

Institutions Matter but ... Organisational Alignment in Knowledge-Based Industries¹

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Abstract

A comparison of the current structures and dynamics of UK and German biotechnology-based industries reveals a striking convergence of industrial organisations and innovation directions in both countries. This counteracts propositions from theoretical frameworks such as the varieties-of-capitalism hypothesis and the national innovation systems approach which suggest substantial differences between the industrial structures of the countries due to differing institutional frameworks. In this paper, we question these approaches and show that the observed structural alignment can be explained by the network organisation of research and production in knowledge-based industries.

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1 Introduction

In knowledge-based economies the mechanisms of knowledge creation and utilisation are changing. Industrial economics and new innovation theory consider the increasing complexity of knowledge, the accelerating pace of the creation of knowledge, and the shortening of industry life cycles to be responsible for the rising importance of innovation networks. Knowledge-intensive industries such as IT and biotechnology have already undergone structural changes towards these collective modes of knowledge production and application. Such networks seem to be an important component of the emerging knowledge-based economies in which knowledge is crucial for economic growth and competitiveness.

For some authors, the omni-present networks even "constitute the new social morphology of our societies" (Castells 2000: 500) which are accordingly labelled as *network societies*. However, this suggests that network formation follows some global and universal trend affecting, unifying, and arranging all parts of society in "variable geometries" (Castells 2000) where heterogeneity and diversity is sacrificed for a single over-powering pattern of development. As we have mentioned elsewhere (Pyka/Ahrweiler 2004), this view does not take into account the complex reality of economic phenomena deeply intertwined with cognitive, institutional, organisational and political aspects, i.e. a world of institutional variety, historicity and path-dependence.

In this article, we argue that the relation between knowledge, networks and heterogeneous institutional frameworks is much more complicated than acknowledged by the protagonists of "globalisation" or the so-called network society. Network formation is, on the one hand, closely linked to the knowledge-intensity of a few industries and, on the other, not substituting but complementing the influence

of institutional frameworks in order to co-ordinate economic action. The next paragraphs will work out these propositions in more detail.

2 Institutions matter

"At the start of the twenty-first century the role of institutions and the conditions for institutional change are at the core of the economic debate in Europe" (Amable 2003: 1). Neo-institutional approaches (e.g. North 1981; Olson 1984) claim that institutions shape the structure and dynamics of societies: they emphasise that each national society has developed a context and path dependent institutional infrastructure (politics, law, economy, culture). Economic actions are strongly influenced by these specific infrastructures, which accordingly lead to different national industrial structures and performances.

2.1 Varieties of Capitalism

Although, as the sociological "varieties of capitalism" (VoC) thesis states, national industries do look different, each formation can offer a particular comparative institutional advantage enabling economic success within the different national frameworks (Hall/Soskice 2001). VoC studies (e.g. Petit/Amable 2001; Amable 2003) maintain that UK and Germany have completely different institutional infrastructures: while the UK is labelled as a "liberal market economy", Germany is deemed to be a "co-ordinated market economy". The differences are traced back to national regulations of labour and corporate law, to institutional differences in competence development and technology transfer, and to differences in financial systems. Considering these wide-ranging differences in the institutional frameworks in UK and Germany, summarised in Table 1, it seems reasonable to expect substantial differences in the organisation of their national industries. Generally, Ger-

Table 1- National institutional frameworks in Germany and the UK

	Germany	UK
Labour Law	regulative (coordinated system of wage bargaining; constraints on employee dismissals)	liberal (decentralised wage bargaining; fewer barriers to employee turnover)
Company law	stakeholder system (two tier board system plus codetermination rights for employees)	shareholder system (minimal legal constraints on company organisation)
Skill formation and technology transfer	organised apprenticeship system with substantial involvement from industry. Close links between industry and technical universities in designing curriculum and research	no formal apprenticeship system for vocational skills. Links between universities and firms almost exclusively limited to R&D activities and R&D personnel
Financial system	primarily bank-based with close links to stakeholder system of corporate governance; no hostile market for corporate control	primarily capital market system, closely linked to market for corporate control and financial ownership and control of firms
Source: Casper/Kettler 2001: 14		

many is considered to be burdened with an "old" institutional infrastructure compared to the UK. German industrial society contains nationally unified institutions such as large industrial corporations, bureaucratic organisations, professional management, dual professional education systems, social security systems, labour unions and formal regulation, hierarchical co-ordination and a Taylorised structure of work. As Heidenreich states: "There are no signs that Germany and other Continental European economies will follow the British lead and will get rid of their institutional structures developed over decades. These particular institutional settings cannot be dismissed as the *old garbage of industrial society*" (Heidenreich/Toepsch 1998: 14; own translation).

Compared to the UK, some requirements of modern knowledge societies (see e.g. OECD 1996) are less likely to be fulfilled by the institutional infrastructure in Germany. Focussing on knowledge creation, knowledge transfer and the commercialisation of knowledge, knowledge-based economies require permanent access across

borders between nations and firms as a pre-condition for economic action. This is needed to achieve, for example, quick commercialisation of scientific results from basic research, easy access to finance for risk-intensive projects, the motivation of scientific entrepreneurs, and the availability of participative management skills. To satisfy project requirements, highly-qualified and flexible staff have to be able to migrate without the hindrances resulting from firm and education barriers (for German difficulties in this area see Soskice 1997, EPOHITE 2000). Table 1 summarises the issues.

The VoC literature would seem to predict that innovative industries, characterised by a high research intensity, extensive capital needs, and high risk and uncertainty, would face difficult development conditions in Germany and would be far less developed than the UK's – and that this will stay as it is because institutions change slowly, if at all. Compared to the UK, the comparative advantage of Germany would be best maintained by concentrating its strength in the conventional industrial sectors.

2.2 National Innovation Systems

The notion of "national innovation systems" (NIS) was introduced to innovation research in the 1980s to emphasise the important role played by the specific national institutional settings and non-economic actors for the innovative performance of an economic system. According to Beije (1998), an innovation system "can be defined as a group of private firms, public research institutes, and several of the facilitators of innovation, who in interaction promote the creation of one or a number of technological innovations [within a framework of] institutions which promote or facilitate the diffusion or application of these technological innovations" (Beije 1998: 256).

The NIS approach (Lundvall 1992; Nelson 1993) focuses on actors and their interactions embedded in a national institutional infrastructure. Innovation and innovation-based economic performance is organised differently across national borders. Like the VoC literature, the NIS approach concentrates on "the systemic aspects of innovation [and of] diffusion and the relationship to social, institutional and political factors" (Fagerberg 2003: 141). Lundvall, additionally, contributes an emphasis on competence building and the learning capabilities of individuals, organisations, regions and nations (Lundvall/Tomlinson 2002: 218, see the Aalborg-Freeman approach of NIS (Lundvall 1992)). Differentiating, elaborating and complementing the NIS concept, recent research targets sectoral systems of innovation (Malerba 2002), technological systems, regional innovation systems and local technology clusters (Feldman et al. 2005).

The NIS approach suggests a diagnosis similar to that of the VoC studies³.

Balzat summarises the results of the 2003 innovation report of the German Ministry of Economics: "On the negative side, Germany has problems to catch up with the USA and with the Nordic European countries in the development and dissemination of technologies such as ICT and biotechnology. A rapid reversal of the German "backwardness" in this high technology field seems rather unlikely for three main reasons. First, Germany has lost ground in the level of ICT expenditure within the last decade. Second, the German labor market falls short of highly qualified workers and technical engineers. Third, the industry in the Eastern part of Germany is still far behind the West German in productivity levels and in the innovativeness of business firms" (Balzat 2004: 115). In order to compare different national institutional frameworks of innovation, Balzat constructed a NIS model containing 54 indicators that operationalise 19 sub-blocks of six main NIS components (knowledge base, financing conditions, internationalisation, innovation and learning incentives, innovative efforts, framework conditions)⁴. Figure 1 shows a simplified version of his NIS performance model.

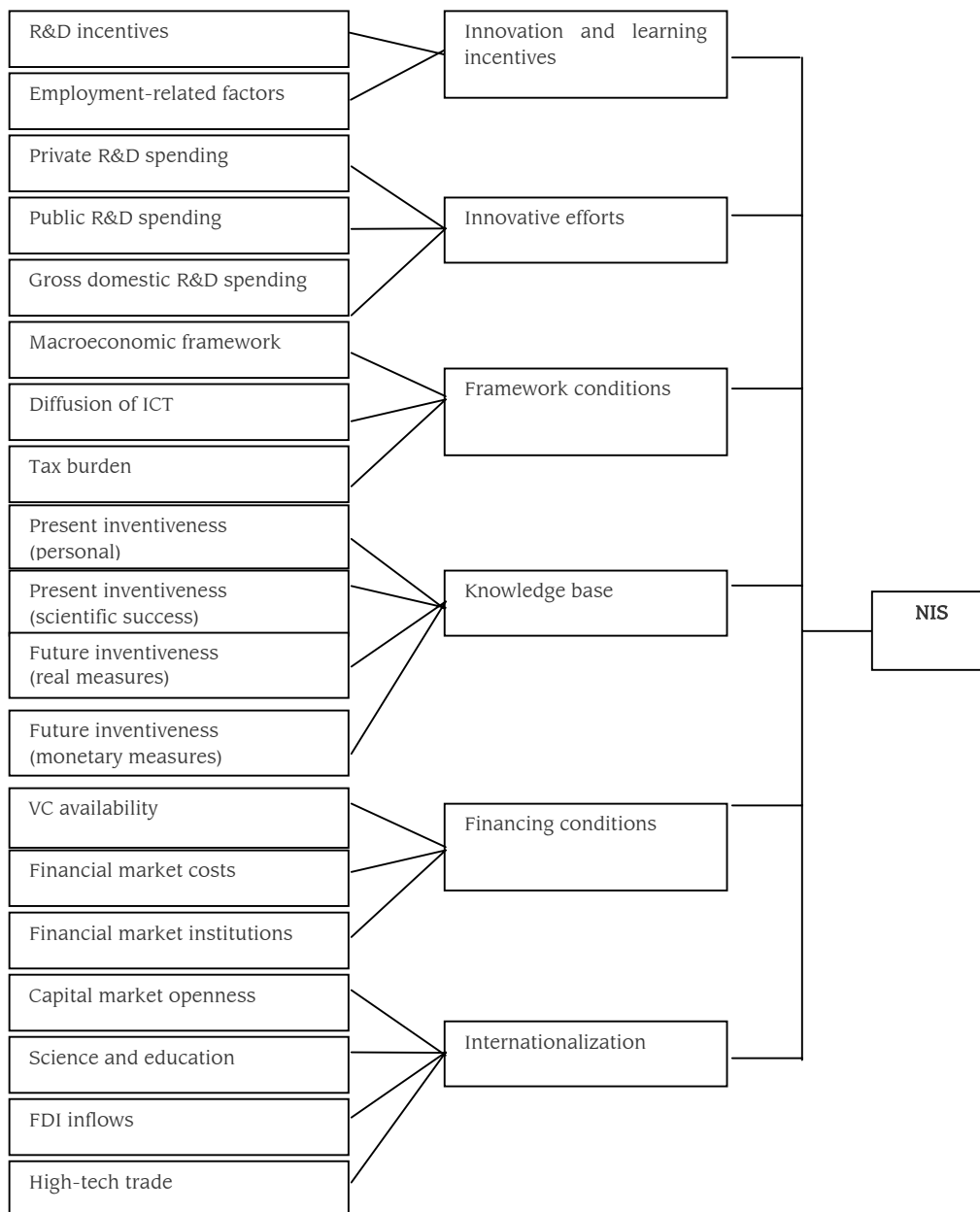
Using this set of indicators with the operationalisation mentioned in Balzat (2004), the differences between the national innovation systems of UK and Germany can be visualised as in Figure 2. The different designs of the national innovation systems in UK and Germany can easily be seen. Whereas the German system performs better in the dimensions of innovative efforts, knowledge base and internationalisation, the UK system shows advantages with respect to financing conditions.

³ For a detailed comparison of recent NIS and VoC approaches see Werle 2005.

⁴ For a discussion of parameter construction, indicator building and interpretation of results, see Balzat 2004: 156-218.

Figure 1: Indicators for comparing different institutional frameworks

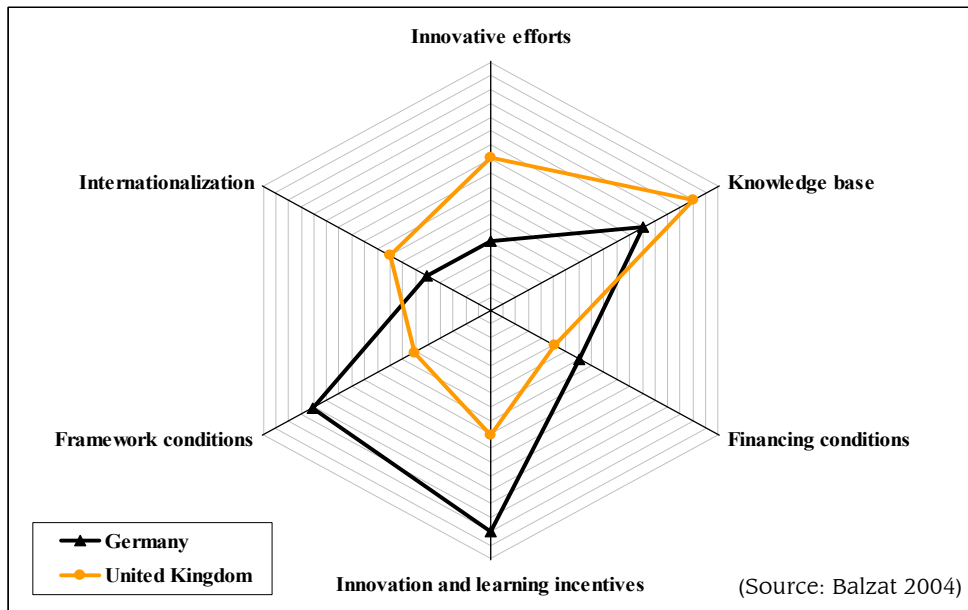
(Source: Balzat 2004: 158)



learning incentives and framework conditions, all features important for the evolution of entrepreneurial industries. Summarising, both the VOC and the NIS approaches leave us with the same set of research hypotheses about Germany's and the UK's knowledge-based innovation. For the UK, as the example *par excellence* of a *liberal market economy* (Amable 2003), we expect entrepreneurial knowledge-

intensive industries supported by progressive venture capital focussing on blockbusters following radical product innovation strategies. For Germany, as the example *par excellence* for a *co-ordinated market economy* (Amable 2003), we expect, *mutatis mutandis*, industries with a small rate of entry, conservative venture capital if any, and focussing on incremental innovation, i.e. process innovation.

Figure 2 - Comparing NIS components of UK and Germany



3 Institutions matter but...

There seems to be general agreement about the varying institutional frameworks of UK and Germany. For the manufacturing industries, in the last twenty years this has led to divergent developments in Germany and Britain (e.g. machine tools and car manufacturing, for an overview comparing industrial structures in both countries cf. Matraves 1997). As the varieties of capitalism hypothesis states, this is also – and even especially – expected for the knowledge-intensive industries.

In the following sections we shall consider the so-called "red" biotechnology sector, which covers pharmaceutical applications of molecular biology, also often referred to as "biopharmaceuticals". Contrary to the expectations we derived from the VoC and NIS approaches, we shall observe striking structural and procedural similarities. The biopharmaceutical industries of the two countries have become more and more similar both in their focus on product *and* process technologies, and in the make-up of their industrial organisations (clusters, start-ups, spin-offs etc.).

3.1 Empirical evidence: the biopharmaceutical sector

In this section we will present some statistics describing the biopharmaceutical industries in the United Kingdom (UK) and in Germany (D).⁵

Figure 3 demonstrates market sizes and their growth, measured by the percentage of GDP of pharmaceutical sales. The markets are of similar size in both economies and the trends show the same direction.

Figure 4 compares the markets for pharmaceuticals in UK and D by depicting the market shares of novelties introduced by national companies within the last 5 years. Again the development and the overall sizes are rather similar for Germany and the United Kingdom. However, the German figure is slightly above the British figure over the whole time period.

⁵ Except that, in some cases, the data we would like to have presented is not available and so we have used data about the pharmaceutical sector as a whole. A considerable part of the new technologies in the pharmaceutical sector are based on methods from biotechnology.

Figure 3 - Market Size in UK and D

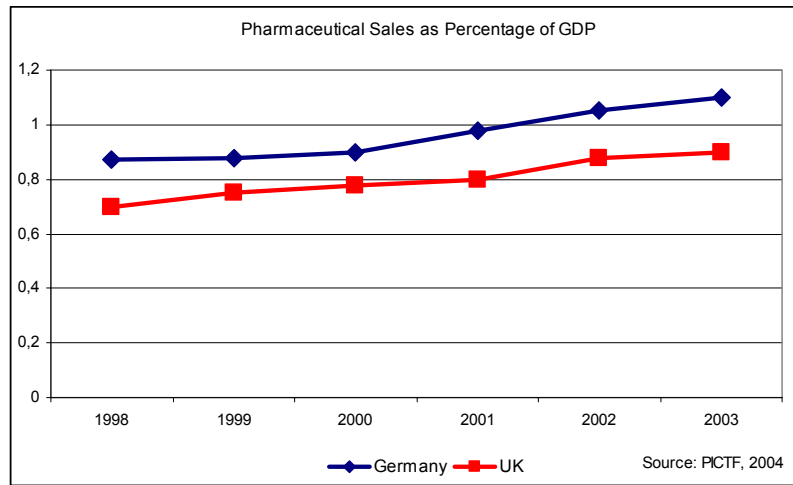


Figure 4 - Share of innovations in the pharmaceutical market in UK and D

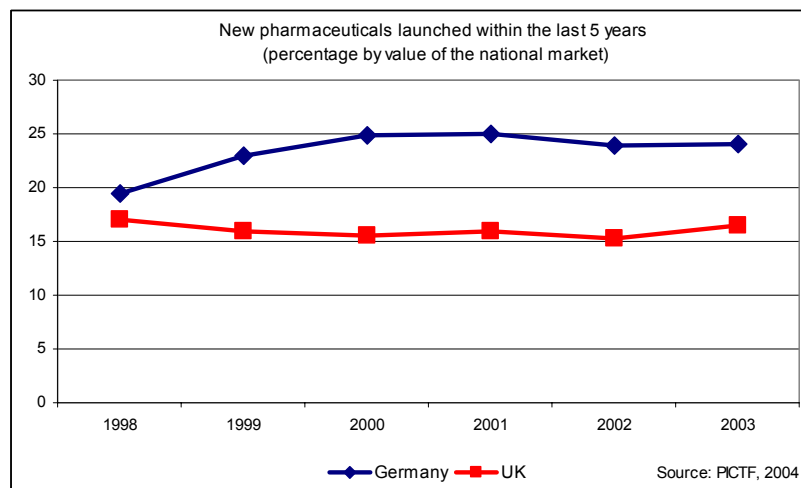


Figure 5 - International comparison of the number of core biotech firms

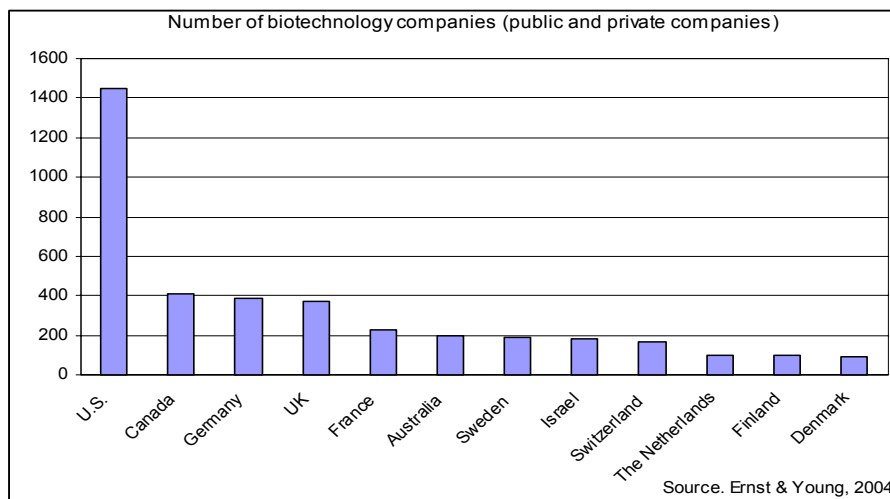


Figure 6 - Development of private biotech firms in UK and D

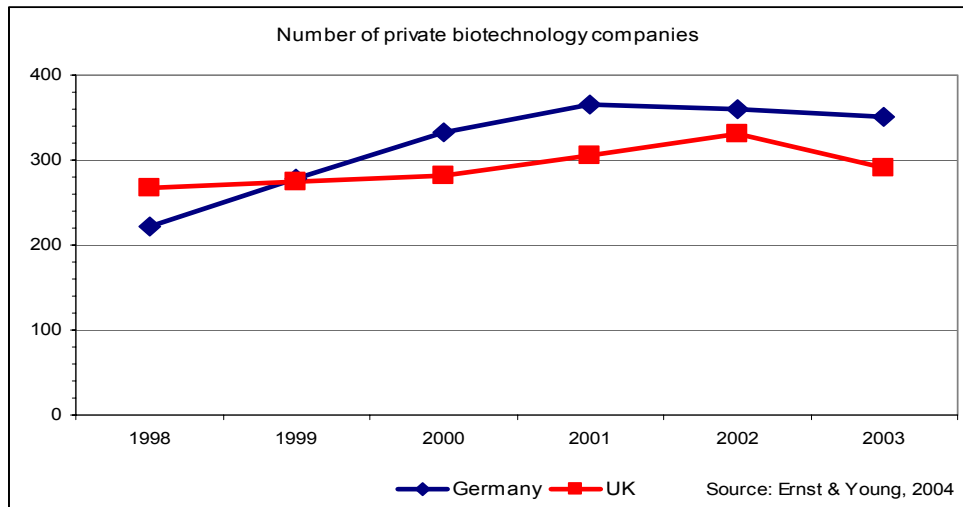
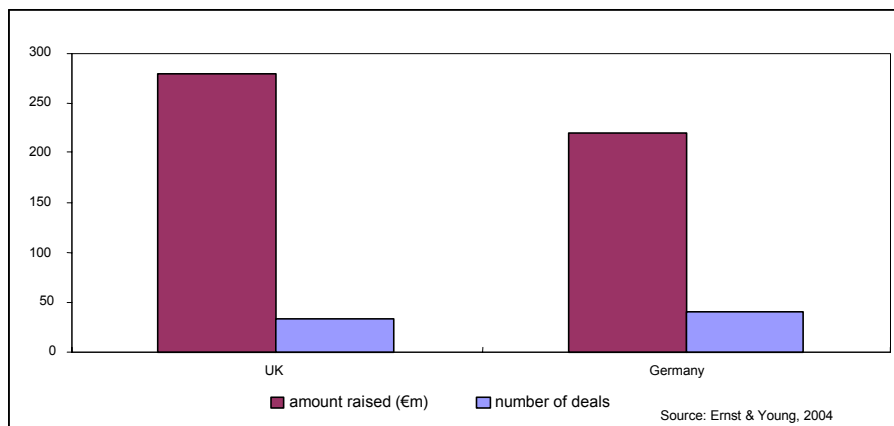


Figure 5 describes the size of the biotech firm population. For 2003, Ernst & Young (2004) records a rather similar number of firms in the two nations. If we look at the development of the firm population over time (Figure 6) we see that the number of German biotech firms has increased

higher in the United Kingdom than Germany.

These findings seem contrary to what would be expected from the VoC literature concerning a comparison between the German and the UK biotech industries. A considerable

Figure 7- VC cooperations in UK and D



continuously and since 1999 is even slightly greater than the number in the UK in the same years.

If we examine the number of venture capital (VC) cooperations in both countries shown in figure 7, a corresponding similarity can be observed. The number of deals in Germany is slightly above those in the United Kingdom, whereas the amount of money involved in transactions is

entry of firms was only expected for the UK; for Germany, a similar development was not expected at all. Of course, a major reason for the proliferation of biotech firms in Germany must be the huge efforts to support entrepreneurial behaviour coming from technology policy.

3.2 Empirical evidence: firm strategies

The VoC studies also suggested that German firms would pursue innovation strategies that excluded product innovation, e.g. the development of therapeutics, expecting this country to stick with process innovation. Instead, data from 2004 show that more than half (56%) of the German biotech companies consider the development of therapeutics as their main area of action. A more detailed comparison from 2002 also points in this direction:

Table 2: Products in pipeline in 2002: comparison of Germany and UK

	Germany	UK
Products in pipeline	200	194
* pre-clinical	117	65
* clinical phase I	34	50
* clinical phase II	22	56
* clinical phase III	3	23

Source: Ernst & Young 2004

In 2004, 32 firms in each country were developing therapeutics that had already reached the clinical phase. Managers from UK and Germany reported similar reasons for their strategic decisions (Ernst & Young 2004). Chances, possibilities and risks are estimated in similar ways by managers in the two countries. A comparison of the number of new drugs introduced to the market in both countries (figure 8) shows that also the final outcome in UK and Germany is relatively similar.

Figure 9 shows German and British R&D efforts in an international comparison. The relative position of Germany slightly worsens in the time period shown, but both nations have very similar shares of the global total.

In Figure 10 we see the percentage of all pharmaceutical patents awarded to a country divided by the percentage of R&D efforts of its pharmaceutical

industry, a measure of R&D efficiency. The efficiency for UK is higher over the four periods investigated. However, again the trend is in the same direction for both countries.

Figure 11 shows the time elapsing between the first application in any market and the launch in the particular national market in Germany and UK. The three main reasons for delay are company strategy (when to apply, when to launch), the length of the regulatory process, and the length of the pricing and reimbursement process. The time between approval and launch in the national market is somewhat shorter in Germany compared to the United Kingdom. However, in Germany it takes considerably longer if the time span between the first application and the application to the national market is considered. The regulatory conditions in Germany are accordingly less favourable in this single respect.

This section has clearly indicated the overall structural similarity of UK's and Germany's biopharmaceutical industries. The similarity is also visible from other countries: the foreign direct investment (FDI) inflows show that Germany, a 'co-ordinated' market economy according to the VoC thesis, is deemed as attractive as the UK, a 'liberal' market economy. Table 3 signifies the general FDI inflows for certain years without distinguishing sectors (here, Germany even overtakes the UK). While there is no data specifically for the biopharmaceutical sector, FDI Media Information (2005) shows that there were 23 FDI projects in the UK and 18 in Germany for the pharmaceutical sector as a whole.

Table 3: FDI inflows (as a % of GDP)

	1995	1999	2002
UK	1,8%	5,8%	1,6%
D	0,5%	2,6%	1,9%

Source: PICTF 2004

Figure 8 - Number of drugs introduced by UK and German firms

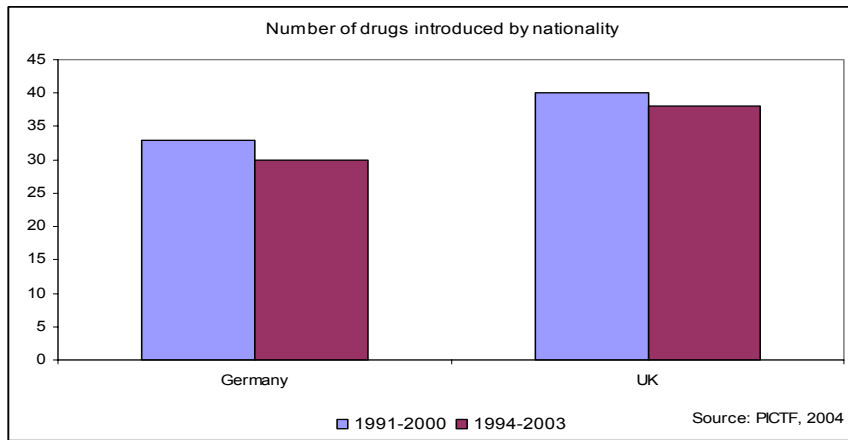


Figure 9 - Relative weight of research in the pharmaceutical industries

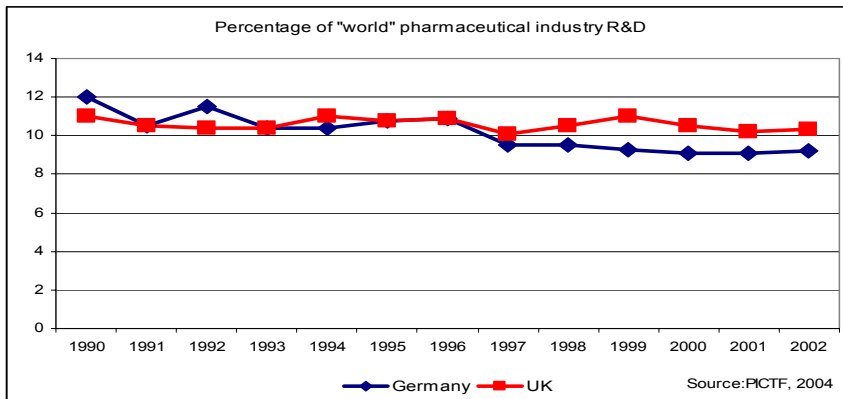


Figure 10 - R&D efficiency

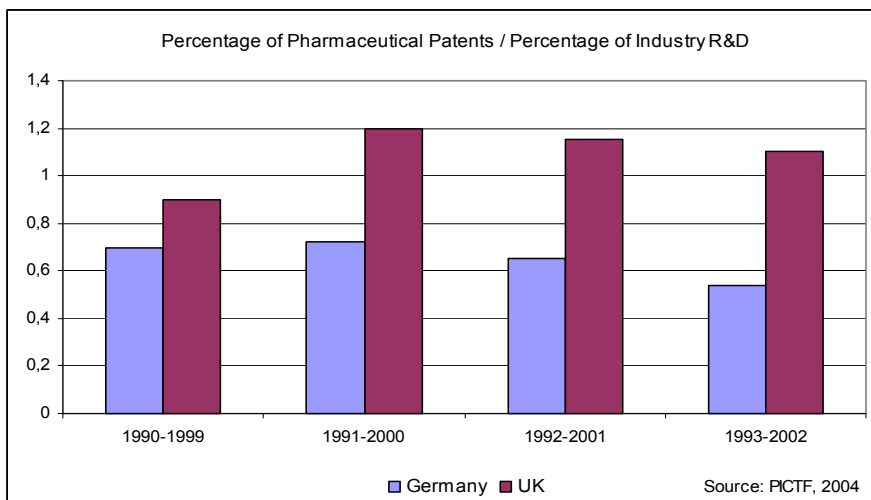
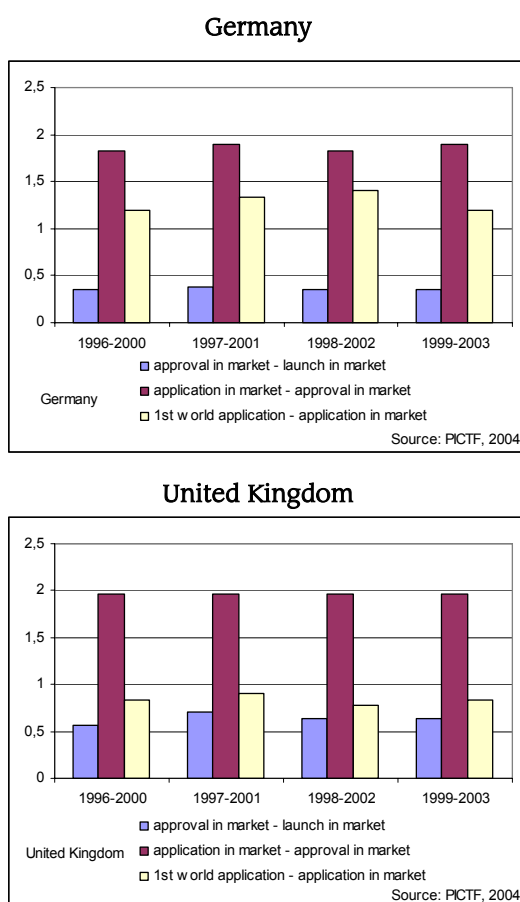


Figure 11: Time spans for market introduction of novelties



Having now presented empirical support to show that the postulated differences between the German and British economies fail to be revealed when the recent development of biopharmaceuticals is examined, the observed convergence needs explanation.

3.3 Explaining the data: organisational alignment via innovation networks

Why do we observe these strong similarities in comparing the UK's and Germany's biopharmaceutical industries? The data summarised in the previous sections clearly offer no support for the research hypotheses arising from the VoC and NIS literature that predicted large differences in the two national settings. One possibility is that the national innovation systems, i.e. the institutional frameworks,

of both countries, have themselves converged. However, this potential explanation is ruled out by recent studies focussing on their persistent differences (cf. Amable/Barré/Boyer 1997; Balzat 2004). Another potential explanation could be that the biopharmaceutical sector has some special characteristics which might overwhelm the effects of national institutional differences.

Our hypothesis is that *all* knowledge-intensive industries have characteristics which differ greatly from other industrial sectors: these characteristics directly affect innovation performance and provoke network formation and internationalisation. In the long run, the network effects of collaborative innovation mitigate or even overcome the effects of differences in institutional frameworks.

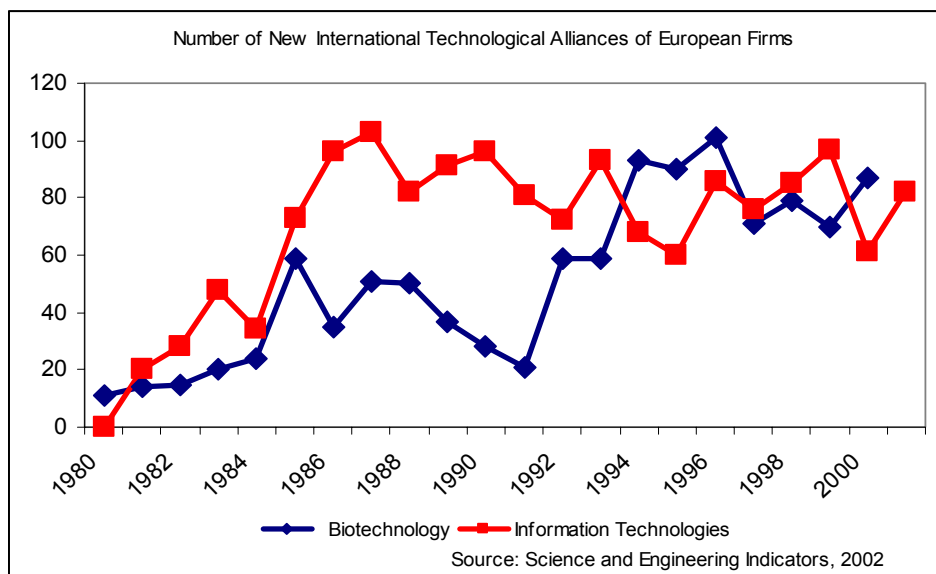
What are the special characteristics of the biopharmaceutical sector that trigger interactional collaborative innovation? Taking drug development as the most prominent feature of radical innovation in the biopharmaceutical industries, the first characteristic is the demand for up-to-date expertise which requires a permanent connection with the frontiers of research. For example, Herrera (2001) states: "research is the engine of Europe's Biotech Industry". Biotech firms are permanently "operating at the cutting edge of a set of technologies" (ibid) closely connected to universities and public research organisations. Furthermore, the development of a single drug needs a combination of different knowledge stocks and specialised expertise in a number of fields; it requires, for example, extensive clinical testing. Small firms such as university spin-offs have to build up a close connection to hospitals and big pharmaceutical firms in order to get access to relevant knowledge in these areas.

Because biopharmaceutical innovations rely on 'combinatorial technolo-

gies', large firms also have a need for networking: "Vertical integration is no longer the only way for pharmaceutical companies to have access to complementary and specific assets, especially at the first stage of cooperation. They take advantage of the complementary and combinatorial nature of biotechnologies to conceive new organisational forms within a cooperative

using the national public and private R&D efforts as input indicators and the number of national patents and other similar measures as output indicators, the VoC and NIS literatures conclude that national knowledge bases are restricted. External and in particular foreign knowledge sources are not adequately considered. Facing the global knowledge requirements men-

Figure 12: Increasing network activity in knowledge-intensive industries



relationship with both start-ups and public or quasi-public research organisations. Most pharmaceutical companies are engaged in more or less complex operations such as mergers and acquisitions, joint ventures, cross-licensing and, more generally multi-firm alliances. They often involve several bilateral strategic alliances with different actors. In this context, the strategy is to focus on many partnerships with widely diverse competencies and goals. At the industry level, this leads to a very complex mapping of ties between actors" (Staropoli 1998: 13-23).

How can these high demands for expertise, knowledge and R&D in various disciplinary fields be satisfied when they require the collaboration of actors from all over the world located in different types of organisations? By

tioned above, these restrictions must be overcome on the firm level by actors who combine their competences and expertises – competences that cannot necessarily be found only at the national level. Innovation performance in knowledge-intensive industries, either incremental or radical, can only be achieved via international and inter-organisational partnerships.

Accordingly, we observe high and increasing collaborative activity in knowledge-intensive industries. Illustrating the general trend, figure 12 shows the new international strategic technology alliances for IT and biotechnology. The amount of collaborative activity at least matches and sometimes overtakes the cumulative number of collaborations for all other

technologies (National Science Board 2002 Fig. 2-36).

In knowledge-intensive industries network formation does not seem to be a passing phenomenon, which disappears with the maturation of the industry. Instead, networks persist as the main structuring principle of the biotech industry despite firms changing their components, attachment strategies and structural properties. For example, in the UK and German biopharmaceutical industries, collaborative activity can be observed as a permanent feature. Collaboration is so important that a number of "match-making" firms (e.g. Pharmedicalensing Intl. Inc., BioScan) have been established whose role is to inform companies about possible international partners.

For example, 86 percent of German dedicated biotechnology firms have R&D partnerships either with other firms or with research organisations (EBIS 2000). Not surprisingly, for both Germany and the UK, we observe a strong increase of collaborative activity in the early phase of the development

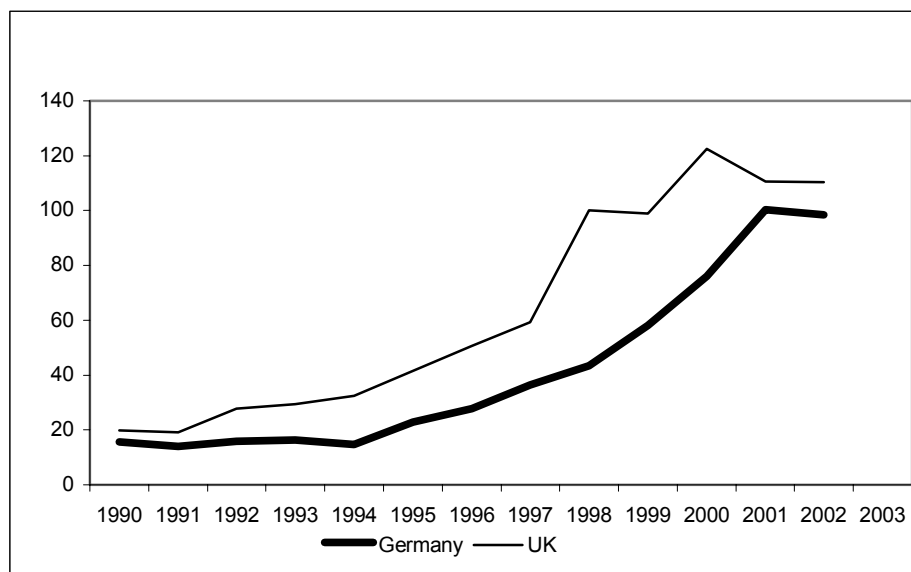
of their biotech industries because of missing absorptive capacities and the inflexibility of established big firms (large diversified firms, LDFs), which have to rely on specialised small high tech enterprises (dedicated biotech firms, DBFs) to act as translators in order to bridge knowledge gaps (Pyka/Saviotti 2005). For their part, DBFs need the LDFs as commercialisers of their technological knowledge. As a result, we observe a change of the sectoral knowledge base: LDFs collect competences via fusions and acquisitions; and DBFs and LDFs form networks in order to benefit from one another's competences. The observed early co-operations between LDFs and DBFs are not restricted to a national level, as can be seen in table 4.

Later in the development of the sector, the composition, attachment strategies and structural properties of the networks change to a stronger focus on DBF-DBF partnerships and to the growth of financing as a tie between firms, in addition to R&D links (for a description of a similar evolution of network dynamics in the US biotech industries, see Powell et al. 2005). The

Table 4: Examples of international LDF-DBF networks

LDF	AHP	Bayer	Boeh. Ingel.	Dupont Merck	Eli Lilly	Glaxo Wellc.	Hoechst	Roche	Merck & Co	Novartis	Pfizer	SKB	Warn. Lamb.	Zeneca
DBF														
Affymax	2					1	1		1	2				
Affymetrix	1							2						
ArQule	2							1						
British Biotech.	1					2				1	1	2		
Celltech			1						2					2
Chiron							1	1		1			1	
CoCensys	1									1			1	
Human Genome Scie.								1				3		
Incyte Pharma		1			1		1			1	1	1		
Millenium Bio Therap.	1				2			1						
Neurogen	1										3			
Onyx		1			1								2	
Repligen					1	1			2	1	2			
Scios				1	1		1	1			1			
Sequana Therap.			1			1		1					1	
SIBIA					1	1				1				
Xenova													2	

Source: Pyka/Saviotti 2000: 28

Figure 13: Biotechnology patents (UK and D) with foreign partners

Source: OECD Corporate Data Environment and own estimations

trend towards international network formation also increases. Figure 13 shows the co-patenting activity of German and UK biotech firms with foreign partners.

UK firms have a higher proportion of co-patents but have less patents in total, which means that the two curves converge, providing yet more evidence of the similarities of the industries in the two countries, noted above.

Another factor leading to network formation and internationalisation is the biopharmaceutical industry's need for capital. To develop a new drug, capital of about 600 Mill. EUR must typically be available and the development will need a period of about 10-12 years until the point when commercialisation is a possibility. The immense resources required for R&D, clinical testing and marketing exceed the capabilities of single firms. The risks and uncertainty inherent in new drug development are indicated by the high exit rate of projects and firms.

When Germany is stated in the VoC and NIS literature to be at a disadvantage in the area of radical innovations such as drug development or in suc-

cessfully establishing knowledge-based industries as a whole, it is the capital requirements and risks that are mainly considered. Summarising, it is argued (Casper/Kettler, 2001: 16f.) that the national institutional framework in Germany makes money scarce for risk-intensive and expensive projects (see above). However, this is true – at least in these dimensions – for any national economy, including the UK. To overcome the problem, network formation is the strategy of choice in both Germany and the UK. The missing resources are gained within globally-oriented innovation networks (international VC-DBF partnerships; international DBF-LDF partnerships, cross-border mergers and acquisitions). In addition we have shown in section 3.2 that foreign direct investment is important for the biotechnology-based industries as an external source for financing innovation.

4 Conclusions

National frameworks alone cannot provide the necessary knowledge stocks and financial resources to produce innovation in knowledge-

intensive industries. Complementing the collaborative activity on the national and regional level which is already significant, we observe increasing international network formation as the main organisational feature of research and production. These collaborations are intended to alleviate the disadvantages stemming from the restrictions of national institutional infrastructures.

While heterogeneity persists at the level of institutional frameworks and path-dependent innovation environments, the differences are of decreasing relevance in knowledge-intensive industries, where networks dominate industrial organisation and lead to convergence and alignment. In knowledge-intensive sectors such as the biopharmaceutical industry, the necessities of knowledge exchange, transfer, co-operation and diffusion between firms leads to a strong structural and dynamic alignment of national industries. Inter-organisational networks seem to offer a kind of "second order co-ordination" alongside institutional frameworks shaping economic action. Commonalities and differences of different "capitalisms" (as proposed by the VoC approach) or national institutional frameworks (the NIS approach) must be re-considered for modern knowledge societies.

Research is necessary to show how networks perform this alignment process and which network features qualify for what organisational reflexes. Social network analysis (e.g. Granovetter/Swedberg 2001; Kadushin 2004) suggests that dense networks (e.g. those now being established in the knowledge-based industries) tend to show the alignment of members and processes as a typical effect due to knowledge distribution in networks. The network members become more similar not only in their knowledge but also in their intentions and strategic behaviour. Agent-based modelling of network formation in knowledge-based industries (Gilbert et al 2001,

Ahrweiler/Pyka/Gilbert 2004) sheds some light on the procedural aspects of these issues. Nevertheless, further theoretical, empirical and modelling efforts are required to work on the complex features of innovation dynamics and industrial organisation in knowledge-based economies.

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