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by Dirk Dohse and Tanja Staehler

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BioRegio, BioProfile and the Rise of the German Biotech Industry

Dirk Dohse* and Tanja Staehler

Abstract:

The BioRegio contest and the BioProfile contest initiated by the German Federal Government have drawn much international attention as prototypes of a new kind of technology policy aiming at the exploitation of regional innovation and growth potential through clustering. There is, however, little systematic analysis of their actual impact on the development of commercial biotechnology in Germany. The current paper tries to fill this gap.
We find that although these contests have catalyzed the emergence and early growth of German commercial biotech it takes more than isolated policy action by national governments to grow a self-sustainable biotech industry in Europe.

Keywords: clustering, biotech, technology policy, regional development

JEL classification: R11, R38, O3

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1. Introduction

The era of modern biotechnology began in 1973 when Herbert Boyer and Stanley Cohen first inserted a piece of DNA into a bacterial plasmid and transferred it into E.coli where it was translated. The birth of genetic engineering launched a revolution in molecular biotechnology and opened up vast entrepreneurial opportunities. As early as 1976, the first biotech company (Genentech) was founded in the United States. Today there exist about 2000 companies on each side of the Atlantic which employ the advanced methods of modern biotechnology (Critical I, 2006).

Despite the fact that there has been some excellent basic research in biotechnology-relevant disciplines and despite the fact that there are large German pharmaceutical and chemical companies, commercial biotechnology had a late start in Germany. Some observers noted that in the early 1990 "Germany provided perhaps the most inhospitable climate for biotechnology in the Western world." (Dickman 1996: 1454) In an attempt to transform the country virtually overnight into a biotech powerhouse the German Federal Research Ministry (BMBF) started a new funding concept, the *BioRegio* contest, in 1995. The BioRegio contest has been called a prototype model of *region-oriented (or cluster-based) technology policy*[1] and has drawn a great deal of international attention. Its innovative conceptual design has extensively been discussed and analysed in the scientific literature.[2]

BioRegio's main purpose was to encourage local biotech communities to interact more closely, to create an entrepreneurial spirit among scientists and to help them in the setting up of their own business. The ambitious long run goal was to make Germany Europe's number 1 in commercial biotechnology. The three regions selected by the jury as winner regions were Munich, Rhineland[3], and the Rhine-Neckar Triangle[4]. The small East German region of Jena received a "special vote" for its "especially positive new-orientation" in the field of biotechnology after re-unification. Public funds amounting to 76,7 million € were reserved for the winners in the BioRegio contest, which served the federal government as best practice examples in the following years.

BioRegio was followed and supplemented by *BioProfile* in 1999. The BioProfile contest has been designed to allow regions to define a specialization within the overall biotechnology area in which they have a regional competitive advantage. This approach is open to smaller regions

[1] Dohse (2003, 2007).
[2] Cf. Cooke (2002), Dohse (2000b, 2003), Eickelpasch and Fritsch (2005), Koschatzky (2005).
[3] Including the cities of Cologne, Aachen, Düsseldorf and Wuppertal.
[4] Including Heidelberg, Mannheim and Ludwigshafen.

that do not have the high level research capability that was required for success in BioRegio. The winners of the BioProfile initiative are the clusters around Berlin (with its focus on *nutrigenomics*), Hannover (focussed on *functional genome analysis*) and Stuttgart (focussed on *regeneration biotechnology*).[5] The Federal Ministry of Education and Research (BMBF) has earmarked a total of € 50 million for five years, which is shared among the three winning regions.

The focus of this paper is not the innovative conceptual design of these policy measures which has been analysed in depth elsewhere,[6] but rather their practical impact. We are well aware of the fact that such an impact analysis typically faces two important obstacles: (i) we simply don't know how the winner regions (and commercial biotechnology in Germany as a whole) would have developed without the massive intervention by the federal government[7] and (ii) it is extremely difficult to disentangle the impact of BioRegio and BioProfile from that of the manifold other government interventions in this field.[8]

In view of these difficulties, the aim of the current paper is a modest one: We intend to shed some light on the relative performance of the BioRegio and BioProfile winner regions before, during and (in the case of BioRegio) after the operation time of the contests, present some qualitative assessment of the contests by firms and research institutes in Germany (such that received funding from these programs and such that didn't) and to have a closer look at the overall development of commercial biotechnology in Germany from an international perspective. The complementary evidence generated from these three different perspectives will be put together to obtain a tentative (and rather careful) assessment of BioRegio's and BioProfile's role in the context of the development of German commercial biotechnology since the mid-90's.

The structure of the paper reflects this approach: In section 2 we present some evidence on the development of the BioRegio and BioProfile winner regions as compared to the rest of

[5] We just speak of Berlin, Hannover and Stuttgart for the sake of simplicity. In fact, the Berlin cluster also encompasses the neighbouring city of Potsdam, the Hannover region also encompasses Braunschweig and Göttingen and the Stuttgart region (STERN) also encompasses the smaller cities/counties Tübingen, Esslingen, Reutlingen and Neckar-Alb.

[6] See the literature quoted in footnote 2.

[7] One might just extrapolate the development before the start of the respective programs. This is, however, a rather naïve approach in view of the rapid change of the macroeconomic and global environment.

[8] We have conciously abstained from performing a (cross-section) econometric analysis because the number of observations (i.e. the German biotech regions) is rather small such that we don't have enough degrees of freedom to control for the multitude of other variables (apart from government funding) and other government programs (apart from BioRegio and BioProfile) that influence the development of commercial biotech in Germany. Needless to say that the time horizon is too short for a meaningful panel analysis.

Germany, using standard indicators such as number of dedicated biotech firms, employment growth, venture capital funding, etc, augmented by some additional indicators which are less common. Section 3 complements and combines these quantitative indicators with the qualitative assessment of the BioRegio and BioProfile instruments from a survey of more than 1000 biotech firms and research institutes in Germany. Section 4 analyses the development of commercial biotechnology in Germany from an international perspective, giving special emphasis to a comparison with the UK as the leading biotech nation in Europe and the US as the world's leader in commercial biotech. Section 5 concludes.

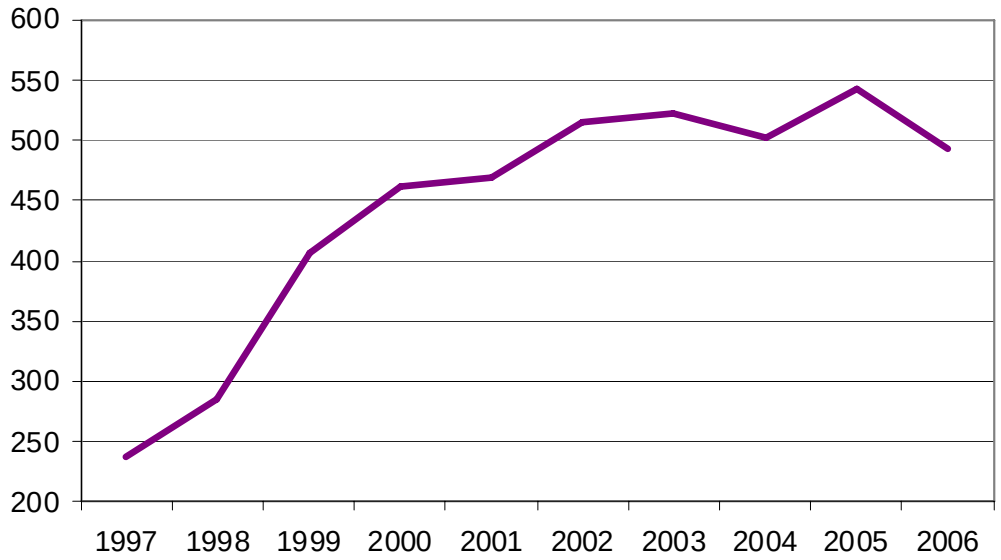
2. Performance of the BioRegio and BioProfile winner regions relative to the rest of the country

2.1 Number of Firms and Employment in Dedicated Biotech Firms

A major goal of BioRegio – as well as of BioProfile – was the stimulation of academic entrepreneurship which is reflected by the number of newly founded *dedicated biotech firms*. Dedicated biotech firms (DBFs, for short) are biotechnology active firms whose predominant activity involves the application of biotechnology techniques to produce goods or services and/or the performance of biotechnology R&D (OECD 2005).[9] Suppliers and research organisations that are only partly involved in biotech are excluded by this definition, as well as big corporations for which biotech is just a minor part of their activities.

As can be seen from figure 1 the number of dedicated biotech firms (DBFs) in Germany increased rapidly from less than 250 in 1997 (the year in which the first payments from the BioRegio program were disbursed) to more than 500 in 2002 and oscillates around 500 firms since then.

Figure 1: Dedicated biotech firms in Germany



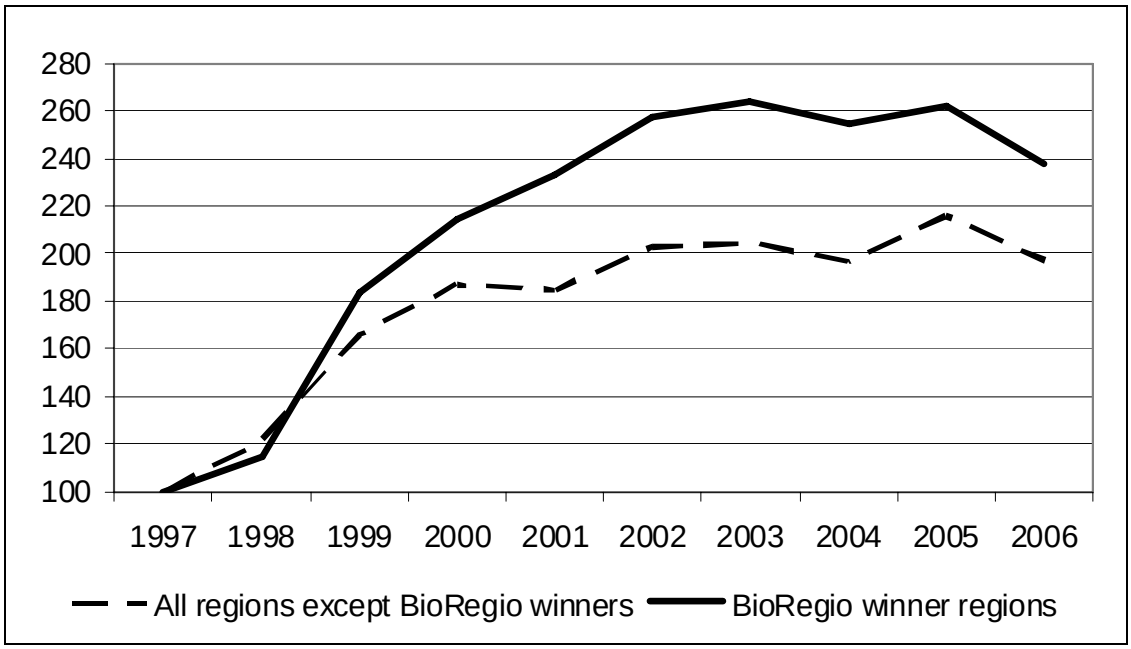
Source: BioCom AG 2006, own calculations

[9] The OECD definition was adopted by BioCom AG, Critical I Ltd. and other data providers.

In 2006 there was a total of 494 DBFs, 145 of which were located in the BioRegio winner regions and 135 of which were located in the BioProfile winner regions; i.e. the seven BioRegio and BioProfile winner regions together accommodated a majority (57%) of all dedicated biotech firms in Germany.

Figure 2 illustrates the increase in the number of DBFs in the BioRegio winner regions as compared to the rest of Germany, taking 1997 as the base year.[10] It can be seen that the increase in the number of DBFs in the BioRegio winner regions was far above average, in particular in the period 1998 until 2003, i.e. the operation time of the BioRegio contest.

Figure 2: Increase in the number of DBFs in the BioRegio winner regions and in the rest of Germany (1997=100)



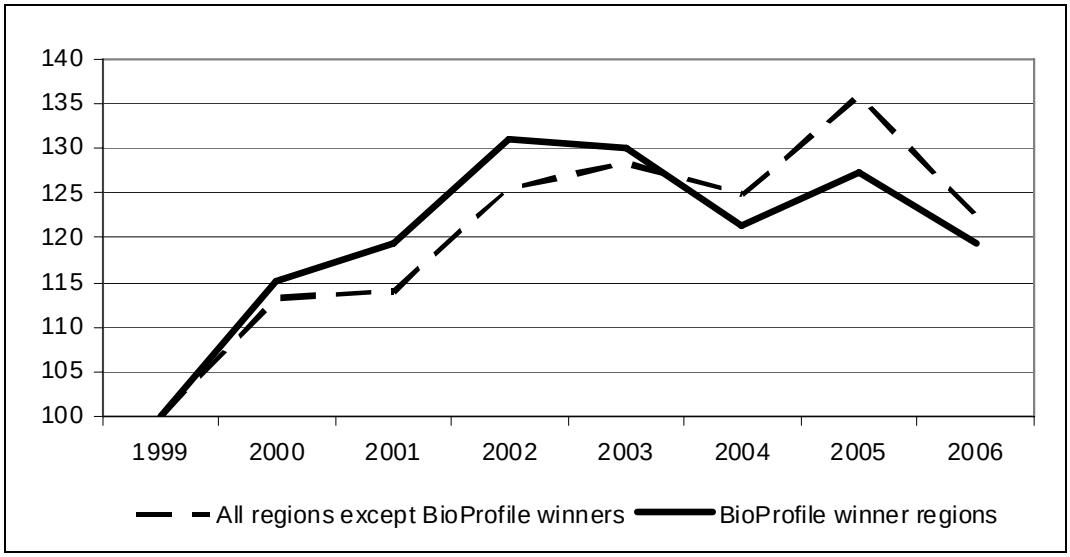
Source: BioCom AG 2006, own calculations

Repeating the same exercise for the BioProfile winner regions (and taking 1999, the start date of the BioProfile contest, as base year) yields quite different results: The BioProfile winner regions did not perform better than the rest of Germany with respect to the increase in the number of DBFs (figure 3).[11]

[10] This means that the number of DBFs in 1997 was set equal to 100.

[11] Even if we drop the particularly strong BioRegio winner regions from the "rest of Germany" aggregate the BioProfile winner regions performed only slightly better than the rest of Germany.

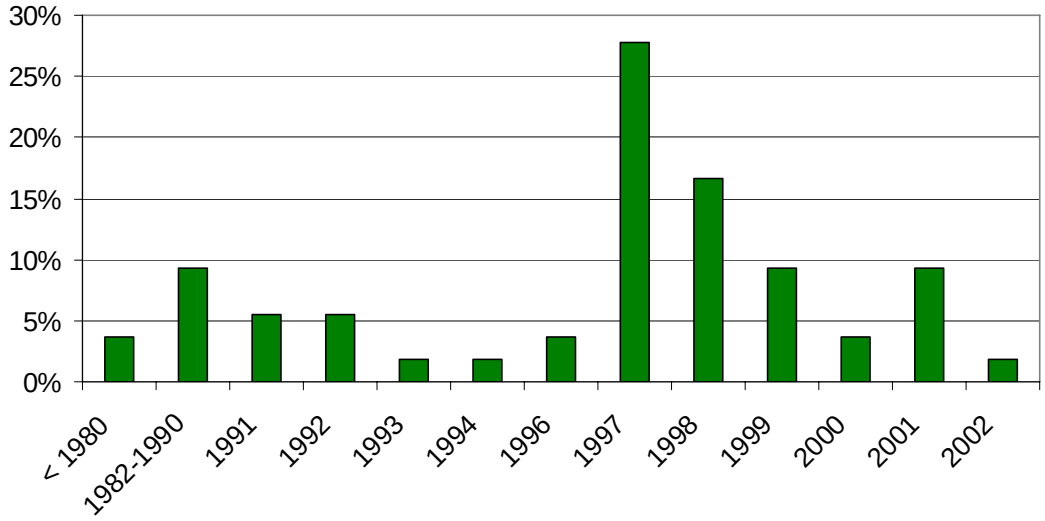
Figure 3: Increase in the number of DBFs in the BioProfile winner regions and in the rest of Germany (1999=100)



Source: BioCom AG 2006, own calculations

The stronger impact of BioRegio on the firm population in Germany can partly be traced back to the fact that BioRegio contributed to a greater extent to start-up financing than BioProfile. The largest part of the total BioRegio funding (more than 60%) was disbursed to private companies the majority of which were start-ups.[12] As is shown in figure 4 about two-thirds of all companies that received BioRegio funding were founded in 1997 or later, i.e. within the operation time of BioRegio.

Figure 4: Percentage of firms that received BioRegio funding by founding year



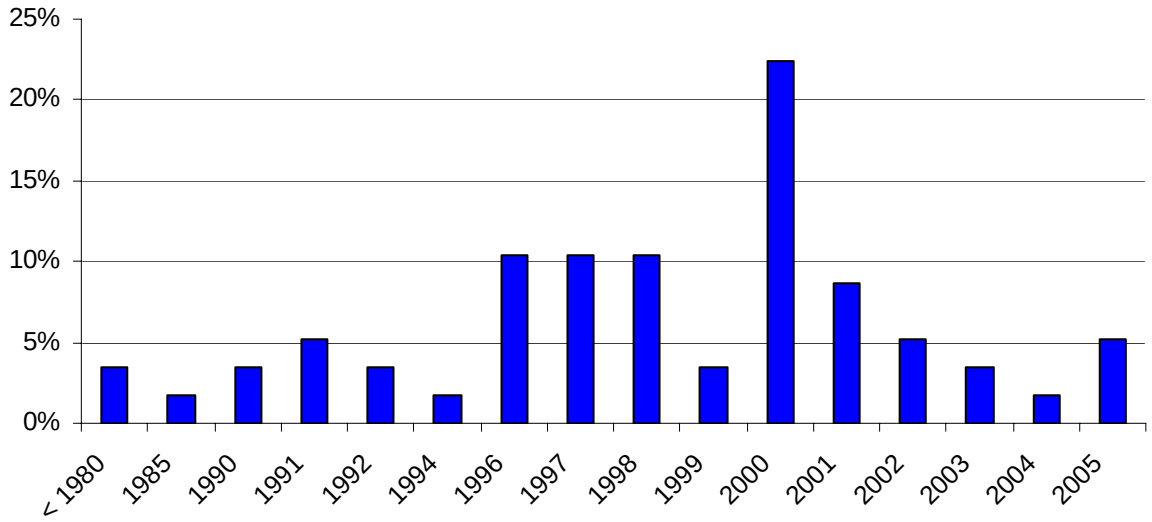
Source: PTJ Förderdatenbank, own calculations

[12] Own calculations, based on PTJ Förderdatenbank.

In the case of BioProfile things look quite different. The lion's share of the the BioProfile funding was disbursed to actors other than private companies (universities, research institutes, program management institutions) while private biotech firms received roughly 37% of the total BioProfile funding disbursed until the end of 2006.[13] As in the case of BioRegio the majority of firms that received funding are rather young (founded later than the mid 1990's). The share of recipient firms that started their business within the operation time of BioProfile (i.e. 2001 or later) is, however, clearly lower than in the case of BioRegio as can be seen from figure 5.

Against this background it is not too surprising that the number of dedicated biotech firms increased more rapidly in the BioRegio winner regions than in the rest of Germany, whereas the BioProfile winner regions did not perform better than the rest of the country in this respect.

Figure 5: Percentage of firms that received BioProfile funding by founding year



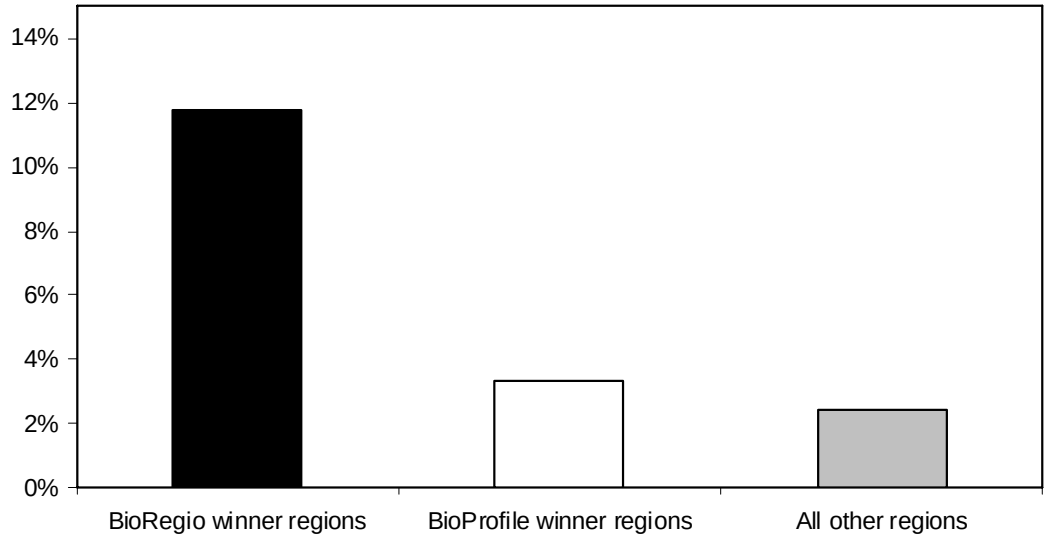
Source: PTJ Förderdatenbank, own calculations

How did the BioRegio and BioProfile winner regions perform in terms of employment growth? To answer this questions we compared the compound annual growth rates (CAGR) of employment in DBFs in the three regional aggregates BioRegio winners, BioProfile

[13] Result of own calculations, based on PTJ Förderdatenbank.

winners and rest of Germany, which means in this case all German bioregions that are neither BioRegio nor BioProfile winners (figure 6).[14] We observe that the annual employment growth rate in the BioRegio winner regions (11.8 %) was considerably higher than elsewhere, whereas the BioProfile winner regions (3.3 %) performed only slightly better than the rest of Germany (2.4 %).[15]

Figure 6: Compound annual growth rates of employment 1998 – 2006 in per cent



Source: BioCom AG 2006, own calculations

2.2. Acquisition of venture capital

In the late 80's and early 90's a venture capital market for biotechnology in Germany was nearly absent. German companies typically turned to banks for credit financing which prevented rapid expansion. "The concept of high-risk, high-return equity investment of venture capital was foreign to both German investors and entrepreneurs." (Müller and Rump 2002: 441) This situation has changed rapidly since the mid-90's: Total VC investment in German biotech firms increased more than tenfold (from far below 50 million € in 1995 to nearly 500 million € in 2000 and 2001 (BVK 2007)). The stock market crash of 2000/2001 stopped the venture capital boom since stock market listing as an exit option for venture

[14] See appendix 1 for a listing of bioregions in Germany.
[15] In interpreting this indicator one should, however, be aware of the fact that the better performance of the BioRegio winner regions in terms of employment growth does – at least partly – reflect the faster growth in the number of firms and is therefore not necessarily due to a superior employment growth of *existing* firms.

capital was no longer available for a couple of years. However, since 2005 there is a marked recovery under way (BVK 2007, Ernst and Young 2006, Schudy 2006).

An important goal of BioRegio and – to a lesser extent – BioProfile was to improve the conditions for venture capital investment in German biotech firms (i.e. to mobilize private investment by public funding) but there were various other activities that went into the same direction and it is therefore extremely difficult to separate which part of the venture capital boom in German biotechnology was directly or indirectly caused by these instruments.

In an attempt to better understand the relationship between BioRegio and BioProfile funding and private venture capital investment the Kiel Institute for the World Economy created a unique data set on venture capital investment in German biotechnology.[16] The data set consists of 88 firms which received private venture capital amounting to 2.1 billion € in the period 1995-2005. 21 of these firms had received government funding by BioRegio, 11 had received government funding by BioProfile and 56 had received neither BioRegio funding nor BioProfile funding.[17]

As can be seen from figure 7 the average amount of private venture capital investment in firms that had received BioRegio funding (35 million € on average) was 60 % higher than the average amount of venture capital investment in firms that had received neither BioRegio nor BioProfile funding (21.5 million €) and almost doubled the average amount of venture capital invested in firms that had received BioProfile funding (18.5 million €).

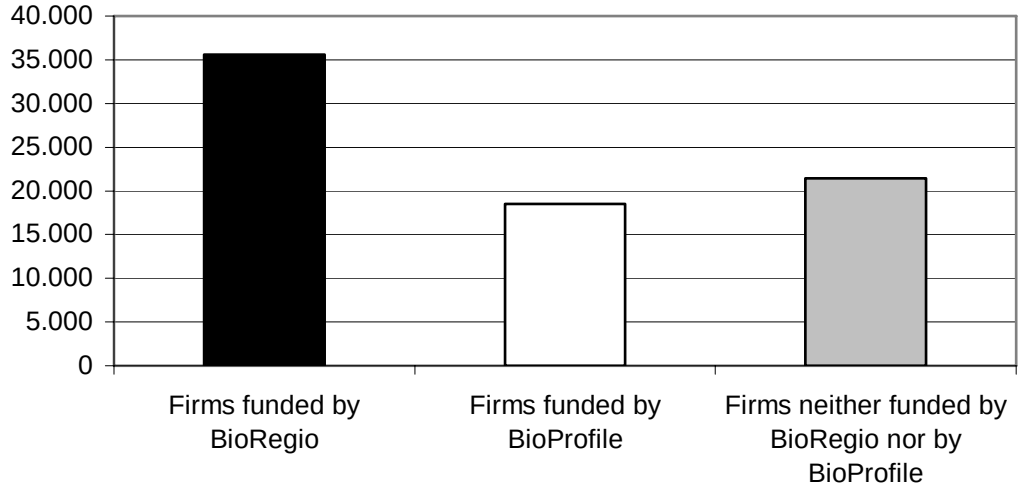
This finding may be interpreted in two different ways. The first interpretation is that the BioRegio funding has had a substantial positive impact on the attractiveness of the funded firms for private investors (i.e. the aim of mobilizing private equity by initial public funding was reached), whereas the BioProfile funding as yet has had no identifiable positive impact on private equity investment. The second interpretation is that BioRegio has addressed the strongest firms (in terms of attractiveness for VC investors) whereas the firms funded by BioProfile with their rather specific profiles appear to be less venture capital compatible than others.

[16] We had access to the electronic versions of all issues of the life sciences news magazine "Transcript" that were published between 1995 and 2005. These issues were systematically scanned for information on venture capital finance of German (dedicated) biotech companies in the period 1995-2005. "Transcript" is the most important news magazine for the Life Science sector in German-speaking Europe and contains all important business news, including finance. It is published monthly.The information gained from the analysis of "Transcript" was verified and supplemented with information from other sources such as Capital Consors or BioPlus. For further details see Schudy (2006).

[17] We can, however, not exclude that these firms received government funding other than BioRegio or BioProfile in the period under consideration.

We cannot decide which interpretation is true on the basis of the data we have available. In any case, BioRegio funded firms have clearly outperformed non-funded firms and firms funded by BioProfile with respect to venture capital acquisition. This result is in line with recent empirical work by Engel (2003) and Champenois, Engel and Heneric (2006) who find that firms located in BioRegio winner regions have a significantly higher probability of raising funds from venture capital companies than firms located outside these regions.[18]

Figure 7: Average amount of private venture capital investment per firm 1995 – 2005 (in 1000 Euro)

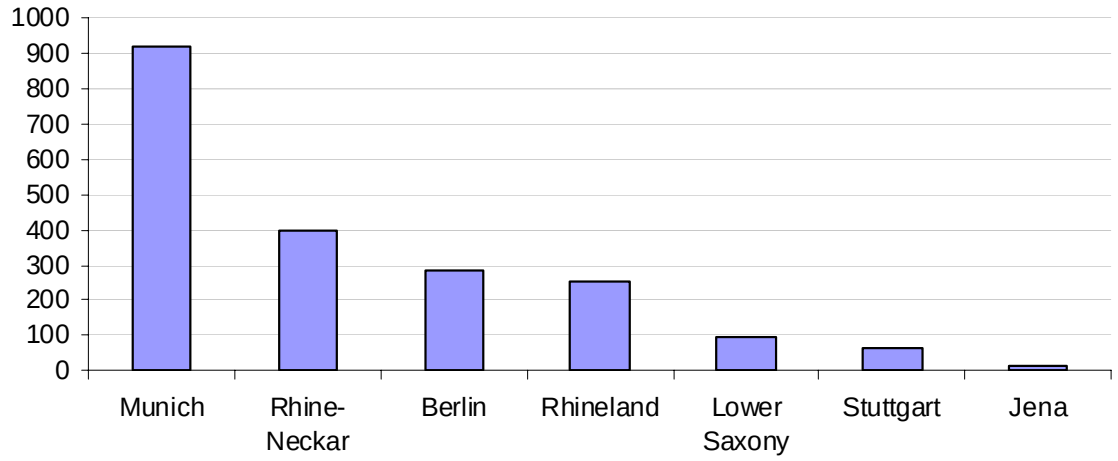


Source: Own calculations, Schudy 2006

Figure 8 gives an overview of the regional distribution of venture capital investment in the BioRegio and BioProfile winner regions in the 1995-2005 period. It can be seen that the Munich region with nearly one billion € was by far most successful in attracting venture capital in the period under consideration, and it is followed by the Rhine-Neckar (Heidelberg), Berlin and Rhineland regions.

[18] The chosen approach in these studies does, however, not allow to decide whether the higher likelihood of raising venture capital is a consequence of participation in the BioRegio contest or may result from unobservable characteristics of the regions (the firms located in these regions, respectively).

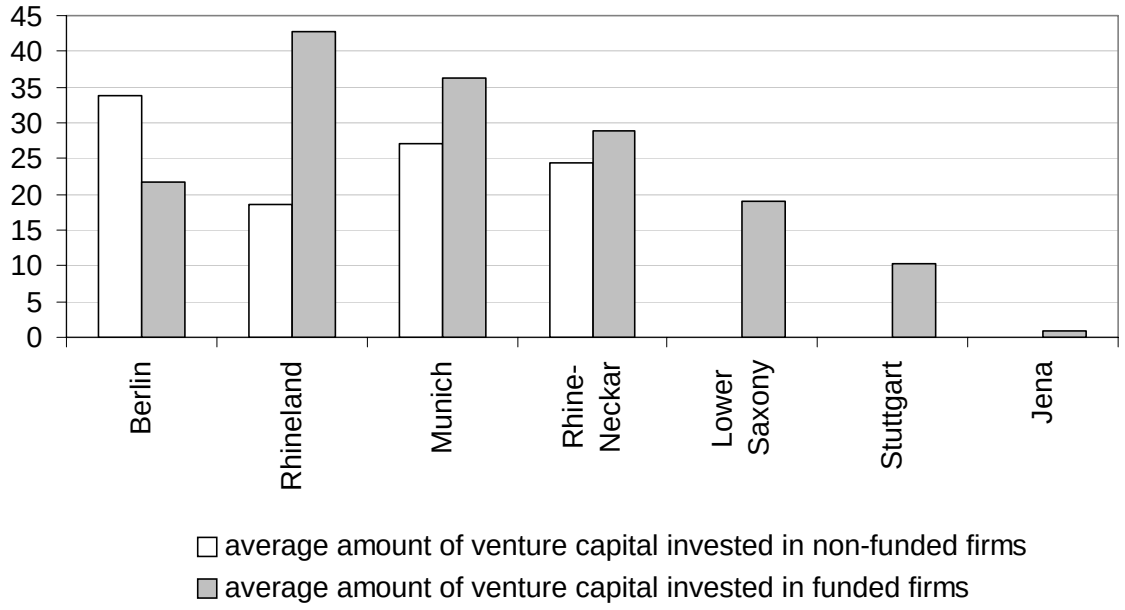
Figure 8: Venture capital investment in the BioRegio and BioProfile winner regions 1995-2005 (in Mio. €)



Source: Own calculations, Schudy 2006

The data set also allows us to compare the relative performance of the BioRegio-/BioProfile funded firms and the non-funded[19] firms within their respective regions (figure 9).

Figure 9: Average venture capital investment 1995 – 2005 in funded and non-funded firms (in million €)



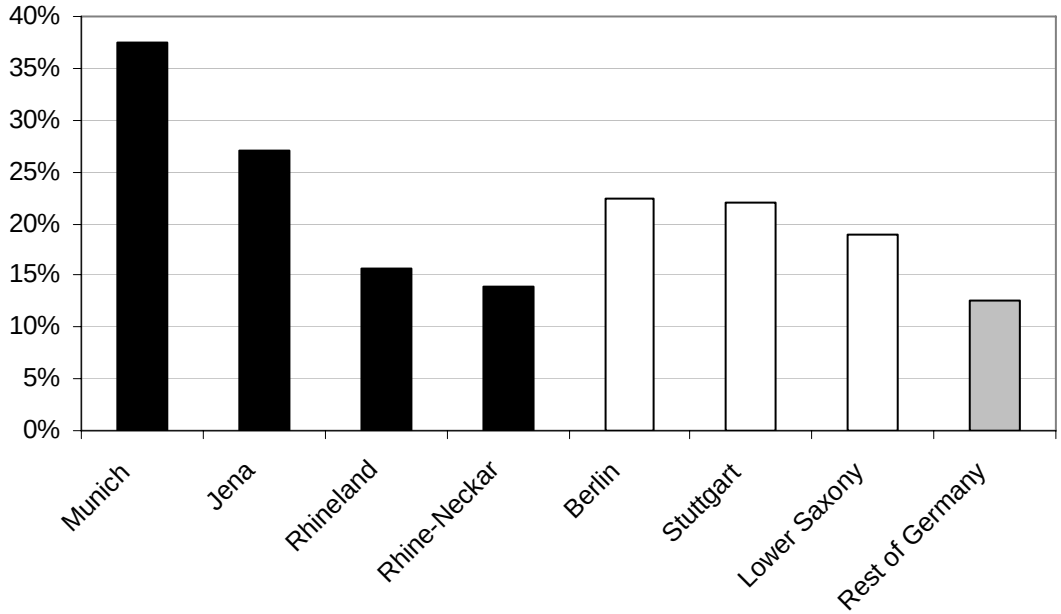
Source: Own calculations, Schudy 2006

[19] "Non-funded" in this context means not funded by BioRegio or BioProfile. It is quite possible that firms belonging to this category received funding from other governmental programs.

In six of the seven regions under investigation the firms that received BioRegio/BioProfile funding attracted on average more private capital than their non-funded counterparts. The better performance of funded firms is particularly apparent in the Rhineland, Lower Saxony and Stuttgart regions. The only outlier is the Berlin region where the non-funded firms performed better in terms of venture capital acquisition than those who received (BioProfile) funding. This puzzling result for Berlin can, however, easily be explained by the special nature of the region's "bioprofile". The BioProfile funding in the Berlin region is focussed on nutrigenomics which is – according to interviews with venture capital experts – currently less attractive for venture capital investment than other sub-disciplines of modern biotechnology.

We close this section with an interregional comparison of the shares of firms which are (at least partly) venture capital financed. Figure 10 underlines Munich's outstanding position in this respect with a 37 % share of venture capital financed biotech firms.

Figure 10: Share of venture capital financed biotech firms[20] by region



Source: Own calculations based on Rammer et.al. 2006

[20] Note that Rammer et al. (2006) only considered biotech firms that where founded between 1991 and 2004 and received venture capital until 2004.

More important, however, is the fact that the share of venture capital financed firms in all BioRegio winner regions (marked black in figure 10) and in all BioProfile winner regions (marked white in figure 10) is higher than in the rest of the country.
This suggest that firms located in the BioRegio and BioProfile winner regions have been more successful in attracting private equity than firms located elsewhere in Germany.

2.3 Research funding by the German Science Foundation (DFG)

While the acquisition of venture capital is an important indicator (and determinant) of the success of young biotech enterprises the acquisition of funding from the German Science Foundation (Deutsche Forschungsgemeinschaft, in short: DFG) is an important measure of a region's scientific excellence, in particular in basic research.
As can be seen from table 1 the average annual DFG funding in the fields of biotechnology and medicine[21] has strongly increased from roughly 266 million € in the 1991-1995 period to more than 381 million € in the period 2002-2004. The joint share of the BioRegio and BioProfile winner regions is about 50 % in all sub-periods which reflects these region's outstanding scientific position within the German research community, although their joint share has slightly decreased from 49.7 % in 1991-1995 to 47.8 % in the most recent period (i.e. 2002-2004).

Table 1: DFG funding in the area of biotechnology and medicine (different periods)

		2002-2004	1999-2001	1996-98	1991-95
Total DFG funding (annual average, in million €)		381,53	373,07	318,47	265,84
Share of **BioRegio-Winners**	Rhineland	10,4%	10,4%	10,0%	9,3%
	Munich	9,3%	10,0%	9,2%	10,5%
	Rhine-Neckar	5,3%	5,0%	5,3%	6,1%
	Jena	1,4%	1,3%	1,1%	0,7%
Share of BioProfile-Winners	Lower Saxony	7,7%	8,2%	8,6%	8,7%
	Berlin	8,5%	8,1%	8,8%	7,8%
	Stuttgart	5,3%	5,5%	6,4%	6,6%
Rest of Germany		52,2%	51,6%	50,6%	50,3%

Data Sources: DFG Förderranking, 2006 und 2003, DFG-Bewilligungen an Hochschulen 1996-98 und 1991-95, own calculations.

[21] There is, unfortunately, no separate biotech category within the DFG funding statistics.

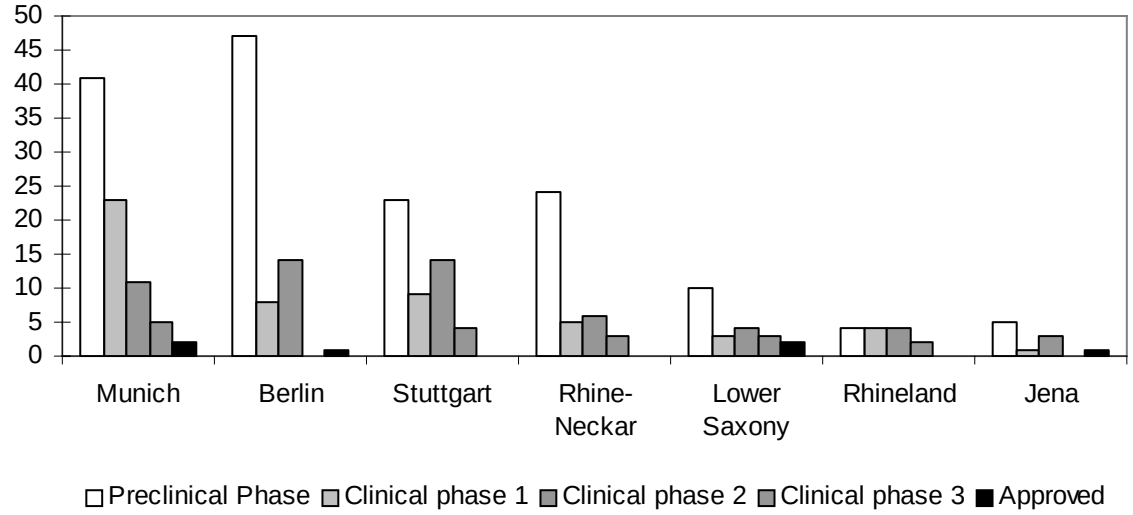
The development of the individual winner regions over time was, however, rather non-uniform: Of the larger regions, Rhineland and Berlin could raise their shares since the early 90's, whereas the shares of Munich, Rhine-Neckar, Lower Saxony and the Stuttgart area (STERN) tended to decrease. Most remarkable is, however, the rapid increase of DFG funding in the small Jena region which doubled it's (initially very moderate) share of 0.7 % to 1.4 % in 2002-2004. This increase was strongest in the 1996-1998 period, i.e. directly after Jena's surprising success in the BioRegio contest.

2.4 Drug candidates

The number of drug candidates in the preclinical and clinical (1-3) phases is a key indicator of both the technological capabilities and the commercial potential of core pharmaceutical biotech firms. According to Ernst and Young (2006) the number of drug candidates in Germany increased rapidly from 95 in 1999 to 285 in 2005.

We performed a survey among the regional biotech coordination agencies of the winner regions in 2006 that sheds some light on the geographical distribution of drug candidates in the various development steps (preclinical phase, clinical phases (1-3), already approved) in late 2005. As can be seen from figure 11 the Munich region is also leading in this respect with 82 drug candidates (thereof 2 already approved) in 2005. Munich is closely followed by the Berlin region with 70 drug candidates (1 product already approved) and the largest number of drug candidates in the preclinical phase of all German regions. These "big two" are followed with some distance by Stuttgart, Heidelberg (Rhine-Neckar) and Lower Saxony. Even the small region of Jena has 10 drug candidates (with 1 product already approved) whereas the performance of the large BioRegio winner region Rhineland is – in this respect – rather disappointing.

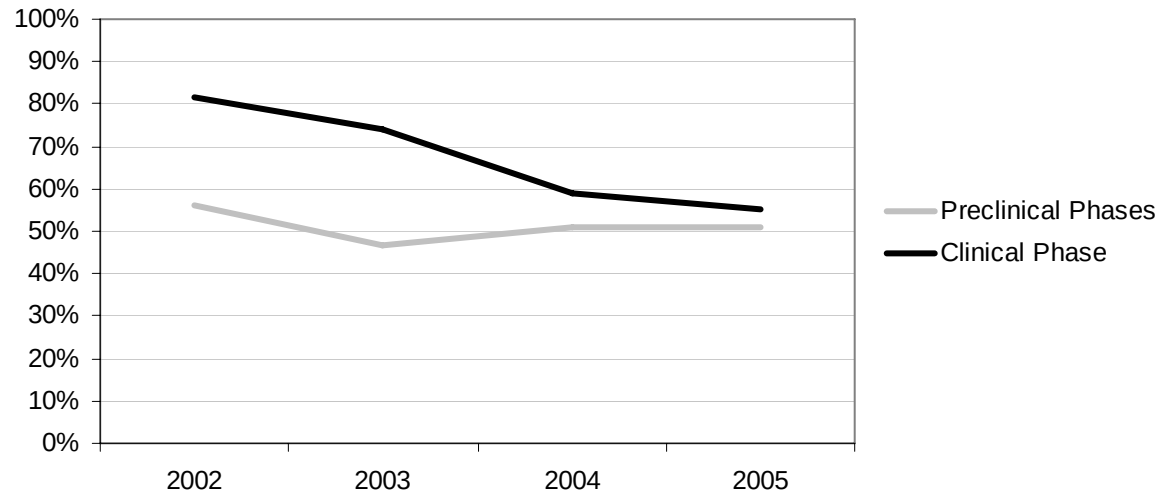
Figure 11: Number of drug candidates by region (2005)



Source: Own survey

The dominance of Munich and Berlin is also reflected by the fact that more than 50 % of all German drug candidates originate from these two regions (figure 12). The joint share of the "big two" has, however, been decreasing in recent years (slightly in the preclinical phase and more pronounced in the clinical phases) which means that other regions are catching up and that the geographical basis for the development and commercial launch of new drugs in Germany has become broader.

Figure 12: Joint Share of Munich and Berlin in German drug candidates



Data Sources: Own survey; Ernst & Young 2006

To sum up, more than a decade after the launch of BioRegio and more than six years after the launch of BioProfile the product pipeline of core pharmaceutical biotech firms in Germany is well-stocked. The geographical focus of new drug development and testing lies in the BioRegio winner regions Munich and Heidelberg (Rhine Neckar) and the BioProfile winner regions Berlin, Stuttgart and Lower Saxony.

It should be noted, however, that drug development only refers to the "red" (i.e. pharmaceutical) biotechnology and allows no assessment of product developments in other biotech sectors such as diagnostics, bio-analytics, platform technologies or "white" (industrial) biotechnology.

2.5 Summary

In a nutshell, the BioRegio winner regions displayed a superior performance with respect to nearly all of the usual (and available) performance measures, whereas the BioProfile winner regions – although promising in new drug development – had a rather moderate performance with respect to new firm formation, employment growth and the acquisition of venture capital.

Part of the different performance may be explained by the different operation time of the two programs. The BioProfile funding began to flow much later (in late 2000) than the BioRegio funding (mid 1997), such that BioRegio had more time to unfold positive impact than BioProfile. Even more important, however, BioRegio faced a much more favourable macroeconomic and financial environment than BioProfile: The BioRegio contest coincided with (and arguably accelerated) the technology and stock market boom of the late 1990's, whereas the start of the BioProfile funding coincided with the stock market crash and the burst of the technology bubble in Germany.

Another part of the difference may be explained by differences in the conceptual approach. The philosophy behind BioRegio was strengthening the strongest biotech regions in Germany without imposing thematic restrictions while the BioProfile funding was not only limited in a regional but also in a thematic respect. As a consequence, the winning BioProfiles had problems in bringing together a critical mass of innovative firms dedicated to their specific "BioProfile" and they proved relatively unattractive for venture capitalists. The latter is true for tissue engineering in the Stuttgart region and, in particular, for nutrigenomics in the Berlin region.

3. Assessment of BioRegio and BioProfile by researchers and entrepreneurs

In 2006 the Kiel Institute for the World Economy performed a survey among 1032 German biotech firms and research institutes which had their main focus on biotechnology.[22] Included were all dedicated biotech firms in Germany according to the BioCom enterprise list and all biotech-related research institutes in the seven winner regions of BioRegio and BioProfile and in three control regions (Hamburg, Freiburg and BioConValley).[23] The subject matter of this survey was the international competitiveness of German biotechnology and the role of public funding with special emphasis on the BioRegio and BioProfile instruments. Tables 2 - 6 illustrate some of the most important results with respect to the policy instruments under consideration here.

3.1 The importance of regional clustering

The BioRegio and BioProfile instruments are both based on the assumption that the regional environment is of crucial importance for the generation and commercialisation of biotech innovation, and that technology policy in the field of biotech should therefore address the region as a whole rather than single firms or industries. The pertinent literature in this field does in particular emphasize the role of regional clustering as a means of securing innovativeness and competitiveness, especially for young and small firms in knowledge intensive industries such as biotech (see, for instance, Porter and Sölvell 1998, Cooke 2002, Ketels 2004).

Notwithstanding the predominantly positive assessment of regional clustering in the literature it is important to know what the actors who actually innovate and bring innovation to market – i.e. the biotech firms and research institutes – think about the role of the regional environment for biotech innovation and whether they think that there is scope for improvement in their respective region.

As can be seen from table 2 a large majority of firms and research institutes in Germany confirms that the regional environment is of crucial importance for the generation and commercialisation of biotech innovation[24] and that it is in particular the small and medium

[22] The kind assistance of BioCom AG, PTJ (Projektträger Jülich) and the German Federal Research Ministry (BMBF) in performing the survey is gratefully acknowledged.

[23] The rate of return was 49.5 % (i.e. 511 of the 1032 questionnaires were returned).

[24] 48 % of all respondents consider this definitely true and 40 % state that this is at least partly true. Only 12 % deny that the regional environment plays a crucial role.

sized firms (which form a major target group of both BioRegio and BioProfile) that benefit from the location within an innovative cluster. The rate of consent in the control group of firms and research institutes that did receive neither BioRegio nor BioProfile funding is similarly high which indicates that this assessment is hardly dependent on the fact whether respondents directly benefited from BioRegio/BioProfile or not.

Table 2: Survey Results – Regional Clustering and Biotech Innovation

	all respondents			respondents that didn't receive funding		
answers (in %):	(a)	(b)	(c)	(a)	(b)	(c)
The regional environment is of crucial importance for the generation and commercialisation of biotech innovation	48	40	12	46	41	13
Small and medium-sized firms are the main beneficiaries of regional clustering	47	40	13	43	44	13
My firm/ research institute has suffered from a lack of regional cooperation/networking in the past	29	40	31	29	39	32

a = definitely true, b = partly true, c = not true

Source: Own survey.

Furthermore, a large percentage of all respondents declare that they have suffered from insufficient regional cooperation or partnering opportunities in the past (table 2, row 3), which indicates that there is ample scope for the improvement of regional biotech innovation systems in Germany.

Taking this evidence together we conclude that instruments of region-oriented technology policy (such as BioRegio and BioProfile) appear in principle suitable to improve the innovativeness and competitiveness of young biotech firms and research institutes in Germany. In other words: BioRegio and BioProfile pass the test for *strategic efficiency.* [25]

3.2 Have BioRegio and BioProfile improved networking and cooperation?

The principal suitability of a policy instrument is one thing, its actual performance is something quite different. We therefore wanted to know whether BioRegio and BioProfile have initiated cooperation projects that would otherwise not have been carried out, whether

[25] See Kuhlmann and Holland (1995) for an in-depth discussion of the concept of strategic efficiency.

these cooperations are viewed as successful by the German biotech community and whether they will have a lasting impact (i.e. will be continued after the operation time of the BioRegio and BioProfile instruments).

The answers of our respondents are affirmative with respect to all three questions (table 3): 90% of all respondents agree – at least partly – with the statement that BioRegio and BioProfile have triggered off cooperation projects that would otherwise not have come about; 91% view these cooperations as successful and 94 % expect these cooperation projects to have a lasting impact.

The respondents from the control group (those who didn't receive funding) are a bit more critical in all three respects, but in principal their assessment is also quite positive.

Going further into detail we found that the respondents from BioProfile winner regions are a bit more positive than the respondents from BioRegio winner regions and that firm representatives are a bit more sceptical than representatives of research institutes. The deviances in the results for the different subgroups are rather small, however.[26]

Table 3: Survey Results – The impact of BRC and BRP on cooperation and networking in the regions

	all respondents			respondents that didn't receive funding		
answers (in %):	(a)	(b)	(c)	(a)	(b)	(c)
BRC and BRP have initiated cooperation projects that otherwise would not have come about	45	45	10	38	51	11
Cooperation within the regional networks has been successful	25	66	9	16	73	11
The cooperation projects triggered off by BRC and BRP will be continued after the end of these programs	21	73	6	15	79	6

a = definitely true, b = partly true, c = not true

Source: Own survey.

It can thus be concluded that there is a high rate of consent throughout the German biotech community that BioRegio and BioProfile have triggered off cooperation projects that otherwise would not have come about and that these cooperation projects are successful and have a lasting impact.

[26] That's why we decided not to present them explicitly in the paper. They are, however, available from the authors upon request.

3.3 More general impacts

What are the most important strengths of BioRegio and BioProfile and what are potential weaknesses? Have BioRegio and BioProfile boosted the catch up process of German commercial biotech with its most important competitors? Tables 4-6 show how German biotech firms and research institutes view these issues.

The most important advantages of the BioRegio and BioProfile instruments appear to be the strengthening of biotech research in Germany, the creation of an innovation-prone regional environment in the bio-regions and the improvement of the international reputation of Germany as a biotech location (table 4). This is evidenced by very high approval rates, even among those who didn't receive funding.

Table 4: Survey Results – Strengths of BioRegio and BioProfile

	all respondents			respondents that didn't receive funding		
answers:	(a)	(b)	(c)	(a)	(b)	(c)
BRC and BRP further ...						
biotech research in Germany	53	40	7	43	48	10
the evolution of an innovation prone regional environment	50	42	8	43	47	10
the international reputation of Germany as a biotech location	39	43	18	33	45	21
the faster diffusion of knowledge within the regions	28	51	21	23	53	24
the development of competitive biotech clusters	26	50	24	23	50	28
the image of biotech in the German public	25	43	32	23	45	32

a = definitely true, b = partly true, c = not true

Source: Own survey.

The most important shortcomings of BioRegio and BioProfile are – according to the actors' view – that they discriminate innovative firms and research institutes which are located outside the winner regions of the contests and that they have induced the formation of too many new firms, part of which appear unable to survive in the longer run (table 5). The latter

point is particularly emphasized by respondents from the control group (i.e. those who didn't receive funding).

Table 5: Survey Results – Shortcomings of BioRegio and BioProfile

	all respondents			respondents that didn't receive funding		
answers (in %):	(a)	(b)	(c)	(a)	(b)	(c)
Discrimination of firms and research institutes located outside the winner regions	35	49	16	41	46	13
Funding has led to the formation of too many new firms, part of which are unable to survive	26	58	16	30	61	9
Higher bureaucratic effort than other programs of comparable size	23	41	36	26	42	32
Lack of excellent projects in the winner regions	33	55	12	35	56	9

a = definitely true, b = partly true, c = not true

Source: Own survey.

Have BioRegio and BioProfile boosted the catch up process of the German biotech sector as a whole? 91 % of all respondents do – at least partly – confirm this (table 6). The approval rate is nearly 100% among those who received funding and a remarkable 88 % of those who didn't receive funding from these programs. Again, representatives of research institutes were a bit more positive (consensus rate 94%) than firm representatives (88 %).[27]

Table 6: Survey Results – General assessment of BioRegio and BioProfile

	all respondents			respondents that didn't receive funding		
answers (in %):	(a)	(b)	(c)	(a)	(b)	(c)
Have BRC and BPC boosted the catch up process of German biotech?	41	50	9	33	55	12

a = definitely true, b = partly true, c = not true

Source: Own survey.

In a nutshell, we find that the overall assessment of the BioRegio and BioProfile instruments by the German biotech community is quite positive, even in the control group of firms and research institutes which did not receive funding from these programs.

[27] The results subdivided by firms and research institutes are available from the authors upon request.

4. Performance of the German biotech industry relative to its major competitors

4.1 The number 1 in Europe?

The ambitious long-run objective of the BioRegio contest (revived by BioProfile) was to make Germany's lagging biotech sector the number 1 in Europe, and there are some indications that one has come quite close to that goal. Germany is by now host to the largest number of dedicated biotech firms in Europe (Critical I Ltd. 2006, Ernst & Young 2007) and has the by far largest share of all European countries in biotech patents filed at the European Patent Office (EU Commission 2007). In 2005, the amount of venture capital invested in German biotech companies (approximately 290 million Euros) for the first time exceeded the amount of venture capital invested in British companies (approximately 250 million Euros; Ernst &Young 2007). However, this advance could not be sustained in 2006: Venture capital investment in Germany dropped by 35 % (to 213 Million Euro), whereas venture capital investment in British biotech companies remained roughly constant in 2006 (Ernst & Young 2007). The probably most encouraging news with respect to commercial biotech in Germany comes, however, from the product development front: The overall pipeline (public and private firms) in Germany consisted of 324 compounds in development in 2006 (Ernst & Young 2007). With pipelines that are deep and more mature (124 products are already in the phase of clinical examination) German biotech firms appear to be well poised to bring innovative new products to market.

These positive developments should, however, not obstruct the view on a fundamental weakness of the German biotech industry: There are only 17 publicly listed German biotech firms, compared to 42 publicly listed British firms (biotechnologie.de 2007). Although Germany has the largest number of DBFs in Europe the large majority of them are micro or small firms that generate (yet) very low revenues and face an insecure future. The UK, by contrast, has fewer but stronger firms in terms of employment, revenues and R&D investment (Critical I 2006). The latter is also reflected by the 2007 EU Industrial R&D scoreboard, which shows that among the top 50 European biotech companies with respect to R&D investment there are 22 British but only 5 German firms (EU commission 2007b).

In a nutshell, there is currently no clear-cut answer to the question whether German biotechnology is actually the number 1 in European biotechnology (i.e. whether the ambitious long-run objective of the BioRegio contest has been reached) or not. There is, however, little

doubt that German biotech has rapidly caught up with its main competitors in Europe since the mid-90's and that BioRegio and BioProfile played an important role in this context.

4.2 The Global Perspective

For an overall assessment of the competitiveness of commercial biotechnology in Germany – and the success of German biotech promotion policy – it is, however, necessary to look beyond European borders. Commercial biotech in Germany (as well as commercial biotech in Europe as a whole) is still lagging far behind North American biotech. In this context, two facts appear to be of particular importance: The first is the westward drift of parts of the European biotech scene towards the US, and the other is the poor growth performance of European biotech companies relative to their US competitors.

In recent years several more mature European firms have been acquired by better funded US firms, whereas there has been little reciprocal business in the other direction. Moreover, a large number of (particularly British) firms have moved large parts of their business to the United States.[28] The process of outsourcing commercialisation to US entrepreneurs is referred to as "conveyor belt" method of innovation or simply as "decapitation" (Cooke 2006). *Decapitation* means retaining R&D capabilities in Europe while accessing commercialisation capabilities in the US (Ward 2005). In some cases the driving force behind decapitation is access to product markets, to US management and US regulators; in other cases it is the access to capital (Critical I 2006: 8). Phil Cooke has nicely summarized the economic rationale behind this phenomenon, stating that "Europe … has exploration knowledge capabilities", whereas "… the most highly developed exploitation knowledge capabilities are concentrated in US bioscience megacenters" (Cooke 2006: 35). This spatial asymmetry of knowledge capabilities explains why it is attractive for private companies to perform R&D in Europe and to outsource commercialisation to the US. At the same time, however, it raises some critical questions for policy makers in the UK, Germany and other European countries. Decapitation in the above-mentioned sense means that intellectual value added is created in Europe, whereas the corresponding commercial value added is created and appropriated in the US. Given that large amounts of European taxpayers' money have been expended on biotech research and start-up promotion, such a division of labor is bad news for European policy makers (and taxpayers), since the European economies are deprived of business opportunities,

[28] Among the most prominent examples are firms like Cyclacel, BioVex, Solexa, Zeneus, Lorantis or Microscience. See Ward (2005) and Cooke (2006) for further details.

revenues, employment and – in the longer run – investment opportunities (which include R&D investment).

A second – and clearly related – problem is the poor growth performance of European companies as compared to US companies. It is well known that European biotech companies are on average smaller, invest less in R&D, employ less people and generate less revenue than US companies. This gap is often explained by the fact that European firms are on average younger than US firms, since Europe entered the field of commercial biotechnology later than the US. Such an interpretation that blames European underperformance solely on the youthfulness of Europe's commercial biotech sector is comfortable as it suggests that European commercial biotechnology is likely to catch up with the US as soon as it has reached a certain maturity. It is, however, at odds with the facts. A recent study commissioned by Europa-Bio that controls for differences in firm age finds that in nearly every age group the average US biotech company grows faster – and is, accordingly, larger – than the average European company (Critical I Ltd. 2006). This is illustrated in table 7.

Table 7: The typical European and the typical US biotech company at different age groups

	typical European company			**typical US company**		
Age (years)	**3-5**	**6-10**	**11-15**	**3-5**	**6-10**	**11-15**
Employees	17	28	41	28	49	77
Revenues (in €m)	€1.01	€2.6	€6.1	€1.5	€4.7	€7.6
R&D personnel	11	17	18	18	27	47
R&D budget (in €m)	€1.7	€3.3	€4.0	€5.2	€8.7	€13.3

Source: Critical I Ltd. (2006)

The major obstacle to biotech firm growth in Europe seems to be linked with getting adequate finance which enables European companies to take charge of product development themselves. "Instead, they seem forced to licence out their invention to e.g. a large pharmaceutical company, merge with a bigger company, or move to the United States." (EU-Commission 2007: 19) The consequence is that the gap between the US and Europe becomes wider and wider and Europe gets hardly any self-sustainable, larger biotech companies.

5. Conclusion

BioRegio and BioProfile are prototypes of a new kind of technology policy aiming at the exploitation of regional innovation and growth potential through clustering. It has been shown that there are many indications that these innovative, region-oriented funding schemes are appreciated by firms and research institutes (by those who received funding, but also by those who didn't) and that they have contributed to the catch up process of German commercial biotech with its European competitors.
However, the discussion in the previous section has (hopefully) also made clear that the scope for national technology policy in a globalised world gets more and more limited. Public policy programs like BioRegio and BioProfile can foster research and development, stimulate academic entrepreneurship and create an atmosphere of departure. They can, however, not guarantee commercial success and they cannot prevent that firms that have received government funding as soon as they become profitable leave their homecountry and follow the pull of the American market.

Whether the BioRegio and BioProfile funding by the German federal governments will pay in terms on long run growth, employment and prosperity is at best unclear at the moment and has to be seen in the years to come. What is more evident is the conclusion that to grow a self-sustainable European biotech industry it takes more than isolated policy action by national governments (how clever and successful single measures might be in particular cases). European biotech companies suffer from excessive, uncoordinated regulation, fragmented markets (for output *and* finance) and insufficient access to risk finance. These problems cannot be solved single-handedly by national governments but only by joint effort at the European level.
The EU Commission has clearly recognized this and formulated an ambitious life sciences and biotechnology strategy for Europe in 2002. The progress made since then is, however, rather unsatisfactory. The European markets for life sciences and biotech are still highly fragmented, the capital base of European biotech companies is still weak by international standards and Europe is still far away from a coherent legislation and regulation with respect to the life sciences and, in particular, biotechnology.

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Appendix

Table A1 : German Bioregions in 2006

Name	major cities included	BioRegio winner	BioProfile winner
BioConValley	Rostock, Greifswald		
BioIndustry	Dortmund, Essen		
BioM	München	**x**	
BioMedTec Franken	Erlangen-Nürnberg, Würzburg, Bayreuth		
BioPark	Regensburg		
BioRegioN	Hannover, Göttingen, Braunschweig		**x**
BioSaxony	Dresden, Leipzig		
BioTOP	Berlin, Potsdam		**x**
BMD (BIO Mitteldeutschland)	Halle, Magdeburg		
Bremen	Bremen, Bremerhaven		
FFM (BioRegion Frankfurt)	Frankfurt, Wiesbaden		
Freiburg (BioValley)	Freiburg (Basel, Strasbourg)		
Jena	Jena	**x**	
Münster	Münster		
NanoBioNet	Saarbrücken		
Nord	Hamburg, Kiel, Lübeck		
Rheinland (River)	Düsseldorf, Köln, Aachen, Wuppertal	**x**	
Rhein-Neckar-Dreieck	Heidelberg, Mannheim, Ludwigshafen	**x**	
STERN	Stuttgart, Tübingen, Esslingen, Reutlingen		**x**
Ulm	Ulm		
Small Bioregios (BioLago, Marburg, Ostwestfalen-Lippe)	Konstanz, Marburg, Bielefeld		
All other (non-organized) biotech locations			

Sources: According to Rammer et al. (2006) and biotechnologie.de.