in devising and carrying out industrial policies (Streeck, 1997; Katzenstein, 1987; Hall, 1986; Zysman, 1983). The state is labeled "semi-sovereign" because the federal government's power is divided *vertically* (decision making and implementation competencies are shared with impressively strong *Länder* governments) and *horizontally* (shared between two houses of parliament, among parties in the governing coalition, and with strong and politically insulated federal actors like the *Bundesbank* and the Federal Cartel Office). The state moreover assists groups in civil society to organize themselves (*e.g.* making membership mandatory to overcome collective action problems), and then gives them governance functions that in other countries is performed by the government or left to the markets. Thus an enabling but weakened federal government in Germany delegates leadership to a highly organized and capable society: unions, professional and industry associations, and semipublic banks. While the federal government may provide the bargaining tables, these associations work together, often through self-administration (*Selbstverwaltung*), to make and implement agreements.

In the area of biotechnology more specifically, the *Länder* and not the federal government grant or withhold approval to research and production facilities. Their police forces need to protect facilities and experimental fields from sabotage. Their industrial promotion policies, which provide a significant source of funds for firms, can either embrace or ignore biotechnology. The federal state has few institutional competencies in these areas. And yet, the national government was able to induce not just private sector actors but even red-green regional

governments to actively support biotechnology in the mid-1990s. What explains the Federal Research Ministry's observed capacity to influence lower level public and private actors, to lead a top-down revitalization of German biotechnology? I examine two innovative policies – the BioRegio Competition and a public venture capital program called Equity Capital for Technology Companies – to explore how the federal government was able to command such a performance. I argue that rather than being constrained, the national state *mobilized* the distinctively dense interlock of institutions in the German economy. The federal government took a leadership role in defining priorities and strategies, and then activated latent policy communities – networks of banks, parapublic institutions, firms and unions that stood to benefit but had not become active in the new sectors – to achieve these ends.

The paper begins with a review of the biotechnology sector and the government's biotechnology promotion policy from the 1970s to the early 1990s, from which the challenge facing the Research Ministry in the mid-1990s emerges. In section two I examine the Ministry's solution – the BioRegio Competition – patterned according to the Ministry's understanding of the ingredients of the US success. I explore the government's effectiveness in structuring lower level public and private actors' behavior to unleash a biotech boom in Germany, in part with close observation of the process in two BioRegions, Cologne and Munich. Section three considers venture capital in Germany to elaborate on conclusions drawn in section two: namely, that Federal Research Ministry policies were crucial in reversing the reluctance of German financial actors to provide capital in highly volatile new technology sectors. The paper concludes with thoughts about whether the Research Ministry's successful strategy for promoting biotechnology can be applied to other high technology sectors, and why the conventional wisdom – that a highly organized and capable society constrains German state leadership – appears incomplete, tangential rather than essential to an explanation of biotechnology and venture capital trajectories in Germany in the end of the 20th century.

Section One: Germany's Biotechnology Policy, 1970 - 1995

There is no doubt that the German federal government has been the crucial actor in turning around biotechnology in Germany. After removing regulatory hurdles that had nearly killed biotechnology, it devised a solution to rejuvenate the moribund sector. Its goal was to create an environment that supports small startup companies – a goal that the federal government

has met with clear success. The evidence is indisputable. The number of new biotech startups has doubled twice in the past four years, from 75 in 1995 to more than 300 in 1998 (BMBF, BioTechnology in Germany, n.d., p. 1). Between 1995 and 1996, the total revenues of small and medium-sized biotech firms nearly doubled, as did the number of workers they employed, yielding growth rates much faster in both cases than the European or American average (*Der Spiegel*, Jan. 19, 1998). In 1998, these companies received investments of 425 Million DM – a more than six fold increase over 1996 (*Frankfurter Allgemeine Zeitung*, July 1, 1998). According to observers at Ernst and Young, the startup activity is "enormous" and "larger than that in all other countries" (as quoted in *Handelsblatt*, Oct. 22, 1997). German global players like Hoechst, Schering, and BASF have returned some investments to Germany, while German companies like Evotec Biosystems, LION Biosciences, and Morphosys have formed business agreements with international pharmaceutical concerns (BMBF, BioTechnology…", p. 1). As the *Handelsblatt*, a respected business newspaper put it, "bio- and genetic-technology is one of the few sectors developing reassuringly in 'Standort Deutschland'" (*Handelsblatt*, Jul. 22, 1998).

Biotech has only recently been a success story, however. In the 1970s, despite breakthroughs in DNA recombination in 1973, most pharmaceutical companies in Germany were uninterested in genetic engineering, content with their performance in traditional areas.[3] Their exports accounted for about 40 per cent of the world totals in these sectors (Abramson, *et al*., 1997, p. 344; Buchholz, 1979, p. 70, interview B070398.1). German institutes and universities made few contributions in commercial biotechnology. Most of the research remained focused on traditional biology and chemistry. The minority interested in biotechnology rarely licensed or commercialized their work in Germany. Some scientists went to the United States to establish startups; others preferred to publish rather than to patent their work (Abramson, *et al*., 1997, p. 344).

In 1972, the Federal Research Ministry determined to use biotechnology to showcase the Social Democratic/Liberal government's commitment to using public subsidies to spur technology-led growth. Germany became the first country in the world to develop a publicly funded biotech promotion plan (BMFT, 1992, "Biotechnologie 2000…", p. 53). One of the earliest projects supported aimed to address world hunger by creating protein-enhanced grains. The program provided subsidies for broad scientific goals but emphasized bioprocessing

[3] The few notable exceptions include Boehringer Mannheim and Bayer.

(fermentation and enzyme technology), as a consequence of recommendations drafted by a group composed half of scientists and half of industry representatives (Dolata, 1991, p. 629). The Research Ministry also founded a national lab to conduct biotechnology research (the *Gesellschaft für biologische Forschung, Braunschweig [GBF]*). Yet the approach was dominated by second generation biotechnology (bioprocessing) goals; the possibilities of the very new third generation or post-DNA recombination goals (such as genetic engineering) remained largely ignored throughout the 1970s (June, 1987, pp. 265-7; interview B070398.1). Moreover, overall state spending was small and too diffusely awarded to produce cumulative advances. The results, by all accounts including the Research Ministry's, were mediocre.

The quick growth of biotechnology in the US in the early 1980s and Hoechst's well-publicized 1981 decision to invest $50 million dollars to build a genetic research facility in Massachusetts aroused more of German industry and alarmed the Research Ministry. Industry became aware of third generation biotechnology's indispensable position in the pharmaceutical fields. The Research Ministry recognized that its promotion strategies had not been sufficient to create a strong biotechnology sector in Germany. It decided in late 1981 that its strategy of "global direction" in biotechnology needed to be focused, geographically (in institutes) and thematically (on genetic engineering). Still under Social Democratic rule, the Research Ministry sought to support innovative research and technology transfer by increasing spending and by creating three "gene centers." These centers, located in the cities with the strongest biotechnology infrastructure *i.e.* Munich, Heidelberg, and Cologne (and later Berlin), were co-financed by industry, giving underlying commercial direction to developments. In addition, young scientists, many educated in the US, were recruited to lead a number of research projects in the Gene Centers. They were given the funding and facilities usually reserved for the most senior professors, and thus brought new impulses to university research that was feared to have become too hierarchically rigid to embrace such a quickly developing field as biotechnology (Dolata, 1991, *passim*; BMFT 1992 "Biotechnologie 2000," p. 138; interview L090898.3). Yet university research did not transfer to economic progress. Per capita, Germans applied for more international patents in modern biotechnology than Americans between 1982 and 1984, yet Germany had but 15 firms involved in biotechnology research in 1984, while Japan had 157 and the US 245 (Streck, 1990, p. 17; *Frankfurter Allgemeine Zeitung*, Mar. 30, 1984).

The new CDU government continued the catch-up strategy by concentrating funding in biotechnology when it assumed office in 1982. After soliciting further studies by groups composed of scientists and industry, in 1985 the Research Ministry announced its first program for "Applied Biology and Biotechnology." This program substantially boosted subsidies for biotech R&D in industry and research institutes, more than doubling them between 1984 and 1988 to DM 261 million. Despite the word "applied" in the program's title, enhancing basic research became the identified priority and public research institutes received roughly two-thirds of the total Research Ministry spending for biotechnology. Industry and institute collaboration on specific projects did receive some of the increased funding, however; and subsidies were available in biotechnology as in most fields for companies with products in development stages – so-called "indirect-specific" measures (BMFT, 1989, "Programmreport…", pp. 6-14). The government also expanded its fledgling and unsuccessful program providing venture capital to small technology-based companies. Despite increased state spending through the end of the 1980s, German performance remained lackluster, particularly in contrast to the United States. Crucially, Germany lacked the small "dedicated biotechnology companies" driving discovery and commercialization of knowledge in the US: estimates placed the number firms active in biotechnology in the US at 388, and in Germany at 17 (Lux, 1993, p. 371).

One reason the Research Ministry's spending did not spur biotech growth in Germany was the uncertain and fragmented regulatory environment. Germany has no national approval board, no FDA equivalent. Instead, a central commission has set standards to which industry agrees to adhere, and regional authorities retain power to permit or prohibit production of biotechnological goods. Until 1989, there were no national laws setting guidelines or defining risk levels and standardizing production practices necessitated at various levels of risk. Throughout the 1980s, regulatory outcomes were very much regionally dependent. Bavarians put up generally few hurdles; bureaucracies in other states, especially SPD-led states, delayed approval to the point that companies sued the regulatory agencies for lack of due process (interview A081498.1). Through their reactions to local regulatory agencies, Bayer and Hoechst both made headlines. Hoechst applied in 1984 to build a facility in which genetically-altered bacteria would create human insulin, a procedure for which Eli Lilly had already gained approval in the US two years previously. The Hoechst approval process continued until 1989, at which time a regional court in Hesse, in response to a citizens' suit against Hoechst, forbade the

construction or use of production facilities for genetic technology pending the passage of a national law (*Handelsblatt*, Nov. 9, 1989). Hoechst had just paid, joked sympathetic friends, to build the first genetic engineering museum in the world at a cost of DM 70 million (Wandrey interview; *Hessische Allgemeine*, Nov. 9, 1989). While the Hoechst approval was pending, Bayer decided to locate investments for its new "Factor 8" research facilities in Berkeley, California, and not Wuppertal-Elberfeld, Germany. In a well-publicized explanation, the Bayer management claimed that the scientific environment in both locations was comparable, but that the importance of being first to market with costly research made it imperative to invest in a place with a predictable and friendly regulatory environment (Büchel, 1988, pp. 39-40; Wandrey interview).

The difficult regulatory environment was not unrelated to public and political discourse that in the 1980s was heavily opposed to biotechnology. Cautious skepticism, it should be noted, is clearly warranted and welcome, given abuses by biologists and geneticists in the name of Nazism. Reflexive instead of reflective opposition, however, was the order of the day. The Greens, after limiting nuclear energy and research in Germany, turned more attention toward biotechnology.[4] They proudly claimed responsibility for being the first party to politicize genetic engineering, calling it an "irresponsible science" (The Greens, Press Release, 1984), and part of an "unholy trinity" including nuclear and computer technologies – a trinity that had to be frozen by regulations (as quoted in Wandrey, 1997). The unions also viewed genetic engineering skeptically, fearing it would be used to discriminate against employees predisposed to diseases in employment contracts (*Hannoversche Allgemeine*, 1985). In July 1989, in the northern state of Schleswig-Holstein, a special convention of the *Land*-level SPD moved that "access to and application of bio- and genetic-technological advances at all universities and publicly funded institutes should be denied to industry and end-users" (as quoted in Wandrey, 1997). Both the SPD and women in the CSU demanded that an ethical commission investigate the implications of biogenetics (*SPD-Fraktion*, 1985; *Süddeutsche Zeitung*, 1985).

By the end of the 1980s, both proponents and opponents of biotechnology wanted national legal standards: industry, for predictability, and critics, for tight restrictions. The government in 1989 introduced its first version of a national genetic engineering law, which prompted broad condemnation from the opposition SPD and Greens. Simultaneously, prominent scientists, including heads of the national labs and the director of the German equivalent of the

[4] For Green positions since 1980s, see Dann, 1987, and Ulrich, 1996.

National Science Foundation (*Deutsche Forschungsgemeinschaft, DFG*) went public, arguing that the "dangers of genetic technology have been greatly overestimated" (*Frankfurter Rundschau*, Mar. 24, 1990). The chemical workers' union caused tension with the peak labor organization, the *Deutscher Gewerkschaftsbund,* (*DGB*), by agreeing with industry that streamlined and less restrictive national rules on biotechnology were necessary for the German economy and the German worker (Löschner interview; *Bonner Rundschau*, Nov. 10, 1998; *Unsere Zeit*, May 18, 1990). The final version of the law, passed half a year later, left few happy. It was still tremendously restrictive in comparison with the American situation, and yet too permissive for those who wanted genetic engineering strictly regulated in Germany (*Süddeutsche Zeitung* May 12, 1990; *Handelsblatt*, March 30, 1990; on the law, see Karl, Scholz, and Wiesner, 1989, pp. 16-20; Hasskarl, 1994).

Bayer, Hoechst and other large companies publicized their plans to locate future investments outside of Germany – even with national standards (which they in principle supported) they claimed the obstacles to production in Germany were too large. Germany began slipping in to a post-unification recession, and prominent voices began labeling the technology critics' position on high tech growth sectors as a "Morgenthau plan *auf deutsch*" (Wandrey interview). In 1993, the national standards governing biotechnological facilities were relaxed somewhat, and in 1996 they were brought largely in line with American standards. Yet the damage had been done. Those companies that were able had "off-shored" research and production facilities through the 1980s and 1990s, creating jobs in foreign countries, mainly in the United States. Hoechst and Bayer, in the mid-1990s, each had more than 10 biotechnology collaborations with American universities and firms in the US; in Germany, Bayer had one dedicated biotechnology lab, while Hoechst had none (Sharp and Patel, 1996, as cited in Casper and Matraves, 1997, p. 23). Those companies that remained were anemic, stunted by years in an unpredictable and unsupportive environment. And academic research largely remained in the academies. Thus, despite two and a half decades' efforts on the part of the Research Ministry to promote biotechnology in Germany, the sector in the mid-1990s was as much of a headache as it had been in the early 1970s.

Section Two: The Bioregion Competition

In the mid-1990s the Kohl government committed itself to making Germany "number one" in biotechnology in Europe, which presented a non-trivial challenge for the Research Ministry. Increased spending for existing instruments was not an option: budgets were tight, moreover two decades' experience had shown that money alone was not enough to create a vibrant biotechnology sector in Germany. A major hurdle, the federal regulatory environment, was lowered under leadership from the Health Ministry, in charge of drafting revisions to the law. The goal for the "semi-sovereign" federal policymakers in the Research Ministry was thus to identify the best technical strategy for revitalizing the near-moribund sector and, importantly, to compel lower level governments and the private sector to implement it.

The technical strategy. The Research Ministry designed its technical strategy by seeking to understand what makes the United States the strongest home for biotechnology and pharmaceutical companies in the world. In the US, hundreds of small startups are active, concentrated in regional centers of excellence. Startups serve as an excellent vehicle of technology transfer (Abramson, *et al*., 1997) thus addressing the German quandary of how to bring world-quality scientific advances to market. In addition, the presence of biotechnology startups is related to the crossnational competitivity of "red" and "green" firms (*i.e.* biomedical firms, and agro-chemical firms that engineer, for example, disease-resistant, high yield seeds) (Casper and Matraves, 1997; Casper, 1998; *Handelsblatt,* July 22, 1998). In recent years large pharmaceutical companies have begun shifting the locus of discovery outside their own labs – up to 20 per cent of their research is now outsourced (Powell, 1998; Lerner and Merges, 1998, table 2; Casper and Matraves, 1997, at p. 6, and p. 7 n. 9 *Financial Times*, May 24, 1997; *Economist*, 1997, no. 60). Market dynamics favor this strategy for two reasons. First, biotechnological research is expensive and very unlikely to culminate in marketable products: of every 5000 compounds labs begin to develop, only one compound reaches market (PhRMA, 1997, as cited in Casper and Matraves, 1997, p. 7). Second, at any given time several research programs investigate from different angles a single disease: there are at least fifteen distinct research programs targeting Alzheimer's disease (Penan, 1996, as cited in Casper and Matraves, 1997, p. 7). Pharmaceutical companies can diversify their bets and increase their chances of being first to market with new technologies through licensing arrangements with third parties that allow them to survey scientific developments and create alternatives when a given research investment fails

to "pan out".[5] Not surprisingly, evidence suggests that US and UK pharmaceuticals firms outperformed their German rivals in the 1980s in part because they had access to new biotechnology startups and the Germans generally did not (Casper, 1998). In addition, the more possibilities there are for overlapping collaborations, the greater the opportunities to learn, spurring a brisk pace of discovery in the US (Powell, 1998).

The Research Ministry thus concluded that the key to revitalizing commercializable German biotechnology would be to nurture small startups. Biotechnology startups' needs for capital are greater than in most other fields. Drug development, for example, is extremely costly: $100-$300 million per product in the US (Powell, Koput, and Smith-Doerr, 1996). Time horizons are longer: five to ten years to develop a product, and seven to ten years to introduce a product in the market and gain a significant market share (Koschatzky, *et al*., 1995, pp. 24-6). Life sciences startups also face very high risks. Ideas may fail to pan out, or successful innovators may see rewards to innovation negated by other firms who are quicker to market. Although hundreds of biotechnology firms are active in therapeutic research, for example, only 40 drugs they have designed are on the market (BIO, 1998, as cited in Casper, 1998, p. 11). Small technology-based startups also need non-financial support: their entrepreneurs, as scientists and not businesspeople, often have little experience with company planning, marketing strategies, and accounting.

To nurture these small startups with their large requirements, the Ministry again looked across the Atlantic for concrete strategies. In the US, venture capital firms with expertise evaluate projects and link the most fundable projects to people with money; in addition, venture capital firms assist fledgling companies with business strategies and legal advice. An active market for shares in technology companies makes raising money, and quickly recycling it through various investments, relatively easy. And academics play a crucial role as both researchers and entrepreneurs, spurring, and benefiting from, the geographic concentration of public and private research endeavors. The Research Ministry in Germany sought to emulate these conditions. It chose to promote an environment that nurtures small startups by (1) creating functional equivalents for the venture capitalists in the US, (2) mobilizing pools of venture

[5] Thus a "fully integrated pharmaceutical company" is very rare –the US has only one example, Amgen (interview A072298.2).

capital, and (3) enhancing information-sharing between publicly and privately funded researchers.

The political strategy. To ensure that subsidies for biotechnology were awarded to the best projects, but more importantly to ensure that lower level governments and the private sector would use federal grants to implement the startup strategy conceived by the Federal Ministry, Research Minister Jürgen Rüttgers in 1995 announced the BioRegio Competition. The Competition turned out to be a brilliantly effective instrument that spurred ground-up initiatives promoting biotech along the federal government's guidelines in many more regions than actually received funding.

The Competition itself was structured to award the top three applicant regions with federal funding of DM 50 million each over five years, if matched by grants from the private sector – funding that would be used to provide direct subsidies (read "gifts") to startups and other firms of up to a significant 50 per cent of total research costs (European Union and World Trade Organization ceilings). An international panel of experts was convened to evaluate the regional applications, and in November, 1996, this jury selected Cologne, Munich, and Heidelberg, as well as extending a special award for a more specific project to be conducted in the eastern German region of Jena.

The allocation mechanism itself had advantages. Outside experts' decisions were based on technical excellence and not pork-barrel criteria. Moreover, decisions made by an external jury based on merit reduced complaints from nonselected regions that federal funding was being unfairly distributed across the country. The competition further generated federal influence over lower level actors by spelling out criteria along which regional applications would be judged. Applications had to provide evidence of a region's strengths in the following areas – even if the "strengths" were developed during the several-month application period (!):

- the character of approval procedures for biotechnology facilities and experimental fields in the region;
- existing services offered to small firms – patenting support offices, databases, organizations providing advice on getting through approval processes at regulatory agencies and banks;
- existing and planned commercialization of biotechnological advances in region;
- existing measures to attract new biotech firms to the area and/or to encourage the founding of biotech startups;
- commitment of banks and private investors in the region to support biotech firms;
- quality and number of research institutes in the area;

- existing cooperation between research institutes and clinics in the region; and
- quality and extent of existing interdisciplinary links in biotechnology research. (from Warmuth, 1996/7, p. 14-16)

Guided by these criteria, all regions that were serious about their application – and not just the eventual winners – set about developing the kinds of support for small business, venture capital pools, and networks between institutes and firms that the BMBF had determined were key for promoting biotech development. Indeed, *all* interested regions could receive up to DM 100,000 from the Research Ministry simply to prepare a regional application, if that subsidy were matched by private sector or state and local government contributions. As a result, even regions that were not eventually selected had incentives to put in place the kinds of institutions and practices that the government determined were essential for promoting biotech in Germany. And once credible commitments had been gathered and activities commenced – *e.g.* the commitments from banks to provide funding, the creation of semi-public organizations incorporated to serve entrepreneurs, and the enhancing of networks between business and science – many of these gained a momentum of their own without any additional BioRegio funding (these regions, of course, can still apply for normal Research Ministry biotech subsidies). The application process alone stimulated local and regional biotechnology promotion strategies in 17 applicant regions (for an overview of the regional plans, including specifics about their support networks, venture capital provision, and so forth, see the compilation in BMBF, 1996, "Biotechnology in Germany").

The incentive of winning millions of deutschmarks awoke broad interest in the private sector, among researchers, unions, and firms. These private sector actors, in response to the Competition, put pressure on their local governments to demonstrate full support for biotech. During the application process, state and local governments were induced to upgrade regulatory processes in response to the following arguments: "At stake is DM 50 million. Other regions' governments have already improved their regulatory processes and enhanced police protection for experimental fields. Are you going to let them win the money, or are you going to help our application?" The pressure ratcheted up to include an array of financial commitments as well as regulatory support. Governments provided additional project-related subsidies, or financed semipublic organizations that would provide coaching, consulting, and information-sharing services for small startups.

After the BioRegio winners were announced, the pressure on regional governments continued. The non-winning regions lobbied their governments, arguing their region lost because of insufficient Land-level support. They demanded (and sometimes received) more. In addition, even regions that did not enter the BioRegio Competition began petitioning their state governments for help. The Competition specifically requested small regions apply. In the Cologne area, this meant the "Rhineland" applied, but "Westphalia" was excluded. Westphalia, after complaining about Cologne's special treatment, has now received state money for a biotechnology promotion policy tailored to its region from the government of Northrhine-Westphalia, home to both regions. In sum, the Competition unleashed broad private sector activities that involved many more regions in biotechnology promotion than simply the three winners, or even the seventeen applicants (interview A081498.1).

The impact of the BioRegio competition on lower-level actors is interesting enough to warrant short "case studies" of two of the winning BioRegions: Cologne in Social-Democratic/Green-governed Northrhine-Westphalia, and Munich in Christian-Socialist (the sister party of Helmut Kohl's Christian Democratic Party) Bavaria. Both of these regions have histories as the strongest biotech regions in Germany.

BioRegio Rhineland. The Cologne region, under the name BioRegio Rhineland, contains a strong biotech "landscape" including the Bayer facilities in Wuppertal, the research infrastructure in the Gene Center established by the Research Ministry in 1982, and the biotechnology center in the national lab at Jülich. Given the pre-existing infrastructure, Green opposition to biotechnology was carefully contained in the coalition agreements negotiated when the SPD and Greens took over the state government in the early 1990s. The biotechnology sector, however, was faring poorly: in the Cologne region in the mid-1990s alone thousands of jobs were hemorrhaged (interview A072298.2). Scientists, industry, unions, and the media agreed that action was imperative, and in 1992 founded a pressure association (see *Bio-und Gentechnologie*... 1992). Their goal was to increase networking among biotech actors in the area, and to convince investors in Germany and even America to locate research facilities there. Committed to the "responsible use of biotechnology", the association was able in 1994 to secure a small amount of funding from the Northrhine-Westphalian state government to design biotech promotion measures for the entire state, and not just the Cologne region. The pressure organization was renamed "BioGenTec NRW".

State funding increased, however, upon news of the upcoming BioRegio Competition. The state government, persuaded by local-level actors not to pass on the opportunity of DM 50 million in federal job-creating subsidies, agreed to contribute money to BioGenTec's application drive. BioGenTec began identifying the best candidate region, designing its "business" plan, and coordinating private sector initiatives (interviews A072298.1, A072298.2). In addition to spearheading the application, BioGenTec became the crux of the new regional support network for small biotechnology companies. With its overview of the entire market, it now provides advice about industry trends – a role played by the banks in Andrew Schonfield's seminal 1965 characterization of the German political economy. BioGenTec also developed a "Coaching and Consulting" function, extending assistance to small entrepreneurs to do the following: develop business plans to secure funding; navigate the complicated maze of over 1500 public support programs from the EU, the federal government, and state initiatives; apply for patents; and seek legal advice. Some of the expertise is in-house; in some cases, BioGenTec serves as an information link, sending entrepreneurs to outside experts, complete with information about how to get government subsidies for services they are seeking, such as patenting advice.[6]

Also in response to the upcoming BioRegio Competition, the director of the Biotech Center in the national lab in Jülich, Professor Christian Wandrey, began fundraising in tandem with BioGenTec for the region's application. With a DM 100,000 subsidy from the federal research ministry, fundraisers gathered an additional DM 500,000 from the state government, the city of Cologne, and the private sector. The Cologne Region's application became the best funded of all the 17 regions. Money was used to pay management consultants to help develop the application, and to travel to establish public-private networks and secure private financial commitments. To provide evidence of the region's "*existing* measures to attract new biotech firms to the area and/or to encourage the founding of biotech startups," Wandrey convinced a Dutch firm DSM to create a small subsidiary in the "incubator" on the Jülich grounds. The neighboring "technology center" was spruced up to make it an intermediate house for small startups. Wandrey also helped two of his doctoral students found their own companies, largely by developing innovative agreements in which lab production facilities were rented to the young

[6] After BioRegio Rheinland won the Competition, its funding changed. Roughly 5/6ths of its total annual budget is provided nearly equally by the Federal Research Ministry and the State Economics Ministry; 1/6th comes from member fees. Members pay on a sliding scale and include private individuals, small and large firms (interview A072298.1, BioGenTec NRW, 1998, p. 19).

startups at percentages of their revenues – so that production costs accrued only after they had clients. Thus, through Wandrey's work to strengthen the Cologne Region's application, three new biotech companies were created.

The informal application committee also raised private-sector financial commitments. A colleague of Wandrey's and a member of Dechema, a German chemical industry association , secured from Bayer a pledge to provide a DM 20 million pool of venture capital for biotechnology research in the BioRegion Rhineland. BioGenTec and others committed to the project also lobbied the local banks, including the Sparkassen, and all told raised an impressive DM 90 million in venture capital from regional investors – primarily semi-public banks and their subsidiaries -- exclusively for promoting biotechnology (BioGenTec NRW, 1996, 1998).

BioRegio Rhineland's final application contained three key strategies: the Biotechnology Competence Network Rhineland, which supports networking between research and industry; the Biotechnology Consulting and Coaching Network Rhineland, which includes senior consultants and uses the voucher model (subsidized by the state government) to provide "high-level, low-priced consulting," and the Biotechnology Capital Network Rhineland, in which regional credit institutes and investment companies contribute money to biotechnology projects. In 1997, as part of the BioRegio promotion, 14 projects (both foundings and expansions) were funded with a total value of over DM 100 million in the BioRegio Rhineland (BioGenTec NRW, 1998, p. 20 [errata sheet]).

BioRegion Munich. Munich, like Cologne, has historically been one of the "bright" spots in German biotechnology. In fact, all three winning regions were regions that, in the early 1980s, received funding for Gene Centers as a result of their contemporary headstart. According to a member of the BioRegio jury, a deliberate choice was made to fund the strongest regions, not the regions with the best chances for future growth, in light of the government's stated commitment to making Germany number one in biotechnology in Europe (Löschner interview). The Munich region, with three Max Planck Institutes, the Gene Center, the Boehringer Mannheim firm, facilities from Hoechst, Bayer, and other international players, most of Germany's venture capital firms, 20 per cent of all biotech jobs in Germany, and 45 per cent of all venture capital investments in biotech in Germany, is arguably the strongest biotech region in Germany (BMBF, 1996, "Biotechnology in Germany", p. 153).

Munich, unlike Cologne, is located in a state where the "acceptance question" – the public and the parties' acceptance of new technologies – has never been a significant problem. Bavaria has asked, how can we most effectively fund and promote biotechnology, while Northrhine-Westphalia has asked, should we fund and promote biotechnology (to contrast the two states' approaches to public biotechnology policy compare reports prepared for each government: Ammon and Rautenberg, 1990; and Koschatzky, *et al*., 1995). Thus in Cologne, the private sector took the initiative, while in Bavaria, the Economics Ministry has spearheaded biotechnology promotion policy and the BioRegio application for Munich. In fact, the Bavarian government under Minister President Edmund Stoiber has been tremendously supportive of high technology – most spectacularly, it has privatized in 1994, 1996, and 1998 part of its share in power companies and created with the billions of DM a pool of money to be used for subsidizing applied technology developments in the state (interview L070198.1; *Frankfurter Allgemeine*, 1998, "Stoiber…"; *Focus*, 1998, "Das Würmtal…").

In the early 1990s, the first startups were being launched by the researchers at the Gene Center in Munich. The Economics Ministry commissioned a study from one of the Fraunhofer Institutes – publicly funded research institutes devoted to technology transfer – to answer the question of how biotechnology could be best promoted in Bavaria. The study made almost the same diagnosis as the Federal Research Ministry a few years later: biotechnology policy needed to solve the problems of venture capital and management support for small startups, and better facilitate commercialization of research from large institutes (Koschatzky, *et al*., 1995). The Bavarian Economics Ministry in response paid to build an "incubator" that focuses on biotechnology, is closely connected to a major research institution (the Max Planck Society in Martinsried), provides venture capital, and provides consulting. Space in the incubator was already fully rented before construction began in 1995 (interview L090898.3).

Also in 1995, the Economics Ministry decided to enter Munich as an applicant in the BioRegio Competition. At first, others in the area were skeptical. They felt the region was strong enough that it did not need to enter; rather, to enter meant to run the risk of *not* winning. The Economics Ministry nevertheless assembled roughly ten leaders of research and large industry (no banks were involved at the time) who committed themselves to developing an application. The bid was successful, due more to Munich's strong (especially for Germany) biotech infrastructure than its application, which contained less completely worked-through plans than

many other regions. Indeed, the final decision on region number three – between Munich and Berlin – was very close (Löschner interview and interview L090898.3). Unlike in Cologne, it was first *after* the award that the real work of designing plans for BioRegio promotion in Bavaria began.

The initial handful of supporters set up an organization to coordinate biotechnology promotion in the Munich area. They planned to create an advisory organization under the name BioM (the counterpart organization in Cologne, BioGenTec NRW, had been set up before the competition). But representatives from Boehringer Mannheim encouraged the planners to "think bigger" and offered to provide enough capital for BioM to become a corporation (*Aktiengesellschaft*) that would make investments in startups with its shareholders' money. At this suggestion, the Economics Minister himself became involved, and lobbied banks and other funding agencies to support the initiative. Unlike in Northrhine-Westphalia, in Bavaria the private banks were more interested than the semi-public in getting involved. They willingly became shareholders in BioM in order to learn about the biotech industry, its growth cycles, and the kinds of loans that make good investments. The banks, as shareholders in BioM, also benefit from its services – it provides them expert evaluations, rendered by its two world-renowned biotechnology specialists, of fledgling companies as possible investment objects.

BioM has thus become a company owned by the Free State of Bavaria (with DM 3.75 million in stocks), banks and venture capital companies (together with roughly DM 4 million in stocks), and pharmaceutical and chemical companies (all told another DM 4 million) (BioM pamphlet, 1998). BioM's mission is to invest its stockholders' money in good companies, not to make an immediate profit (which with high burn rates and long development cycles in biotech is nearly impossible). It aims over the long run to create reasonable returns for shareholders who also benefit from learning about the biotechnology industry, and from that industry's healthy development. In addition, BioM coordinates the BioRegion's promotion concept "Genome-based Product Development," provides seed-financing to new biotech startups, and provides the full range of services and contacts that these small firms need to survive. Information services are given for free. To help companies afford services that cost money – such as patent fees, equipment, lawyers' fees – BioM assumes additional shares in the new company, thus putting money into the hands of the entrepreneurs enabling them to seek expert advice. BioM also introduces small companies to regional venture capitalists. In the first 15 months of BioRegio

promotion in Munich, 33 projects had been submitted; 10 projects with a total investment value of over DM 26 million had received funding, and an additional 7 projects with a total value of over DM 71 million had been sent to the national BioRegio project administrators with recommendations to fund (BioM pamphlet, 1997).

According to all players involved, the BioRegio Competition made a significant impact in the two states. The semi-public organizations dedicated to supporting small biotech startups and linking scientists and companies were developed on a broad scale and with significant state and local funding only when the regions entered the BioRegio Competition. Moreover, commitments for millions of Deutschmarks in venture capital were received from semipublic banks and industry in response to fundraising initiatives by the shapers of the BioRegions' applications. As will be shown in the following section, the federal government's risk-assumption guarantees for venture capital providers predate the BioRegio initiative; they were not fully exploited in biotech, however, until after the Competition raised biotechnology's profile among investors (interview A072298.2). Similarly, the various pre-existing support initiatives – patent subsidies and the like – were not being routinely used by entrepreneurs until the BioRegio Competition focused the spotlight on, and spurred local actors to augment, the services available to small companies. As a result of the BioRegio Competition, biotechnology promotion policies have been implemented and funded in applicant and non-applicant regions alike, closer links have been built between industry and researchers, and banks have begun learning by doing as they fund small startups. State regulatory environments have become friendlier: even though Hessen's candidate region did not win, the Hessian officials finally, 14 years after the initial request, permitted Hoechst-Marion-Roussel to produce human insulin with genetically-altered bacteria (*Die Welt*, March 18, 1998). Sabotage in experimental fields has gone done to 10 per cent of total (*Blick durch die Wirtschaft*, Nov. 21, 1998). One hundred fifty new biotech firms were founded in the first year and a quarter in the BioRegions alone, and more than DM 560 million in private equity capital was made available for startups in just these three regions (*Faktenbericht 1998*, p. 129).

Before the BioRegio Competition, existing public policy had not been enough to jump-start Germany's biotechnology industry. The German environment needed support from local governments, engagement from the lenders, and entrepreneurial initiatives among scientists. The federal government's BioRegio served as a catalyst that unleashed social capital. While the jury

is still out on whether Germany's biotechnology firms will be quite as nimble as those in the US (see section four), the German government did, unexpectedly to most observers, help create a credible base for Germany in a turbulent, new technology.

Section Three: Public Venture Capital.

The Research Ministry designed the BioRegio competition with a specific sector in mind. The Research Ministry has also supported venture capital, a catalyst for innovation and growth across a variety of sectors. As in biotech, the Research Ministry identified its goal by looking at success case USA, where studies indicated that jobs and technological innovation were being created by small startups nourished on venture capital. For Germany to remain a strong global player in technology, and to grow jobs to reduce unemployment, small startups were needed, which in turn needed venture capital (high risk funds) and venture capitalists (experts at risk evaluation and entrepreneurial support). The Research Ministry has sought since the 1970s to spur venture capital markets in Germany by influencing banks' and private investors' investment strategies. After several false starts, the Research Ministry has in the mid-1990s hit on an effective strategy that has transformed the market for seed financing in Germany from a dwarf to the largest in Europe.

Small technology-based startups cannot cover their costs through profits until late in their development cycle. The large investments that must be made to bring a project from the drawing board through development and trials to market must occur before any sales, and even before it is known whether a successful product will emerge. In the United States, venture funds provide money – often by assuming equity – to small startups. These venture capitalists make profits as the value of their shares soars in those rare cases when they fund a success. To achieve the desired 25%-30% return on their investments, venture capitalists need just 10-20% of the companies they fund to be real winners (Zider, 1998, p. 136). Because the failure rate is so high, venture funds are run by analysts (often partners) who possess technical skill and invest considerable time in evaluating and then monitoring the firms to which they extend money. Venture capitalists in the US fund but one per cent of business plans they receive (Fenn, Liang, and Prowse, 1995, as cited in Lerner, n.d., p. 7). In exchange for their funds, venture capital investors receive preferred equity ownership – they are the first investors to get their money back if the venture fails – and privileged representation on the board of directors. They often contact

firms on a daily basis; hold board meetings monthly; and monitor the agents of their principle (equity) very closely. In addition, since the funds' partners have their own income at stake, they provide as many advantages through coaching and consulting as they possibly can give the firms. And yet, even with this close scrutiny and support, a majority of projects funded fails to produce positive returns. As Josh Lerner, an economist at Harvard University and the National Bureau of Economic Research, concludes: "the environment in which venture organizations operate is extremely difficult. It is the mechanisms that are bundled with the venture capitalists' funds that are critical in assuring that they receive a satisfactory return. These circumstances have led [p. 8 – p. 9] to venture capital organizations emerging as the dominant form of equity financing for privately held technology-intensive businesses" (n.d., pp. 8-9).

Modern venture capital developed after World War II in the United States beginning with American Research and Development (ARD) in 1946, started by MIT and Harvard staff and local business leaders to commercialize technology developed during the war years. ARD's best-known investment is Digital Equipment Company (DEC), a stellar success. Yet private venture capital failed to take off until the early 1980s after the Labor Department explicitly permitted pension funds to invest in high risk assets. Between 1958 and 1969, the federally guaranteed risk capital pools in the Small Business Investment Company (SBIC) program provided more than three times the amount of private venture capital invested during the period. In contrast, the private market increased nearly ten fold in the first seven years after the clarification of the "prudent man" rule in the Employee Retirement Income Security Act (ERISA) in 1979; pension funds' share of the total went from 15 per cent to over half (Lerner, n.d., pp. 1-6). In the 1980s and 1990s, "business angels" – rich private investors, many of them successful entrepreneurs – have also contributed to pools of private venture capital. The US has roughly 250,000 of these "angels" who annually invest in between 80,000 and 200,000 firms, often during early ("seed") financing phases, to the tune of $20 to 30 billion (Koschatzky, et al., 1995, p. 183). The large influx of high risk capital is complemented by high stock market capitalization: in a market with plenty of buyers, investors can quickly take a successful company public, exit their investment, and recycle the capital in new ventures, increasing their overall returns.

Finally, venture capital markets provide money in the form of equity, not loans. *Equity* financing is indispensable for entrepreneurs: it frees them from interest payments, and serves as

collateral with which they can raise additional funding through loans, in both cases maximizing the amount of capital available to them in pre-market phases of discovery and development.

The German system of industrial finance is dominated by (1) firms that finance expansion through existing profits, and (2) banks that finance expansion based on *loans* to firms whose credit-worthiness has been determined by evaluating past performance. Neither of these options offers good sources of capital to technology-based startups who have neither track records nor existing profits. (The system is good at financing incremental improvements, however, in mature technologies like mechanical engineering in engines and machinery, in which Germans rank among the best in the world as measured by export share and patent share [Abramson, *et al*., 1997, pp. 250-53]). In addition there exist underfunded, decentralized public and semi-public financing instruments. These include long-term *loans* for young companies with no track record through semipublic investment banks, the *Kreditanstalt für Wiederaufbau (KfW)* and the *Deutsche Ausgleichsbank (DtA)*, and a range of semi-public *equity* stock companies for small and medium-sized enterprises (*mittelständische Beteiligungsgesellschaften*), which are funded by regional banks and Chambers of Industry and Commerce. The long-term loans subsidized by the *KfW* and *DtA* require a *Hausbank* to sign on as partner and assume risks (Vitols, 1996, pp. 6-8). The banks have historically been uninterested in loaning to high risk ventures, however, while the would-be entrepreneurs were often dissuaded by the reality of business plans that included loan-service fees and high personal liability in cases of bankruptcy. The semi-public equity stock companies had very limited funds, and also lacked expertise to provide the management consulting needed by their scientists-turned-businesspeople (Abramson *et al.*, 1997, p. 260).

The result: although through the 1980s almost half of all new small businesses in Germany received support from a publicly or semipublicly-sponsored capital-provision program (Vitols, 1996, p. 7), the overall number of startups was low, especially in high- or new-technology sectors. There remained relative to Great Britain, France and especially the United States an inadequate provision high risk financing for firms developing new technologies. At the start of the 1990s, the US venture capital market was 10 times the size of the German, while the US GDP was only 3 times greater (Kulicke, *et al.*, 1993, p. 217, p. 226, and OECD *National Accounts*, 1999). Only 10 per cent of the total stock of equity capital in the European Union (EU)

was invested in Germany in 1992, while 43 per cent was invested in Great Britain (Koschatzky, et al., 1995, p. 171, 177).

Active involvement by the federal government has begun to change this bleak picture – a change that began in the 1990s after the Federal Research Ministry through trial and error succeeded in developing an effective policy. The German Research Ministry first sought to stimulate the provision of venture capital for technology-based startups by encouraging, in 1975, the 27 leading credit institutes to found a venture capital society called the *Deutsche Wagnisfinanzierungs-Gesellschaft*. This society invested in small technology startups through the end of the 1970s, but lacking adequate experience and risk-evaluation know-how, experienced heavy losses that were covered to 75 per cent by the federal government. The Society shifted its investment focus to *established* technology companies, but was barely able to recoup its losses and never produced noteworthy returns for its members. The experience led the premier credit institutes in the opposite direction than that desired by the federal government – they were less interested than previously in supplying venture capital to young startups (Kulicke, *et al*., 1993, pp. 5-6).

Yet late 1970s and early 1980s studies of startups in the US, attributing to them tremendous job creation,[7] were well-read by the relevant bureaucrats in the Federal Research Ministry, who reaffirmed their commitment to supporting similar companies in Germany. A long term goal was identified: solving the seed-financing crunch in Germany. In 1983 the Research Ministry introduced a trial program called "Promotion of Technology Oriented Startups" to better understand the development trajectories of small startups[8] and to evaluate promotion possibilities. The program aimed to provide a climate favorable to new firms by improving their access to venture capital and consulting services. The Research Ministry extended subsidies to the companies, and assumed some risk from the private sector to encourage it to provide venture capital to the subsidized entrepreneurs. While startups that participated in the program, after a very competitive selection process, failed less frequently than the average startup, the private sector investors who got involved in supporting the small firms again experienced losses, which led to a thorough-going retreat from provision of seed-financing. The Research Ministry drew the following conclusions from the trial results: young companies needed their own capital, and

[7] See Kulicke and Traxel, 1995, p. 1 at note 4 for additional references.
[8] In German, *der Modellversuch "Förderung technologieorientierter Unternehmensgründungen" (TOU).*

not subsidies, to serve as collateral for further loans; that even more management consulting should be made available to the small companies as they designed business strategies; and that any further program had to be successful at involving the market in supporting small startups. Subsidies in perpetuity were to be avoided (Kulicke with Traxel, 1995, pp. 3-5).

The Research Ministry introduced new instruments in a successor "trial" launched in 1989 called "Equity Capital for Newly-founded Technology Companies."[9] This trial had three goals:

- to create incentives for investors to assume shares in the early phases of a startup's existence;
- to develop a venture capital market in Germany that did not rely on public support;
- to determine if a public initiative would be necessary to spur sufficient equity capital provision (Kulicke and Traxel, 1995, p. 10).

To achieve these goals, the two semipublic credit institutes historically employed to provide long-term financing to industry – the Kreditanstalt für Wiederaufbau (*KfW*) and the Deutsche Ausgleichsbank (*DtA*) through its new subsidiary the Technologiebeteiligungsgesellschaft (*tbg*)[10] – were recruited, and two programs were developed. In each case, the semipublic bank would provide up to DM 1 million if a lead-investor, meaning a bank or venture capital firm, were willing to invest the same amount in a small technology-based company.[11] And in each program, 90 per cent of the investors' risk in case of bankruptcy was assumed by the Research Ministry (80 per cent) and the semi-public bank (10 per cent). The equity capital programs proved to be a success, and in 1995 a third "trial" was implemented that but slightly amended the policy instruments.[12] The share of risk assumed from the lead investor was raised to 100 per cent for the *KfW* version, and dropped from 90 per cent to 50 per cent for the *tbg* version, with more generous limits for investments in eastern Germany. Ceilings on the semipublic banks' participation were raised from DM 1 to 3 million (BMBF and BMWi, 1998, pp. 69-70; Kulicke and Traxel, 1995, p. 11).

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[9] In German, der Modellversuch "Beteiligungskapital für junge Technologieunternehmen" (BJTU).

[10] The *tbg* was created in 1989 to provide equity capital (as opposed to loans) to technology-based small firms, as a part of the Federal Research Ministry's venture capital provision program.

[11] The *KfW* provided up to a million DM loan at favorable rates (subsidized by the federal government) to a venture capital company willing to invest this money in a startup in need of re-financing. In exchange, the investor paid the *KfW* 40 per cent of its anticipated profits. The *tbg* in contrast bought up to DM 1 million in passive equity (no management rights) in a company if a "lead investor" committed to a similar investment in the company. In this case, the entrepreneur pays the *tbg* an interest rate that in 1998 was at least 6 per cent, adjusted upwards depending on a firm's profitability. The *tbg* makes no money as the value of its shares changes.

[12] The program was called *"Beteiligungskapital für kleine Technologieunternehmer" or BTU*.

With the switch from providing subsidies to assuming equity, the Research Ministry reformed its policy instrument in a way that markedly enhanced effectiveness and efficiency. First, the switch moved decisions about which companies to finance out of the Ministry's hands and in to a "lead investor's" hands. This helped reduce the case load on the ministry. It also, in keeping with the microeconomic-based theories underpinning much of the ministerial reform in the Research Ministry, put decisions into the hands of people who were investing their own money – a lead investor would have to commit to a project before the bank funded it and the Ministry guaranteed it. This was assumed to lead to more efficient selection of worthy candidates. Second, the switch away from subsidies created tremendously more leverage for each tax *deutschmark* spent. The early 1980s trial program had offered, to entrepreneurs, subsidies (read "gifts") of up to 75 per cent of investments, and to investors, guarantees of up to 80 per cent of the money loaned (Kulicke *et al*, 1993, p. 243). These policies had become hugely expensive. To put a million *deutschmark* in the hands of an entrepreneur, the Research Ministry estimates, was costing nearly DM 800,000 in the 1980s. Moreover, as the EU lowered its subsidy ceilings, a new vehicle had to be found for getting startups the capital they needed. In 1998, it cost the Research Ministry but DM 125,000 to put the same DM 1million in the hands of an entrepreneur via equity capital, a cost reduction from 8/10ths to 1/8th of the capital mobilized (interview B071498.2).[13]

The equity capital programs have also become increasingly popular with private capital providers, the so-called lead investors needed for every federally supported investment. The number of firms in which the Research Ministry has assumed shares through this program doubled from 101 in 1994 to 203 in 1995, and again nearly doubled in 24 months to 398 in 1997. The amount of money represented by the equity shares has increased even faster (Research Ministry documents provided by interview B071498.2). Thus, while only somewhat over half of the available DM 150 million for the *tbg*'s share of the trial program BJTU was used between 1989 and 1994, the entire DM 240 million budgeted in the successor trial for the period 1995 to 2000 was used by 1997. An additional DM 200 million has since been made available (Schitag, Ernst & Young, 1998, p. 27). Biotechnology's share of the total is 15 per cent and growing more quickly than any other sector (Schitag, Ernst & Young, 1998, p. 27; interview B071498.2). From a dearth of seed-financing available to technology startups in the 1980s, Germany now has 64

[13] The cost to the Ministry now arises through guarantees to investors in failed startups.

per cent of all seed-financing available in Europe (BMBF, 1998, *Faktenbericht 1998*, p. 155). According to industry experts, there is no longer any credit crunch in venture capital in Germany (*Handelsblatt*, 1997, "An Kapital…"; interviews A072298.2 and A072998.1)

The above figures for venture capital suggest that earlier shortages, at least in seed-capital where the greatest crunches were and thus where the Research Ministry targeted its efforts, seem to be solved. In encouraging private investors to take shares in startups by assuming much of their risk and little of their returns, the Federal Research Ministry has created a 1990s "El Dorado." But what happens after the BTU program ends? Has the secondary goal of creating a self-sustaining venture capital market been reached? Almost none of the players, from the Research Ministry, to the *tbg*, to regional support organizations, anticipate that the state will actually withdraw when the BTU program period ends in 2000 – expectations based on the belief that the current supply of capital is not self-sustaining. The appendix discusses broader institutional constraints in Germany that reduce yields on venture capital (such as tax law) and as well as demand for venture capital (such as patent or bankruptcy law). These constraints make a self-sustaining market for venture capital unlikely in Germany, indicating a continued role for the federal government. They also underscore how crucial the federal government's role has been in creating a flourishing seed-financing market that supports hundreds of new companies – in an environment in which the private sector, facing a range of disincentives, was uninterested in providing venture capital.

Section Four: Conclusions

When the Federal Research Ministry in the mid-1990s accepted the goal of propelling Germany to a position of leadership in European biotechnology, it had decided that the key to the US dominance in biotechnology was the link between research and commercial reward – the technology transfer conducted so dynamically by small startups, and facilitated by venture capital firms that not only connected people with good ideas to people with extra money, but also helped the scientists-turned-entrepreneurs navigate the confusing world of business plans and accounting. Creating something similar in Germany, however, required the cooperation of lower level governments and the private sector. The Research Ministry thus held the BioRegio Competition that spurred bottom up initiatives from the private sector and lower-level governments in many more regions than those that ultimately won preferential federal support.

The Research Ministry also continued to refine its approach to promoting venture capital in Germany, and as in the BioRegio competition, designed policies that mobilized and directed crucial non-governmental actors, including the semi-public banks that provided passive equity capital, the industrial associations that provided small business support and risk analysis, and the "lead investors" who made venture investments. In both cases, the government's policies have been a clear success when measured by their influence over lower-level actors' activities, and by the seed-financing available and the number of startups founded. The German state may be one of several actors, but it has clearly assumed a leadership role and affected the course of biotechnology and venture capital in Germany.

The success of the BioRegio competition raises the questions of why it worked as well as it has, and whether it could be used as successfully to promote other new technologies. Students of federalism have long known that federal grants with strings attached can be effective in getting lower level behavior to change. As US President Richard Nixon argued in one of his revenue sharing messages, "because competition between localities for limited Federal dollars is most intense, local officials are highly motivated to meet both the formal requirements and the informal preferences of Federal officials as they file their applications" (as quoted in Reagan and Sanzone, 1981, p. 59). An entire generation of empirical research on the US case, launched by Martha Derthick (1972), reveals however that federal officials have "tremendous difficulty in executing even straightforward policies precisely because state and local governments enjoy such wide latitude in deciding how best to translate federal policies into action, or whether, in fact, to follow federal policies at all" (DiIulio and Kettl, 1995, p. 18). The states in Germany have considerable rights and abilities when they implement federal law; the key to federal influence in BioRegio was to structure the competition such that regional compliance with federal preferences was necessary *before* awards were made. As a political instrument, a competition like the BioRegio seems likely to be effective in other high tech sectors as well.

The success of the technical strategy rests in part on the federal government's ability to exploit existing societal capacity and existing patterns of industrial promotion. The Research Ministry's recent approach to promoting biotechnology, despite its novelty, must be acknowledged at some basic level as very German: the state has played its time-honored function of enabling the private sector to compete. Where the German bureaucrats and the private sector can play off national institutional strengths to support the globally defined strategy, where they

can engage established patterns of industrial promotion, they are doing very well. In fact, support provided small biotech firms may be even greater than in the US. However, where new skills are necessary, success has been more measured. Skilled provision of venture capital has been harder to create in the German institutional environment.

There are certain reasons to suspect that the Research Ministry's "nurture small startups" approach may have been particularly well-suited to biotechnology, with the implication that other technology sectors may not respond as favorably. German biotechnology already had relatively strong academic research and strong industry. What was needed was a link, precisely what small startups provide through their commercialization of intellectual property. Small dedicated biotech companies, moreover, are especially important to the competitive strategies of the life sciences' biggest firms – the pharmaceutical companies – and so promoting small companies was key to attracting and retaining investment from large players. In other sectors, such as computer sciences, Germany lacks both strong academic research and world-class industry. In this case, the money and services made available to small startups would not compensate for a dearth of good ideas and demand from commercial end-users. Moreover, in other technology sectors the activities of small startups are arguably less crucial. Mechanical engineering and material sciences, for example, are fields in which seminal discoveries are not often generated by small firms with two or three employees. Rather, advances in these fields are largely incremental in nature, and occur most frequently along more traditional paths, in in-house industrial laboratories, or through more customary industry-academy research collaboration. This fact helps account for the less impressive results being produced by the Research Ministry's *Leitprojekte* or Key Projects Competition, which was introduced after the effectiveness of the BioRegio Competition was recognized.

The Research Ministry's broader program for promoting venture capital has been affected by a range of features of the German political economy: the organization of financial and labor markets, and tax, bankruptcy and patenting laws (see appendix). This interaction suggests there may be limits to the strategy of employing national institutions to imitate the resources provided by venture capital firms and markets in the US. It is very unlikely that a self-sustaining market for venture capital will have emerged in Germany by the time the government is scheduled to withdraw. This suggests policymakers have two options: they must either continue certain kinds of deregulation to stimulate supply and demand for venture capital, or

make a conscious decision to retain their national institutional frameworks with the implication for public policies that arise.

To consider the first option first, it should be emphasized that "looking more American" in high technology promotion will not imply a complete withdrawal of the state. Instead, the US's global advantage in information- and bio-technologies can be directly linked to US defense spending and educational grants that gave birth to the high tech region known as Silicon Valley, and to National Institutes of Health (NIH) spending on basic life sciences research. Moreover, US startups relied for several years quite heavily on public venture capital, and even in the late 1990s the public sector plays a key role in financing many of the smaller startups whose capital needs hence anticipated returns are too minor to attract venture funds. For *private* venture capital and small startups to become self-sustaining in Germany, however, laws governing taxes, civil servants' employment, intellectual property, and bankruptcy would have to be changed. These broad framework issues were acknowledged by a VIP panel of union, industry, bank, and academic leaders convened by the Kohl government in 1996 to take stock of the state of biotechnology in Germany (BMBF, 1997, "Biotechnology, Genetic Engineering…"). Yet even during Helmut Kohl's tenure, regulatory reforms were incremental and occurred but slowly (on implementation of the Chancellor's Council biotechnology recommendations, see Bundesregierung, 1998). The likelihood of the reforms moving further under the Socialist/Green government need not be overestimated.

The other alternative assumes that national institutional systems determine the kinds of innovation to which political economies are best suited. Put more strongly, this alternative suggests that Germans possess a comparative institutional *advantage* in certain kinds of innovation. The German system, with its long-term capital, powerful employer associations, and cooperative unions, solves certain collective action problems, and thus makes possible the kinds of incremental innovation in high quality engineered products and traditional chemicals for which Germany is famous (Soskice, 1996). Radical convergence on the US system might actually undermine the innovative strengths of Germany's traditional technology sectors, sectors which have made Germany one of the biggest exporters in the world. Thus rather than deregulate, under this alternative policymakers should compensate for the lacunae in private incentive structures with public policy. Indeed, in the 1990s German decisionmakers have clearly endorsed this option, in part due to the difficulties of building reform coalitions, but also perhaps

due to their conviction that the German approach has advantages. The Research Ministry's tactics for providing venture capital and supporting startups – including "El Dorado," "evaluation-for-fee," and "soft-exits" (as explored in appendix) – are clear examples of public policy creating incentives not provided by the labor and capital markets. In addition, the Research Ministry has supported the creation of patenting and licensing offices in the universities to commercialize intellectual property (the so-called "An-Institute") and has worked to develop high-prestige networks of rich individuals who invest in technology startups in Germany (the so-called Business Angels Network Deutschland, or BAND; see *Frankfurter Allgemeine Zeitung*, Aug. 26, 1998).

Limits to public policy's ability to compensate for gaps in incentive structures exist, and suggest that firms' institutional homes will continue to shape their competitive strategies. As long as corporate governance and labor market structures reduce the powerful incentives (such as stock options) that motivate American researchers to work long hours, and that enable managers to quickly hire and then let go specific talents they require, German firms will have trouble beating their American firms to market. Not surprisingly, in high risk niches like pharmaceuticals, German firms are underrepresented and American firms dominate. In contrast, more stable niches, like "enabling" or "platform" biotechnological advances, have attracted a higher number of German firms that are doing quite well globally (interview B070398.1; Casper, 1998).

In sum, rather than ignoring or jettisoning their longstanding institutions in response to fierce competition in a global economy, federal decisionmakers have *exploited* these institutions to create competitive advantage. The dense patterns of cooperation and the resulting sovereignty-sharing among public and private actors thus matter very much, in this sense, to the strategies selected by the federal government. Contrary to the image of a limited German federal government, national policymakers have actively and independently selected strategies and compelled lower-level governments and the private sector to implement them. The story of growth in the biotechnology and venture capital sectors in Germany would be impossible to tell without attention to federal government leadership. Is this capability new? Why do these cases differ from the conventional picture of Germany's political economy? One plausible answer is that federal government leadership is of recent origin, developed perhaps in response to rigors of the globalized economy – rigors that place a premium on effective state policymaking

(Friedman, 1999). Another plausible answer, however, is that the leadership is longstanding, but more evident at early stages in a technology cycle before private sector capabilities have been developed. Thus studies of the postwar German economy, motored by mature sectors with established private/semi-public actors, have revealed little leadership while examinations of emerging sectors, such as biogenetics and e-commerce in the late 20th century, may reveal a very different, equally accurate, picture of national policymakers' autonomy and influence. Comparisons with the development of chemicals and steel in the Bismarck era suggest themselves as useful, as does attention to the Bismarck government's active leadership in organizing unions and other societal associations to meet state objectives during Germany's drive to industrialize. While these observations are speculative, the research in this article reveals a role for the state that is not adequately captured with the "semi-sovereign" and "enabling" labels. Further research across time and cases is necessary to tease out the character and importance of the state leadership evident in the trajectory of Germany's biotechnology and venture capital sectors.

Appendix: Institutional determinants of the supply and demand of venture capital in Germany

Venture capital markets link those in need of high risk money to those with money to invest. Due to the risk involved, returns to successful investments must be high. An industry expert in the United States estimates that were deals structured as loans, the interest rate would need to be an illegally high 58 per cent compounded annually to create average fund returns above 20 per cent (Zider, 1998, p. 135). There are three reasons to suspect that attractive yields in Germany, absent Research Ministry risk-assumption, are harder to achieve than in the United States and may be inadequate to attract a supply of high risk capital for small companies, whether loans or equity. Yields are affected by "exit" opportunities – the ability to cash in on one's share in a company – by tax laws, and by risk evaluation skills. In the US, as argued in section three, an active stock market enables venture capitalists to quickly recycle investments and thus boost overall yields. In Germany, however, only four per cent of all exits occur when firms "go public." A good third of exits relies on entrepreneurs raising enough money to buy their shares back. Over half of the exits were "trade sales" to industrial investors, sales which require time and energy to identify good matches and thus have information costs avoided by an IPO in the United States (BVK, 1998, *BVK Statistik…,* p. 9). Although Germany has seven regional bourses including Frankfurt, and, since March 1997, a NASDAQ-equivalent called the *Neuer Markt*, overall market capitalization is much lower in Germany than in America. In 1995, there were seven times more companies – per capita – listed in the U.S. than Germany (Mackewicz & Partner, 1998, p. 42). Without the ability to quickly recycle profits, effective yields on venture capital are reduced.

(The *tbg* has acknowledged that exit is a problem for investors, largely due to the difficulty in going public. Money from the *tbg* cannot be used by the entrepreneur to buy back control from the lead-investor in the Research Ministry's trial program, so *tbg* managers developed their own instruments to create "soft exits." Under this new approach, the "*DtA*'s Technology Investment Program," the *tbg* purchases shares in a startup, providing money the entrepreneur can use to buy back her company from the lead investor. These *tbg* shares are no longer "passive equity" and the returns to the *tbg* are no longer fixed interest rates. Instead, the *tbg* will make or lose money as the value of its share of the company changes. The *tbg* only invests, in this program, in firms that it shepherded through the Research Ministry's early trial

programs, so the *tbg*, as venture capitalists in the United States, has intimate knowledge of the companies in which it is risking money. This program is a qualitatively new program for the *tbg* in that it risks its own money and foregoes constant returns or federal guarantees [interview in *tbg*]).

Yields on venture capital investments in Germany are also lower than in the US due to tax law, which offers no preferential treatment of such gains.[14] Finally, real yields – absent risk-assumption by the Research Ministry – are lower for German investment companies to the extent they are less skilled at picking fundable projects than their American counterparts. Even in the United States, the world leader in venture capital, venture capital funds eschew small startups since the costs of evaluation and monitoring make it more profitable to engage in fewer but larger partnerships. Conventional wisdom to the contrary, early stage firms in the US received only about 30 per cent of the disbursements made by venture capital funds in 1995. This creates an important place for public venture capital for small businesses in the US: in 1995 the amount of equity financing provided through and guaranteed by national agencies' and state-level governments' small business financing programs was, at $2.4 billion, 60 per cent of the sum made available by traditional venture firms that year (Lerner, n.d., p. 2). And, even in the US, although venture capitalists carefully choose to fund but the top one per cent of the business plans submitted to them, the most frequent outcome in a venture is failure: Paul Gompers (1995, table 3) finds that only 22.5 per cent of a sample of 794 venture capital investments made over three decades ended in going public.

In Germany, banks (which with their subsidiaries provide 60 per cent of Germany's venture capital [Mackewicz & Partner, 1998, p. 36]) are widely regarded as lacking the ability to turn a profit based on their assessment of risk in new technology-based proposals.[15] Moreover, the universal banks in Germany may lose reputation if a startup for which they have issued bonds goes bankrupt – a loss in reputation that could affect their other savings and lending operations (Abramson, *et al*., 1997, p. 262). Yet some banks behave in ways that suggest they are interested

[14] For recommendations on tax law changes to spur the venture capital market, compiled by a panel of experts convened as the Chancellor's Council on Research, Technology, and Innovation, see BMBF, 1997, "Biotechnology, Genetic Engineering and Economic Innovation".

[15] See, for example, the conclusions of the Binational Panel on Technology Transfer Systems in the United States and Germany, co-authored by the National Academy of Engineering and the Fraunhofer Institute for Systems and Innovation Research, cited here as Abramson, *et al*., 1997; and the conclusions of the interdisciplinary panel of experts convened as the Chancellors' Council on Research and Technology, cited here as BMBF, 1997, "Biotechnology, Genetic Engineering…"

in remedying this deficit. As seen in section two, above, banks in Bavaria were interested in buying BioM shares in order to watch as the company led by world-class scientists invested in startups in BioRegion Munich. To help the banks make investment decisions in startups, the Federal Research Ministry is encouraging the publicly supported Fraunhofer Societies to provide contract research – for a fee – to banks. Prominent clients include the Deutsche Bank and the association of Sparkassen (BMBF and BMWi, 1998, pp. 73-4). About 10 per cent of the Sparkassen have used this service; and those that do, use it repeatedly. In addition, the semi-public and private organizations that have traditionally supported small and medium-sized industry, from the Entrepreneurs' Centers (*Gründerzentren*) and Technology Transfer Centers, to the small business support organizations found in every region, to the Association of German Electricians and the Association of German Engineers (*VDE, VDI*), are being asked more frequently to perform, for fees, risk evaluation for the banks. It is assumed that with their closer contact to the small firms and often their technical expertise, staffers in these organizations can better evaluate future potential (interview B071498.2).

Not only is supply of venture capital limited by yields in Germany, demand for venture capital is also lower than in the US. In one survey, over two-thirds of the entrepreneurs questioned said they worried they would lose entrepreneurial freedom were they to enter an equity partnership (Mackewicz & Partner, 1998, p. 32). This so-called *Herr-im-Hause* (Master in his own home) mentality[16] is one reason entrepreneurs have responded well to the *tbg*'s participation – they have fewer misgivings about sharing control when a semipublic organization is involved (interview A072998.1). This distrust of private venture capitalists, the worry that these outsiders might try to run their company, is also changing as entrepreneurs experience equity partnerships: of 50 entrepreneurs polled in a representative survey, 80 per cent were "quite satisfied" or "very satisfied" with the equity partnership, and only 6 per cent were less than "satisfied" (Mackewicz & Partner, 1998, pp. 32-3).

Other inhibitors of demand for venture capital may be slower to change. Laws governing patents and pensions, employment law and bankruptcy law contain entrepreneurial disincentives. Since the 1970 Bayh-Dole Act in the US,[17] American universities have been actively assisting

[16] See also Kulicke and Traxel, 1993, p. 6, and Abramson, *et al*., 1997, pp. 262-3.
[17] Abramson, *et al*. (1997) provide a good overview of the Bayh-Dole Act, which "gave nonprofit organizations such as universities and small businesses the right to patent inventions they developed with federal support; granted government-owned and operated laboratories the authority to grant exclusive licenses to inventions which they

their staffs to patent and license ideas. In Germany, professors and not the university that employs them have rights to the intellectual property they develop, and thus universities have had little incentive to assist faculty in procuring patents.[18] Moreover, professors in Germany often prefer to publish rather than patent their advances: European patent law, unlike US patent law, has no year-long grace period. Once an idea is in circulation, according to European rules, it is no longer patentable. For their careers, publishing is often more rewarding. Moreover, until very recently the Research Ministry required that publicly supported research be made publicly available – *i.e.* only non-exclusive licenses could be granted. Without exclusive rights to an idea however, the long and expensive development process is not worth embarking on, and neither the professors nor firms are interested in commercializing these ideas. As one interviewee observed: "exclusive rights are worth more than free money [*i.e.* federal subsidies]" (interview A072298.2). Finally, German faculty are paid on a twelve month, not nine month basis, and their research is largely covered by base institutional funds releasing them from the need to find additional income through grants or licensing their intellectual property.

Employment law makes it difficult for research staff in institutes or companies to contemplate founding a new company. Professors' and university employees' supplementary public pension entitlements cannot be transferred if they leave to private employment (Abramson, *et al*., 1997, pp. 17-19). In the private sector, courts often uphold competition clauses in employees' contracts such that scientists cannot terminate their contracts and perform a similar job at a competitor for between 12 and 36 months. Moreover, with regulations making it hard to fire workers, German firms have developed "internal flexibility" by encouraging their employees to develop "deep skills" allowing them to implement new technologies and production methods (Streeck, 1992; Casper, 1998, pp. 14-5). After developing a career within a single firm, mid-career managers have high levels of "firm-specific tacit knowledge" – in effect, mid-career labor markets are quite rigid. Leaving a job to found a risky startup in Germany, but

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patented, and prevented public disclosure of information about inventions to allow for patent applications to be filed. Although Bayh-Dole did not originally apply to any of the DOE laboratory management and operations contractors, the law was subsequently amended to include them." (Abramson, *et al*., 1997, p. 19, n. 17 [text on page 364]). As a result, US institutions established offices for patenting inventions and marketing the patents. Universities hope for increased revenue and develop long-term relationships with industry as partners and patrons, with mixed results. The Bayh-Dole Act has, however, definitely increased the protection of intellectual property and the marketing thereof by universities.

[18] Note however that external funders have often claimed a share in the revenues from invention. A portion of all licensing income on inventions supported by the federal government must go to the funding agency (Abramson, *et al*., 1997, p. 20).

not in the US, could involve difficulty in reentering the labor market at a similar level (Casper, 1998, pp. 14-5).

Finally, bankruptcy law makes very real the threat of personal liability should a startup fail. Even when an entrepreneur has formed a corporation, either a "GmbH" that limits liability or a stock corporation (*Aktiengesellschaft*), that entrepreneur may risk her own assets. In a GmbH, entrepreneurs may be liable beyond what they have invested in a firm: "banks often demand personal liability when a limited partnership has liable equity capital of at least DM 50,000." Private assets may also be demanded to repay excess business debt incurred by the partnership of a stock company (*Aktiengesellschaft*). As a binational panel of experts concludes:

> This threat of personal liability in bankruptcy contrasts sharply with the situation in the United States. If somebody goes out of business in the United States, he or she faces almost no problems starting another business. In contrast, one failure in Germany almost always ends the dream of operating one's own business. Therefore, the risk inherent in establishing [a technology-based startup] is higher in Germany than it is in the United States. The apparent risk-averse mentality of founders of German [technology-based startups] can be connected directly to these legal restrictions. Abramson, *et al*., 1997, p. 261.

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