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Institutional embeddedness and the strategic leeway of actors: the case of the German therapeutical biotech industry

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This article aims at examining the strategic leeway of firms pursuing business strategies incompatible with the dominant institutional environment in a given market economy. In order to evaluate this question, we focus on the therapeutic biotech industry and draw a German–British comparison. Proponents of the varieties-of-capitalism (VoC) approach assume that German firms underperform in this industrial sector in comparison to British firms due to the institutional framework in which German firms operate; this framework is assumed to provide them with hardly any strategic latitude. The VoC approach is challenged by two alternative perspectives, in both of which it is believed that firms can have a high level of strategic leeway; in the first approach this is possible due to *institutional heterogeneity* within national market economies; and in the second approach, the above can be seen as the result of economic *internationalization*. Our empirical findings show that British firms are indeed more competitive in the therapeutical biotech industry, but only to a limited extent. German firms perform better than projected by the VoC approach because they operate in an institutionally heterogeneous environment and due to the impact of internationalization. Thus, we argue for the integration of these three perspectives in one explanatory approach.

Keywords: varieties of capitalism, international competition, Germany, United Kingdom, institutional change, labour market institutions

JEL classification: P52 comparative studies of particular economies, P48 political economy, legal institutions, property rights, M13 new firms, start-ups

1. Introduction

The aim of this article is to evaluate the varieties-of-capitalism (VoC) approach with regard to its notion of the comparative institutional advantage (CIA) and

to compare it to competing theoretical perspectives. A key assumption of this approach is that firms focus on innovation strategies that are supported by the dominant national institutional framework. A corollary assumption of the CIA approach is that firms which pursue strategies that are not supported by this institutional framework—i.e. the framework does not support these strategies by providing the required input factors—underperform because of their comparative institutional disadvantage and therefore have hardly any strategic leeway in a challenging dynamic market such as the therapeutic biotech industry. In this article, we follow the conception of institutions implicitly used by Hall and Soskice (2001), the key proponents of the VoC approach: institutions are conceived as rules that actors follow for material reasons. Relevant to this analysis are institutions, or rules, that have an impact on the generation of and access to input factors, which are required for specific innovation strategies. However, the connection between rules and the provision of input factors might not be straightforward; constraining rules might also be ‘beneficial’—in the words of Streeck (1997)—to the generation of input factors.

The notion of the CIA is questioned by two theoretical perspectives: first, scholars such as Allen (2004) and Schneiberg (2007) have questioned whether the institutional framework of market economies is as homogeneous as assumed by proponents of the VoC approach (see also Crouch, 2005). They claim that national market economies are characterized by institutional heterogeneity, which means that not all sectors are affected by certain institutions in the same way, and that apart from the dominant institutional set, institutions might exist which follow different logics. This strand of literature assumes that as a result of this kind of institutional heterogeneity, different models of industry organization are possible within market economies. Second, proponents of internationalization argue that actors are able to offset detrimental institutions by tapping into foreign market economies (Black and Gilson, 1998; Ahrweiler *et al.*, 2006). Similarly, Deeg and Jackson (2007) regard institutional heterogeneity and transnationalization as two key challenges to the VoC approach. Hence, these challengers to the VoC approach assume that firms which pursue strategies that are incompatible with the dominant institutional framework are potentially able to compete by relying on input factors provided by other institutions, be they domestic or part of foreign business systems, and therefore have at least some strategic leeway.

To evaluate the notion of the CIA in relation to innovation strategies, we selected the pharmaceutical biotechnology industry and more specifically the development of therapeutics, along with Germany as the market economy, since, according to proponents of comparative capitalism, the characteristics of this industry and the institutional framework of Germany do not fit together. Whereas the dominant institutions of the German economy are seen to be conducive to incremental innovations and detrimental to radical ones, this segment of

the biotech industry is characterized by radical innovations. The development of biotherapeutics is radically innovative because the technical risks are extremely high and most therapeutics fail, the financial costs are tremendous and in the range of several hundred million US dollars, and the time to market is very long, at least ten years (Casper, 2000; Casper and Whitley, 2004). Interestingly, in the mid-1990s, a biotech sector emerged in Germany, and in recent years many biotech firms have focused on the development of therapeutics. Hence, this case suits well the overall task of this article. However, in order to assess the performance of German biotech firms in the pharmaceutical sector and the extent to which it is supported by the institutional framework, we need to employ a comparison. We opted for the UK since this market economy is supposed to have a CIA in radically innovative industries according to proponents of the comparative capitalism literature (Hall and Soskice, 2001; Amable, 2003; Casper and Whitley, 2004).

The goal of this article is to raise the question of whether (1) the assumption of a comparative institutional disadvantage for firms which pursue innovation strategies that are incompatible with the dominant institutions in a given market economy is valid as argued by proponents of the VoC approach; or, alternatively, (2) if firms have strategic leeway, and the comparative institutional disadvantage is offset, because institutions other than the dominant set of their home country—be they domestic or part of foreign market economies—provide them with the required input factors, as is argued by proponents of institutional heterogeneity and internationalization. The case of the German therapeutic biotech industry shows that all of the above-mentioned theoretical perspectives are corroborated to a certain extent and thus should be integrated. British biotech firms in the therapeutic segment are more competitive than their German counterparts and are embedded in an institutional framework which is more conducive to their success. However, German firms are only slightly behind in their level of competitiveness. This is due to the fact that (1) dominant institutions do not affect all sectors in the same way, (2) new institutions have become established alongside the dominant set and (3) firms succeed in tapping into Anglo-Saxon market economies. Thereby, German firms which pursue radical innovation strategies are able to rely on institutional support—even though not from the dominant institutional framework of the home country—and to attract the required input factors. Hence, their level of strategic leeway is much higher than the VoC approach would predict.

The article is structured as follows: in Section 2, the competing literatures of VoC, institutional heterogeneity and internationalization are outlined. The research design is delineated in Section 3. To evaluate the propositions of the theoretical perspectives, we used a research design that relied on a triangulation of data. Data collection involved semi-structured interviews, publicly available statistics, information on company websites, biotech reports and journals. The

focus of the empirical analysis is on Germany, since this is the theoretically controversial case and since the UK is used rather as a control. The field research took place in 2003–2004. In addition, the empirical material was updated in 2007. Hence, the research design comprises not only a comparative dimension but also a longitudinal one. Section 4 describes the German–British comparison in three subsections that analyse the institutional configurations in which German and British biotech companies are embedded. In this respect, we also examine whether the dominant institutional framework of Germany, such as banks, supports radical innovation strategies. The institutional analysis is focused on the financial system, technology policy and the labour market. In the fifth and final section, we outline to what extent the propositions of each theoretical approach have been corroborated, draw theoretical conclusions and seek to integrate the three theoretical perspectives.

2. Alternative theoretical frameworks and propositions regarding the German and British biotech industries

2.1 *The VoC approach*

A core concept of the VoC approach is that of the CIA. According to this concept, institutional structures differ between market economies and support some kinds of economic activities, whereas they impede others. A corollary assumption is that firms therefore focus on innovation strategies that are supported by the institutional framework. If they act otherwise, they underperform in comparison to firms in other market economies that are embedded in more supportive institutional structures because they are less able to attract the required input factors for these strategies (Hall and Soskice, 2001). Thus, the level of strategic leeway of these firms is low.

Hall and Soskice (2001) do not always use the term *institution* in a consistent way. On the one hand, they define institutions as ‘a set of rules, formal or informal, that actors generally follow, whether for normative, cognitive, or material reasons’ (Hall and Soskice, 2001, p. 9). However, in their empirical analysis of market economies, they focus on the regulative pillar of institutions (Scott, 2008) or on rules that actors follow for material reasons; in this article, we follow the latter understanding of the term *institution*. In their conception, actors in specific market economies support institutional structures, such as German managers supporting co-determination, because they think that it best serves their material interest, and not for normative reasons or because they cannot conceive of alternatives. The link between institutions, or rules, and their support of innovation strategies does not appear in the form of allowing or restricting innovation strategies, but rather in the form of providing the required input

factors for these strategies. The links are sometimes rather indirect; the constraining character of some rules might also have a positive effect on the generation of input factors in some cases. Furthermore, proponents of the VoC approach assume that institutions do not support the generation of input factors independently, but rather that their effect on innovations is interrelated. Complementarities arise if the institutions in specific market economies follow a similar logic, which means that they reinforce each other. In this respect, the VoC approach differs from the approach of National Innovation Systems (Nelson and Rosenberg, 1993), in which interrelations between institutions are largely ignored.

More specifically, proponents of this approach distinguish between two types of market economies: liberal market economies (LMEs), as in the USA and Great Britain, and co-ordinated market economies (CMEs), as in Germany. In LMEs, institutions promote short-term relations and co-ordination based on market mechanisms. In contrast, in CMEs, institutions promote long-term relations and co-ordination based on non-market mechanisms. Proponents of the VoC approach claim that each type has different strengths and weaknesses that virtually mirror each other and that originate from their institutional setting. In LMEs, companies in industries dominated by radical innovations thrive as these industries require great flexibility, whereas those in industries dominated by incremental innovations underperform as they cannot freely develop firm-specific skills. In CMEs, companies in industries dominated by incremental innovations thrive as they are better able to develop firm-specific skills, whereas those in industries dominated by radical innovations underperform as non-market institutions hinder their flexibility. Proponents of the VoC approach also doubt that these different types of market economies will converge in the wake of globalization (Hall and Soskice, 2001).

Although Hall and Soskice assert that companies in CMEs have a comparative disadvantage in radically innovative industries such as biotechnology, a biotech boom occurred in Germany in the second half of the 1990s, 15 years after the emergence of the biotech industry in Britain. The delayed start of the German biotech industry was mainly caused by a hostile regulatory environment, which improved significantly in 1993. In addition, very important for jump-starting the sector were government initiatives promoting activities in this sector (Adelberger, 2000).

Casper and Whitley (2004) compared the competitiveness of British and German biotech firms in the therapeutics sector and concluded that the basic idea of the VoC approach still holds true, i.e. that firms in LMEs have an institutional advantage in sectors characterized by radical innovations compared with firms in CMEs, and the former therefore outperform the latter. They defined competitiveness as the number of therapeutics that companies have in clinical trials in their respective countries. In brief, in clinical trials, therapeutics

Table 1 Therapeutic compounds pipelines of German and British biotech companies

	Pre-clinical	Phase I	Phase II	Phase III	Total
UK (public companies) ^a	32	37	46	13	128
GER (public companies) ^a	2	2	1	1	6
GER (45 university spin-offs) ^b	19	10	2	1	32

Source: Casper and Whitley (2004, Table 5, p. 100); original sources: ^aErnst & Young, European Life Sciences (2001) and ^bCasper and Murray (2003).

are tested for safety and efficacy in human subjects. Clinical trials are subdivided into three stages: the number of participants increases exponentially from phases I–III, as do the related costs (Robbins-Roth, 2001). Casper and Whitley (2004) demonstrated that British biotech companies were clearly more competitive (Table 1). This was most notable in stage II and III clinical trials, which involve the highest financial risks: the British biotech companies outperformed the German companies at a ratio of 59 to 5 (Casper and Whitley, 2004).

Casper and Whitley (2004) interpret the underperformance of the German biotech firms as a mismatch between the radically innovative characteristics of this segment and the institutional environment. Firms are in need of flexible labour markets and investors with industry expertise who are willing to take risks. The long time horizon of product development in the biotech industry seems to be at odds with the short-term relations in LMEs. However, this long-term product development is subdivided into many milestones. Thus, venture capitalists and shareholders are able to evaluate success on a short-term basis and to sell their stake prior to the introduction of the product into the market. In Germany, on the other hand, there is a compatibility issue between the domestic venture-capital industry and the therapeutics sector, since the former emerged most notably due to government funding and hardly has any investors with industry expertise. In addition, German labour laws, works councils and trade unions, along with strong employee representation on the supervisory board, make dismissals very difficult. Finally, the long-term job protection of managers in the pharmaceuticals industry gives them little incentive to switch to a biotech start-up, since in cases of bankruptcy they would face unemployment. In contrast, British biotech firms are better able to cope with the high risks in the therapeutics sector due to the existence of an experienced private venture-capital industry and deregulated labour markets (Casper, 2000; Casper and Kettler, 2001; Casper and Whitley, 2004). Hence, from the perspective of the VoC approach, the first proposition can be formulated as follows:

- (1) German biotech firms developing therapeutics underperform in comparison to their British counterparts because the national institutional framework is detrimental to this innovation strategy.

2.2 *The institutional heterogeneity approach*

Proponents of the VoC approach assume that the various types of market economies follow a single logic of economic action. This view has been challenged by scholars such as Schneiberg (2007) and Allen (2004), who claim that national market economies are characterized by a mix of different types of institutions and that institutions do not affect all sectors in the same way. Due to this fact, we term this body of literature the institutional heterogeneity approach. More specifically, different forms of institutional heterogeneity can be distinguished: first, Schneiberg (2007) shows, for the example of the American infrastructure industries, that institutional elements of a co-ordinated market order remained in place despite the overall victory of a liberal market order and allowed actors to diverge in their economic behaviour and strategies from the dominant model. With regard to the German CME, there might be niches where institutions of a liberal market order have survived and are now providing a platform for biotech firms developing therapeutics. Second, Allen (2004) argues that not all national institutions spread uniformly across industries. Third, scholars such as Streeck and Thelen (2005) assume that market-based institutions can be established in a CME; however, they expect that in the longer term, these new institutions—if they function effectively—will result in differential growth and gradually replace the existing institutional setting. In this respect, they are placed between the VoC approach and the institutional heterogeneity approach. These three aspects of institutional heterogeneity increase the strategic leeway of firms, that is, their ability to pursue strategies that are not supported by the dominant institutional framework. If we transfer this notion of institutional heterogeneity to the German market economy and its biotech industry, the second proposition can be formulated as follows:

- (2) German biotech firms which develop therapeutics are equally as competitive as British biotech firms due to institutional heterogeneity; apart from the dominant institutional framework of the German CME, a more liberal institutional setting exists which is conducive to this innovation strategy.

2.3 *The internationalization approach*

The internationalization approach rests on the assumption that companies are able to offset detrimental institutional settings by tapping into foreign business systems. An institution that has received particular attention in this respect is the market for venture capital. This industry has become increasingly

international in recent years and is no longer confined to the USA (Lerner and Gompers, 2001; Lerner, 2002). The following subsection consists of two parts: first, we refer to Black and Gilson (1998), who suggested that young high-tech firms located in a country without a supportive infrastructure would 'piggyback' on foreign institutions; in the medium-term, this would lead to the establishment of a local institutional setting supporting these types of firms. In the second part, we refer to Ahrweiler *et al.* (2006), who argue that German biotech firms pursuing radical innovations are equally as competitive as their British counterparts. They consider the German institutional framework to be detrimental to biotech firms that pursue radical innovations; however, they argue that these biotech firms are able to offset the disadvantageous institutional setting by attracting international venture capital.

Black and Gilson (1998) analyse the preconditions of a vibrant venture-capital market for young high-tech companies and come to the conclusion that a well-functioning stock market and the possibility of an initial public offering (IPO) as an exit option for venture capitalists is indispensable. In short, several interrelated institutions must be established simultaneously in order to create a strong market for venture capital. Actors in national economies with a bank-centred system, therefore, face a chicken-and-egg problem: a venture-capital market necessitates a stock-market segment for young high-tech companies, but such a segment is in need of a steady supply of deals and entrepreneurs which, in turn, depends on a venture-capital market. Black and Gilson (1998) assume that it is extremely difficult and costly to simultaneously create this interrelated set of institutions for actors in a bank-based system; instead, they recommend accessing the institutions of foreign countries with stock market-centred systems. They regard Israel as a prime example of such a strategy (see also Avnimelech and Teubal, 2006). In Germany, young high-tech companies and their investors could follow this successful example by attracting foreign investors. This would create potential for the emergence of local institutions supporting young high-tech companies (Black and Gilson, 1998).

The contribution of Ahrweiler *et al.* (2006) dovetails nicely with the contribution of Black and Gilson (1998), as they also emphasize the opportunities of high-tech firms to offset the lacking supportive infrastructure in their home country by means of internationalization. Empirically, Ahrweiler *et al.* (2006) compare the biopharmaceutical sectors of Germany and Great Britain in terms of their industrial structure and performance. In their comparison, they discern striking commonalities between the biopharmaceutical sectors of the two countries. The majority of German as well as British biotech firms are engaged in the development of therapeutics. Additionally, they consider the innovative ability of firms in both countries in terms of the number of therapeutics in trials as relatively similar (Table 2).

Table 2 Therapeutic compounds pipelines of all German and British biotech companies in 2002

	Pre-clinical	Phase I	Phase II	Phase III	Total
GER (all companies)	117	34	22	3	200
UK (all companies)	65	50	56	23	194

Source: Ahrweiler *et al.* (2006, Table 2, p. 11).

Although they identify large commonalities between the German and the British biopharmaceutical industries, they do not draw the conclusion that the German institutional setting is conducive to radical innovations; in this respect, they are in line with the VoC approach. Furthermore, Ahrweiler *et al.* reject the notion that Germany has converged to an LME. Instead, they assume that these commonalities between both countries exist due to internationalization. According to Ahrweiler *et al.*, the key weakness of the German institutional framework for therapeutic biotech firms is the lack of financial support; however, they assume that these firms are able to offset this disadvantage through international venture-capital co-operations. Herrmann argues in a similar direction for the case of the pharmaceutical sector in Germany, Italy and Great Britain (Herrmann, 2009). Hence, from the perspective of internationalization, the third proposition can be formulated as follows:

- (3) German biotech firms which develop therapeutics are equally as competitive as their British counterparts because they are able to tap into foreign business systems supportive of such strategies and thereby offset the detrimental domestic institutional framework.

3. Research design

As stated above, the key objective of this article is to examine to what extent the assumption of a comparative institutional disadvantage for firms pursuing strategies that are incompatible with the dominant institutions in a given market economy is valid, or whether that disadvantage is offset by institutional heterogeneity and/or internationalization. We selected the therapeutics segment of the German biotech industry in Germany, because, on the one hand, Germany is considered a CME, regardless of the fact that a certain amount of liberalization has occurred in recent years (Beyer and Höpner, 2003; Lane, 2003; Höpner and Jackson, 2006), and thereby is regarded as prohibitive of radical innovations. On the other hand, the therapeutic biotech industry is characterized by radical innovations. In our study, we define a radical innovation in the field of biotech-

based therapeutics as a development project which involves high financial risks and is based on a radically new therapeutic effect. A 'new therapeutic effect' implies that the therapeutic is aimed at a target that has not been validated. A target is a native substance in the body whose activity may be modified by a drug, leading to a therapeutic effect. This effect is validated when the therapeutic with the 'new therapeutic effect' has received marketing approval by the regulatory authorities. To develop a therapeutic which is meant to affect a target that has not yet been validated involves a considerably higher risk and is therefore radically innovative. We confined our analysis to three institutions: the financial system, technology policy and the labour market, as these are the institutions regarded as important in the institutional literature on innovations in the biotech industry (Adelberger, 2000; Casper, 2000; Ahrweiler *et al.*, 2006). To examine the question of international competitiveness, an international comparison was necessary. Great Britain was selected as the country of comparison as it has a large biotech industry and is classified as an LME, which, according to the VoC approach, should outperform Germany in radically innovative industries. However, our comparison was not balanced, but rather the emphasis was placed on Germany, since it is the more theoretically controversial case. A total of 45 interviews were conducted between 2003 and 2004, and 32 of these 45 interviews were conducted in Germany. We interviewed top executives from 14 German biotech firms and selected firms that already had therapeutics in clinical trials. The selection of these companies was determined by access; the interview partners were either CEOs or other high-ranking members of the management team. Key issues in the interviews were company background and strategy, the technological innovativeness of their therapeutic product(s), and their perception and evaluation of the institutional fields of the financial system, the labour market and technology policy. In addition, 18 interviews were conducted in Germany with experts in these institutional fields, including 8 interviews regarding the financial system (venture-capitalist companies, banks and associations), 4 regarding the labour market (trade unions, employer associations and head hunters) and 1 regarding technology policy (the federal ministry of education and research); and four interviews were conducted with general experts (consultancies, pharmaceutical corporations and research institutes). Thematically, these expert interviews were focused on the respective institutional field from the perspective of the biotech industry. Apart from interviews, publicly available statistics and other data sources related to the institutions mentioned were evaluated.

To achieve an international assessment of the German biotech industry, we questioned four venture capitalists, two each from the USA and Great Britain, with supervisory board experience in both countries. Key issues were the institutional setting for German and British biotech firms, their investment criteria,

and general trends in the global venture-capital industry investing in biotechnology. Two interviews were conducted in British therapeutic biotech firms and two in a consultancy with biotech expertise. Furthermore, five interviews were conducted with innovation researchers who have analysed the British biotech industry extensively. Key issues were the institutional embeddedness and the development of the British biotech industry.

Several indicators were used to compare the competitiveness of the two industries in the therapeutics segment: first, the total amount of therapeutic products; second, marketed therapeutic products; and third, a global ranking of the world's most promising biotech start-ups. The total amount of therapeutic products in development was used as an indicator to ensure compatibility with the results of Casper and Whitley (2004) and Ahrweiler *et al.* (2006). However, we restricted the indicator to therapeutics tested in clinical trials II and III, because in these phases the financial and technological risks are particularly high. We conducted surveys in 2004 and 2007 so as to add a longitudinal perspective. This was important as the biotech industry emerged in Great Britain 10 years earlier than it did in Germany and, thus, it is likely that British firms have stayed ahead of their German counterparts regarding this indicator. However, a longitudinal perspective renders it possible to discern whether a catching-up process is going on and whether the gap, if there is any, is closing. The sources for Germany were the Informationssekretariat Biotechnologie, Deutsche Börse AG and the Jahr- und Adressbuch Biotechnologie. The sources for Britain were the Department of Trade and Industry, the Bioindustry Association and the London Stock Exchange (LSE). As a final indicator for competitiveness, we used the annual selection of the world's 15 most promising biotech start-ups made by *FierceBiotech*, which monitors the global biotech industry.

4. A German–British comparison of biotech companies in the therapeutic segment

4.1 Competitiveness of German and British biotech companies

The data search yielded a total of 34 biotech firms headquartered in Germany and 34 firms in Great Britain with at least one therapeutic product, including both large and small molecules, in clinical trials in 2004. The survey was repeated in 2007 and yielded 35 German biotech companies in accordance with this criterion and 33 in Great Britain. The list of firms surveyed in each country in 2004 and 2007 were not identical. Approximately one-third of the firms surveyed in 2004 disappeared from the list for several reasons: whereas some companies went bankrupt or had to stop their therapeutic projects, others merged, were acquired or out-licensed their therapeutic candidates. However, since the

Table 3 Therapeutic compounds pipelines of German and British biotech companies

	Phase I	Phase II	Phase III	Unclear	Total
Britain (2004)	52	48	12	9	121
Germany (2004)	25	32	9	2	68
Britain (2007)	51	55	21	0	127
Germany (2007)	38	40	13	4	95

Note: Dates of enquiry: October 2004 and July 2007.

companies surveyed in 2004 were not constantly observed until 2007, but rather the surveys were merely repeated in 2007, it is not possible to state exactly which specific reasons led to specific disappearances. In addition, we want to point out that according to our definition of radical innovations, not all, but indeed the majority, of development projects of the firms in which we conducted interviews could be classified as radical innovations. A key result of all interviews conducted was that despite the invention of several new technologies for discovering and developing drugs—such as combinatorial chemistry, high-throughput screening and genomics—in the 1990s, the failure rate of therapeutic projects remained high; thus, the field is still characterized by radical innovations. Furthermore, four interviews conducted with Anglo-Saxon venture capitalists with experience in the German and British biotech industries led to the conclusion that no differences are discernible pertaining to the level of innovativeness of firms' therapeutic projects. The results of the surveys are presented in Table 3 and the identities of the firms in Table 4.

Two main findings pertaining to the results in 2004 stand out: first, British biotech companies have a significantly larger number of therapeutics in clinical trials. However, this is not a surprising finding when we take into account that the British biotech industry emerged 10 years earlier. The second, more surprising, finding is that the gap between British and German biotech firms regarding this indicator narrowed considerably between 2001 and 2004. The Casper and Whitley survey (Table 1), which dates back to 2001, showed that: (1) overall, British biotech companies had 464.71% more therapeutics in clinical trials than German biotech companies, and (2) with regard to therapeutics in the more-expensive stages II and III of clinical testing, British biotech companies had 1080% more products than their German counterparts. The survey by Ahrweiler *et al.* (2006), which dates back to 2002, showed that, overall, British biotech companies had 114.76% more therapeutics in clinical trials than their German counterparts and 216% more therapeutics in stage II and III trials (Table 2). Our survey, which dates back to 2004, showed that British biotech companies

Table 4 German and British biotech firms with therapeutics in clinical trials in 2004 and 2007*German biotech firms in 2004*

4sc, Antisense, Avontec, Axaron, Biofrontera, Biosphings, Biosyn, Cardiopep, CellControl, CellGenix, Curacyte, Develogen, Genopia, GPC Biotech, G2M, IDEA, Jerini, Jomaa Pharma, Liponova, Medical Enzymes, Medigene, Micromet, MultImmune, Neurobiotec, Paion, RESprotect, Revotar, Scil, Sirenade, Selecore, Symbiotec, Trion, Viscum, Wilex

British biotech firms in 2004

Acambis, Alizyme, Antisoma, Arachnova, Arakis, Ardana, Ark Therapeutics, Arrow Therapeutics, Biovex, Cambridge Antibody Technology, CeNeS Pharmaceuticals, Cyclacel, Evolute, Hunter Fleming, Ionix Pharmaceuticals, KuDos, Metris, Microscience, M.L. Laboratories, Neutec Pharma, Onyvax, Oxford BioMedica, Oxxon Pharmacines, Pharmagene, Pharminox, Phytopharm, PowderMed, Protherics, Regen Therapeutics, Renovo, SR Pharma, Trigen, Vernalis, Xenova.

German biotech firms in 2007

4sc, Affectis, Antisense, Avontec, Axxonis, Biofrontera, Cardiopep, Cellgenix, Curacyte, Cytonet, Develogen, Evotec, Faustus Forschungs Compagnie, Ganymed, GPC Biotech, Heidelberg Pharma, IDEA, Immatics, Jerini, Jomaa Pharma, Key Neurotech, Liponova, Medical Enzymes, Medigene, Multimmune, Neuraxo, Paion, Trigen, RESprotect, Revotar, Sygnis Pharma, Trion, Vasopharm Biotech, Vision J, Wilex.

British biotech firms in 2007

Acambis, Alizyme, Amarin Corporation, Antisoma, Ardana, Ark Therapeutics, Archimedes, Biovex, BTG, Celldex, CeNeS Pharmaceuticals, Curidium, Cyclacel, Evolute, Ferring, Hunter Fleming, Immupharma, Intercytex, Onyvax, Oxagen, Oxford Biomedica, Pharminox, Phynova, Phytopharm, PowderMed, Prosidion, Protherics, Proxima, Renovo, Silence Therapeutics, Vastox, Vernalis, Xenova.

had 77.94% more therapeutic products in clinical trials than their German counterparts. With regard to products in clinical stages II and III of testing, the lead enjoyed by the British had dropped to 46.34% (Table 3).

Although, according to this survey, the difference between British and German companies regarding therapeutics in clinical trials is much smaller than expected, there is still a substantial gap. In order to analyse whether German biotech companies have continued to catch up or not, we repeated this survey in 2007 (see Table 3).

The results for 2007 in Table 3 show that German biotech companies have continued to catch up with British companies in terms of the total number of therapeutics in clinical trials; the British lead has dropped drastically from 77.94% in 2004 to 33.68% in 2007. However, regarding the clinical stages II and III, the German biotech firms have only minimally caught up, since their British counterparts still have 43.40% more therapeutic candidates in these stages compared with a lead of 46.34% in 2004. Hence, the catching-up process of the German biotech firms pertaining to this indicator has slowed down considerably during the last 3 years, which can be interpreted as an indication of the superiority of the British firms in this segment.

In addition, we analysed how many therapeutics were marketed by biotech companies in both countries. In 2004, nine therapeutics were marketed by British biotech firms, while only one was marketed by a German firm; and in 2007 it was 10 and 1, respectively. None of these therapeutics had high market potential; an Internet analysis revealed that the market potential ranged between € 7 and 100 million. In addition, it should be mentioned that the majority of the marketed therapeutics were in-licensed: 6 out of 10 in the case of Great Britain and 1 (out of one) in the case of Germany. Regarding this indicator, Great Britain has a clear lead, although its success is far from impressive with four self-developed marketed therapeutics generating only low market turnover.

Finally, we investigated how many German and British biotech firms were selected as one of the world's 15 most promising biotech start-ups by the journal *FierceBiotech* in the period from 2003 to 2007. The overwhelming majority of these firms originated from the USA (61 firms/81.3%), along with four firms from Great Britain (5.3%) and three firms from Germany (4%). All British and German biotech firms selected for this prize were active in therapeutics development. This indicates the superiority of the British biotech industry over that of Germany, and also that Germany is only slightly behind.

From this analysis we can draw the following conclusion: on the one hand, the British biotech industry is more competitive in the therapeutic segment than the German one. With regard to the number of therapeutics in clinical trials in stages II and III, British biotech companies have a substantial lead, and this lead has not been shortened significantly since 2004. Additionally, British biotech companies engaged in the therapeutics segment have an advantage concerning marketed therapeutics. On the other hand, there are strong indications that German biotech firms active in the therapeutics segment are not far behind in their level of competitiveness. Regarding the total number of therapeutics in clinical trials, the German biotech firms have caught up considerably and have a substantial number of therapeutics in the latest clinical stage. The annual selection of the world's 15 most promising biotech start-ups also shows that German therapeutic biotech companies are internationally competitive.

4.2 Comparison of the German and British institutional environments for therapeutical biotech firms

The financial system for therapeutical biotech firms in Germany and Great Britain

In order to assess the financial systems in both countries, this section is structured as follows: first, we describe the emergence of the German and the British venture-capital industries and stock exchanges relevant for biotech firms. Second, we compare both countries in terms of annual venture-capital investments, the capital raised by therapeutical biotech firms via IPOs as well as the

market capitalization of publicly listed therapeutical biotech firms. The annual venture-capital investments and the capacities of the stock exchanges for therapeutical biotech companies in terms of market capitalization and capital raised via IPOs have been measured since 2004 so as to avoid bias introduced by the 2000 biotech boom, which notably occurred in Germany. The year 2004 was selected as the initial point of comparison because in this year, the IPO window for biotech firms reopened in Europe after being closed for 2 years. Finally, we reflect on the relevance of the key actors of the German CME, banks and large corporations, for financing the domestic biotech industry.

The profile of venture capitalists engaged in the German biotech industry has changed considerably over the past several years. In 1995, only two venture-capital companies with expertise in biotech existed in Germany: Atlas Venture from the Netherlands and Techno Venture Management (TVM), a German-USA venture-capital house. The latter was founded in 1984 by Siemens, the private German bank Matuschka, and representatives of a British (Advent Limited) and an American venture-capital company (TA Associates). Investors included many large German corporations. However, they largely withdrew in the 1990s and were replaced by foreign investors.

Owing to government initiatives, many new venture-capital funds investing in biotech have emerged since 1995. However, in contrast to the inception of TVM, large German corporations did not play a role in supporting domestic biotech start-ups. Several experienced foreign venture-capital companies also invested in the nascent German biotech industry. In 1997, the Deutsche Börse created the Neuer Markt as a segment for young high-tech companies. Thereby, companies that were not yet profitable could also go public. Five biotech companies succeeded in going public in 1999; their share prices rose tremendously in 2000 in the wake of a global biotech boom, which, in turn, increased biotech-related venture-capital activities. However, most of these investors lacked industry experience, including, for example, German saving banks that had set up venture-capital funds for biotech start-ups. A new phase began in 2002, after biotech companies were devaluated on a global scale at the end of 2001. Because of this, 90% of the venture capitalists, including the saving banks, stopped investing in the German biotech industry, resulting in a sharp decrease in invested venture capital. The massive withdrawal of German investors was, according to a representative of one of Germany's few experienced venture-capital companies, to a certain extent offset by foreign investors, particularly from the USA and Great Britain. This view is corroborated by the fact that the percentage of foreign investment in financing rounds of 5 million euros or more was 62% in 2003 compared with 30% in 2002, although in 2006 the percentage of German investors recovered to 61% in financing rounds of this dimension (Ernst & Young, 2004, p. 92). Nevertheless, foreign investors, with a rate of 39% in 2006, have remained

Table 5 Annual venture capital investments (in million euros) in the British and German biotech industries

Year	2004	2005	2006
UK	366	257	238
D	236	326	213

Source: Ernst & Young (2007, pp. 71–72)

important for the financing of German biotech companies. Furthermore, it is noteworthy that biotech funds of German venture-capital firms are mainly financed by foreign investors, as was revealed in interviews with German venture capitalists.

In Great Britain, technology-based venture-capital investments became popular in the 1980s, and established US technology funds served as a role model. However, in the period between 1984 and 1988, the percentage of technology investments dropped significantly from 33.3% of the value of total investments to 8.9%. This was due to the fact that many venture capitalists shifted their focus to mature industries (Murray and Lott, 1995). In 1980, the Unlisted Securities Market (USM) was established to improve financing opportunities for young high-tech companies. This step occurred because the LSE rules did not allow the listing of companies that could not prove 5 years of profitable trading, which was hardly possible for young biotech companies. In the early 1990s, these strict rules were relaxed; this was due to the fact that two British high-tech firms succeeded in going public on the NASDAQ; the LSE was afraid of losing investment opportunities (Senker, 1996). In 1995, the USM was replaced by the Alternative Investment Market (AIM), which allows companies to float shares with a more flexible regulatory system than is applicable to the main market.

Pertaining to venture capital in the period from 2004 to 2006, the amount invested annually in the German biotech industry was in 2004 and 2006 below the level of investments in the British biotech industry, but it exceeded the latter in 2005 (Table 5).

It must be stressed that according to the Ernst & Young reports about the German biotech industry, the majority of the large financing rounds were related to therapeutics firms (Ernst & Young, 2002, 2005, 2006, 2007). On average, the venture-capital investments in this industry accounted for 287.33 million euros in Great Britain compared with 258.33 million euros in Germany. Even though this is not a large difference, the British financial system is superior in terms of this indicator. In this context, the tax environment for venture-capital funds must be mentioned; according to the Benchmark of the

European Venture Capital Association (EVCA), in 2008, it was more favourable in Great Britain than in Germany.¹ In interviews, German venture-capital managers complained about the lack of clarity regarding the taxation of funds. However, the negative effect on venture-capital activities in Germany is negligible, since funds can easily be set up in countries with more favourable tax regimes, as was often pointed out in interviews in Germany. The German venture-capital company Wellington Partners, for example, set up their fund in Guernsey due to the legal situation in Germany (Maier, 2004).

In the same period, therapeutical biotech companies raised the total amount of 241.96 million euros in IPOs on the LSE in Great Britain, compared with 158.3 million euros in IPOs on the Deutsche Börse in Germany. On the LSE, 10 IPOs of therapeutical biotech firms occurred, whereas on the Deutsche Börse there were only four. Similarly to venture-capital investments, these results indicate a slight but significant advantage of the British financial system pertaining to IPOs of therapeutical biotech companies. The advantage of the British financial system is also reflected in the case of the Germany-based firm Atugen. In 2004–2005, the company's management was confronted with a lack of financing opportunities and used the financial instrument of a reverse takeover in order to get financing from British institutional investors. A reverse takeover occurs when a publicly traded smaller company acquires ownership of a larger company. Atugen conducted a reverse takeover into SR Pharma, which was publicly listed on the AIM of the LSE. The latter company had only two employees in London and very low cash reserves. Through this reverse takeover, the newly built company combined several products in development and a promising technology with direct access to the British capital market. It succeeded 4 weeks after the reverse takeover in acquiring 15 million euros from British investors. This would have been more difficult for Atugen without direct access to the British capital market (Ernst & Young, 2007, p. 89).

Pertaining to the market capitalization of therapeutical biotech firms on the respective stock exchanges, the final results were: from 2005 to 2007 (date of surveys: July 15, 2005 and September 16, 2007), the market capitalization of companies listed on the LSE rose from 2.343 billion euros (based on 19 companies) to 3.176 billion euros (based on 31 companies). In the same period, the market capitalization of companies listed on the Deutsche Börse rose from 0.974 billion euros (based on 6 companies) to 1.543 billion euros (based on 11 companies).

The key actors of the German CME, large corporations and banks, were only of minor relevance for the financing of the domestic biotech start-ups. Large

¹European Private Equity and Venture Capital Association, benchmark accessed at http://www.evca.eu/uploadedFiles/08-10-08-PR_Benchmark.pdf on October 12, 2008.

German corporations such as Siemens, Volkswagen and Mannesmann were active in the inception of TVM in 1986, the first professional venture-capital group in this country; however, this remained the only activity in this direction. These corporations were not involved in establishing venture-capital groups in the mid-1990s biotech boom; surprisingly, savings banks played a role in this process but withdrew in the downturn of the industry. Even though German corporations such as Allianz AG invest in venture-capital funds, they avoid funds based in Germany because they are regarded as lacking experience. When the German venture-capital group Wellington Partners set up a new fund in 2004, investors originated mostly from abroad (Maier, 2004). Besides, interviews showed that loans are not an option for German therapeutic biotech companies; this is due to the high risks in this sector and the fact that they cannot lend against security.

To sum up, the financial system of Great Britain regarding therapeutic biotech firms outperforms that of Germany in terms of all analysed indicators. However, the difference between the two countries pertaining to these indicators is small. This is due to the fact that investors from abroad have become interested in the German biotech industry—particularly, therapeutical biotech companies. Additionally, it is notable that in 2006, domestic investors regained the majority in venture-capital rounds of German biotech companies, and the IPO window reopened for German therapeutic biotech firms after the burst of the New Economy bubble in 2001. Large German corporations and banks have not played a significant role in the financing of this industry.

Technology policy and public funding for therapeutic biotech companies in Germany and Great Britain

In order to assess the importance of government funding for therapeutic biotech companies, we analysed which programmes have been available for firms in both countries. In addition, we investigated how much public funding was received by German and British biotech firms with therapeutics in clinical development, what the sources of this funding were and for what purposes these grants could have been used.

In Germany, the first federal funding programme was the BioRegio competition. Three regions received a total of 90 million euros, and 100 biotech companies were funded with this capital from 1997 to 2002. The BioChance (1999–2004) and BioChancePlus (2004–2006) programmes that followed had grant volumes of 50 and 100 million euros, respectively. The tbG, a publicly-owned investment bank, also plays an important role in financing German therapeutics companies. The tbG invests up to 1.5 million euros in young technology companies. As shown in Table 6, tbG investments peaked in 2000, when they reached 136 million euros,

Table 6 Investments (in million euros) of the tbg in the German biotech industry

	1995	1996	1997	1998	1999	2000	2001	2002	2003
tbg	5.91	4.47	19.04	59.13	83.03	135.1	65.24	15.0	9.0

Source: Presented in October 2003 by the tbg and the venture capital company TVM in Cologne.

but decreased sharply in the following years since many biotech companies went bankrupt subsequent to the downturn of the biotech industry in 2001–2002.

Britain, on the other hand, has no government programmes explicitly designed for funding biotech companies. However, there are grant programmes for which biotech companies can also apply. The most important is the LINK Collaborative Research Scheme, which was established in 1986. The LINK focuses on supporting research partnerships between the public-sector science base and industry in Britain and is funded by the Department of Trade and Industry (DTI). In 1997, the total grants for biotechnology-related LINK research programmes amounted to 23 million euros. Several other public seed funds were set up in the 1990s with the goal of improving technology transfer via company spin-offs (Martin, 2000). Moreover, 15 seed funds were established at British universities within the scope of the government's University Challenge Seed Fund Scheme, with total endowments of 65 million euros.²

To examine the extent to which German and British biotech companies have access to government funding, we evaluated the available data on the websites of the companies with therapeutics in clinical trials contained in Tables 7 and 8 for the period from 2000 to 2007: whereas German companies received 30.26 million euros, their British counterparts received 24.66 million euros of public funding; the difference is small. Furthermore, interviews with biotech therapeutics firms in both countries showed, first, that government funding was of minor relevance compared with overall funding and, second, that funding from the EU could not be used for therapeutics in clinical trials because this is not considered pre-competitive.

What is notable is that a considerable percentage of the funding does not originate from domestic sources; more specifically, this proves true for 26.20% (7.93 million euros) in the case of Germany and even 67.60% (16.67 million euros) in the case of Great Britain. Even if we consider funding from the EU as a domestic source, 10.34% of funding received by German firms and 34.67% of funding received by British firms are of foreign origin. The most important reason for this striking finding is that public funding in the USA is also available for

²Department of Trade and Industry, accessed at <http://www.dti.gov.uk/ministers/archived/sainsbury100400.html> on April 27, 2005.

Table 7 List of German biotech companies with therapeutics in clinical trials which have received public funding (in million euros)

4sc	EU (2.2 M); EU (1.3 M); BMBF (2.9 M); EU (1.3 M)
Biofrontera	State of North Rhine-Westphalia (4 M)
Curacyte	BMBF (1.1 M); State of Thuringia (1.7 M); NIH/USA (unknown)
Develogen	BMBF (4.0 M); BMBF (1.0 M)
GPC Biotech	BMBF (2.2 M)
Immatics	BMBF (1.2 M); BMBF (0.56 M)
Jerini	BMBF (0.85 M)
Medigene	BMBF (0.4 M)
Selecore	BMBF (1 M); BMBF (0.5 M)
Wilex	US Department of Defense (3.13 M); BMBF (0.92 M)
Total	30.26

Source: Websites of companies in Table 4 (dates of enquiry October 2004 and July 2007).

Table 8 List of British biotech companies with therapeutics in clinical trials which have received public funding (in million euros)

Acambis	US Department of Defense (1 M); US National Institutes of Health (2.51 M)
Ark	EU (1.2 M); The Employment and Economic Development Centre of Finland (2.19 M)
Cyclacel	DTI (0.66 M); Scottish Executive (0.66 M)
Immupharma	ANVAR, ANR / France (1 M)
Intercytex	DTI (2.72 M)
KUDOS	DTI (0.7 M)
Onyvox	EU (4.2 M)
Oxford	Department of Health (0.73 M); DTI (1.31 M); DTI (0.37 M); DTI (0.58 M); DTI (0.2 M)
BioMedica	
Protherics	Welsh Assembly Government (1.47 M)
SR Pharma	US National Institutes of Health (1.85 M)
Vastox	Welsh Development Agency (0.4 M); DTI (0.91 M)
Total	24.66

Source: Websites of companies in Table 4 (dates of enquiry October 2004 and July 2007).

non-US companies. In contrast to funding within the EU, this is even possible for therapeutics in clinical trials. This is due to the fact that the key objective in the US public funding is in many cases not the improvement of national competitiveness but the improvement of health. Executives of several German biotech firms remarked, pertaining to technology policy, that clearly the USA, and not Europe or Germany, would be the place where firms in this sector could acquire huge sums of government funding and were amused about the image of the USA as a free market economy with hardly any government interference.

To conclude, government policy played a more active role in the emergence of the biotechnology industry in Germany than in Great Britain. However, in recent years, the differences have shrunk. Apart from that, biotech companies with therapeutics in clinical trials received around 25 million euros in Great Britain and around 30 million euros in Germany from 2000 to 2007. These amounts pale in comparison to the average development costs of therapeutics.

The Labour market for therapeutic biotech companies in Germany and Great Britain

In line with proponents of the VoC approach, experienced venture-capital managers in both countries reported a greater lack of managers with a background in pharmaceuticals in German biotech companies than in British ones. However, the cause of this relative scarcity remains disputed. From the venture-capital managers' perspective, the main reason was the consolidation process in the pharmaceutical industry, which started in Britain 10 years earlier than in Germany. Since this process has also started in German pharmaceutical companies in recent years, they feel that this difference should vanish over time. On the other hand, managers at two German biotech firms stated that it is because of long-term job security that they have great difficulty in attracting managers from German pharmaceutical companies. However, these two companies went bankrupt soon after the interviews. One may therefore assume that their financial fragility may have also been a cause for their difficulties in recruiting pharmaceutical managers. Although the British labour market is deregulated, many British biotech companies experienced similar problems when their financial positions were rather precarious in the 1980s (Martin and Thomas, 1998). Nevertheless, most German biotech companies at which interviews were conducted had attracted managers with previous experience in the pharmaceutical industry. According to a head hunter, pharmaceutical managers are often willing to move to a German biotech company if they are positive about the longevity of the company.

In addition, our analysis showed that German biotech companies can dismiss employees in the case of financial difficulty or project failure since hardly any of these companies are profitable. Dismissals are possible under German labour law, provided that the company can demonstrate a direct effect of negative circumstances on employment. The basic difference is that the minimum period of notice is 3–6 months in German biotech companies compared with only 1 month in British ones. Company law also does not prohibit biotech companies from dismissing employees since an employee representation of 50% on the supervisory board—which is often an effective hurdle against dismissals—is only required for companies with more than 1500 employees. In addition, works councils are extremely rare in German biotech firms, a fact which is

based, in part, on the fact that scientists tend to pursue their interests individually. Trade unions are absent in the German biotech industry, at least in the area of pharmaceutical biotechnology. Finally, our analysis of the websites of German biotech firms with therapeutics in clinical trials in 2004 revealed that they used the supervisory board to attract the additional expertise often lacking in these firms: venture-capital managers were the largest group with 45%, the majority originating from abroad and most notably from the US and Great Britain. The second largest group, with 23%, were top managers from the pharmaceutical industry mainly originating from Germany.

To conclude, the labour law in Great Britain is more advantageous than in Germany for biotech therapeutics firms: British firms are able to dismiss employees more quickly than their German counterparts and are better able to attract pharmaceutical managers. On the other hand, these differences are rather small. German therapeutic biotech firms are able to dismiss a considerable percentage of their employees without legal problems within a short period of time, and they are also able to attract managers from the pharmaceutical industry in Germany. Finally, works councils rarely exist in the German biotech industry.

5. Conclusion

The thrust of this contribution has been to analyse the extent to which firms pursuing strategies that are not promoted by the dominant institutions in their home country are economically sustainable, and thereby to evaluate the strategic leeway of actors. Proponents of the VoC approach assume that it is low, because firms lack the input factors required for these strategies and therefore underperform. In contrast, proponents of the institutional heterogeneity and internationalization approaches regard the level of strategic leeway as considerably high. They assume that these firms are able to rely on institutions other than the dominant framework of their home country—be they divergent domestic institutions or part of foreign market economies—and by that means they are able to compete. In the following, we first outline in which ways the propositions of the three theoretical perspectives have been corroborated before we draw theoretical conclusion.

The VoC approach has been supported since German therapeutic biotech firms are less competitive than their British counterparts. Furthermore, the institutional environment in Great Britain is more favourable. On the other hand, differences are much smaller than predicted by this approach. German firms are only slightly less competitive. Besides, German therapeutic biotech firms are able to dismiss employees and attract pharmaceutical managers, and they are not considerably behind in terms of acquiring venture capital or raising capital via IPOs.

The institutional heterogeneity approach is corroborated because apart from the national institutional framework of a CME, a more liberal institutional setting exists which supports biotech firms which develop therapeutics. One reason for this institutional heterogeneity is that institutions do not spread uniformly across all industries and companies. The strong dismissal protection in Germany applies only to companies with large financial reserves; similarly, employee representation in the supervisory board, which strengthens dismissal protection, only applies to large companies, and codetermination is virtually non-existent in this sector. Additionally, new institutions have become established that support young high-tech companies: unprofitable firms are now allowed to go public and a small group of professional domestic venture-capital funds has emerged.

According to proponents of internationalization, firms are able to offset a disadvantageous institutional setting by tapping into foreign business systems and using their institutions. This proved true particularly for the financial system. At present, foreign investors are important for the German biotech industry, since they invest substantially and thereby prevented a breakdown of the sector after 2001. Additionally, German venture-capital companies set up their funds abroad to avoid the unfavourable domestic legal environment. Surprisingly, also in the field of government funding, actors have the opportunity to acquire international financial support, most notably from the USA. Finally, German firms use the supervisory board to gain additional expertise from foreign venture capitalists.

To sum up, each of the three theoretical perspectives has been confirmed to a certain extent. As assumed by the VoC approach, the institutional environment in Great Britain is more favourable for biotech therapeutics companies than in Germany, and firms are competitive. Thus, the level of strategic leeway of actors is lower than expected by proponents of internationalization and institutional heterogeneity; the fact that British biotech therapeutics firms are more successful than the German ones indicates that the latter are not able to offset the less favourable institutional environment completely. However, the competitive advantage of British firms in this radically innovative segment is minimal. Thus, we conclude that actors have more strategic leeway than projected by the VoC approach. This is due to the fact that it overestimates the institutional homogeneity of the German market economy and that internationalization lessens the effect of an unfavourable institutional environment. Whereas the VoC approach suggests that globalization tends to increase divergence between different types of market economies, the case of the German biotech industry shows that actors are able to expand their strategic leeway by means of internationalization and thereby reduce this divergence. Although the biotech industry is relatively small in terms of employment and turnover, the results are important beyond this industry. This is due to the fact that the therapeutical biotech sector in the

German CME can be considered an extreme case because these companies have to deal with very high financial and technological risks which are not supported by the dominant institutional framework.

As a consequence of the empirical results, we argue for an integration of institutional heterogeneity and internationalization into the VoC approach. Furthermore, institutional heterogeneity and internationalization should not be seen in isolation from one another but rather as interrelated; for instance, international venture capitalists have been crucial for the emergence of professional domestic venture-capital companies in Germany. The conceptualization of the interplay of the dominant institutions of a market economy, institutional heterogeneity and internationalization would also allow a more dynamic perspective on business systems and how they change and evolve.

An open question is whether the establishment of radically innovative sectors in the German CME could lead to an institutional layering, which results in differential growth and eventually will lead to a profound liberalization (Streeck and Thelen, 2005, p. 23). We assume that institutional layering will take place and that the market for venture capital and the segment for young high-tech companies at the stock exchange will grow. However, we doubt that this process will gradually replace the dominant institutions of the German CME. We should keep in mind that the number of biotech companies and the jobs that they create is miniscule in comparison to such industries as special machinery or automobiles. Hence, a profound liberalization of the German market economy in order to strengthen high-tech firms pursuing radical innovation strategies is unlikely.

In this article, we showed that the German market economy is institutionally heterogeneous and that firms are able to benefit from the institutions of foreign business systems, particularly LMEs. This result is of significant importance to the VoC debate because it challenges its proponents' implicit assumptions about the institutional homogeneity of national market economies and the negligibility of the strategic leeway of firms for the example of Germany, which is considered the typical case of a CME. Furthermore, there are also indications in the empirical data of this article that not only Germany, but also the USA, is institutionally more heterogeneous than expected by VoC proponents. The fact that biotech firms were able to receive substantial public funding from the USA, even for product development in late stages, shows that it is not the clear-cut LME which it is often characterized as. In fact, government programmes are quite important for the American high-tech industries. According to Lerner (1999), there were 28 public subsidy programmes for small high-tech companies in the USA in 1995, which provided high-tech firms grants totalling \$2.4 billion. In comparison, the amount of private venture capital invested in such companies in 1995 was \$3.9 billion (Lerner, 1999). Etzkowitz (2003) estimated the amount of public venture capital provided in 2003 to be \$ 3.5 billion, leading him to conclude

that there was a 'public venture-capital strategy' in post-war US science policy. An intriguing future research question could be: to what extent are government funding and venture-capital investments in the US interrelated?

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