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Knowledge companies in Britain and Germany: A common response to the challenges of the emerging knowledge-based economy?

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Summary

This report presents the findings of a research project, funded by the Anglo-German Foundation, on the emerging knowledge-based economy. It examines and compares, through a multidisciplinary research network of British and German researchers, the trends and implications of the knowledge-based economy in two important European high-technology agglomerations in the West of England and Lower Saxony. The authors attempt to identify the opportunities available to highly innovative and knowledge-intensive firms, and examine how firms' managers are adopting policies that enhance the competitiveness of their companies.

The authors found that, in general, the majority of new start-ups and high-technology companies in both agglomerations are developing a similar, systematic approach, in the form of knowledge management, for the promotion and diffusion of knowledge within their organisations. They perceive that their competitiveness depends to a large extent on their human and partnership knowledge capital. Many of the firms investigated found that they employ a number of indicators for evaluating their knowledge management practices. However, in both agglomerations, knowledge-intensive companies encounter considerable skills shortages, especially in the case of electronic engineers and technicians.

Finally, the comparison of the two regions has some policy implications, as it allows 'best practices' to be discerned. These include, *inter alia*, the adoption of knowledge management techniques for the diffusion of knowledge amongst a company's employees; the development of partnerships with other firms and/or research institutions for the acquisition of knowledge; the encouragement of new ideas and new applications within the firm; and the provision of training for the upgrading of their workers' skills.

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List of acronyms

CEO	chief executive officer
DTI	Department of Trade and Industry
EIH	Existenzgründungsinitiative Hannover Region
EU	European Union
GDP	gross domestic product
HE	higher education
ICT	information and communication technology
IS	information systems
IT	information technology
NVQ	National Vocational Qualification
OECD	Organisation for Economic Cooperation and Development
R&D	research and development
RDA	Research Development Agency
RTD	research and technology development
SMEs	Small and medium-sized enterprises

1 Introduction

There is now widespread recognition that the growth and diffusion of knowledge and information are vital for the competitiveness of enterprises, regions, nations and even regional groupings, such as the European Union (EU). Various observers point out that knowledge is behind the dramatic economic change that is occurring globally. Today's global economy is in transition. It is becoming a *knowledge-based economy*.[1] The unprecedented pace of scientific and technological innovation is an important factor in the rapid globalisation of knowledge and information. Developments such as the Internet and mobile telephony have brought the 'global village' ever nearer. It is also acknowledged that the world's technologically advanced economies are now more dependent on the creation, dissemination, adaptation and utilisation of knowledge than ever before. New knowledge is more likely to be the result of a recombination of accumulated tacit and codified knowledge, so entities embedded in a knowledge-rich environment produce a considerable amount of innovation. The significance of knowledge and innovation has emerged, along with their implications for economic development, as a major subject for discussion during the late 1990s and early twenty-first century. Policy-makers of local, regional and national government, as well as international agencies and supranational institutions such as the EU, Organisation for Economic Cooperation and Development (OECD) and World Bank, are taking a number of initiatives for promoting the knowledge-based economy.

Many knowledge-intensive firms, including those producing high-technology products and services, are now realising the importance of knowledge in improving their corporate performance. They are starting to create knowledge management programmes and to appoint knowledge executives in order to manage their intellectual capital and research and development (R&D) efforts in a globalised environment. More specifically, top management is now committing more and more resources to the production of knowledge. Managers are more likely to undertake long-term and/or blue-sky research, and to sacrifice profits today for growth tomorrow. Also, tacit and codified knowledge embodied in human capital and technology is creating new industries and services, and encouraging the emergence and growth of new knowledge-intensive firms. Although new information technology (IT) can help in the codification of knowledge, it cannot completely replace face-to-face contact, which remains particularly critical for the diffusion of tacit knowledge. Sharing such knowledge within a firm, as well as among firms in a geographical agglomeration, is not so problematic as storing tacit knowledge in a database.

Furthermore, the importance of knowledge has increased as a result of the liberalisation and deregulation of markets for goods and services in Europe and elsewhere. In the light of the intensification of global competition, knowledge-intensive firms are locating sophisticated R&D in dispersed locations. Such locations are mainly in developed countries (plus a handful of developing countries) that have succeeded in building a critical mass of

[1] Many terms such as *information society* and *new economy*, to name but two, are used alongside *knowledge-based economy*.

science and technology capabilities. Decisions to locate R&D facilities in a particular locality are driven by a wide range of factors, many of which are not easily identified in company surveys. However, local or regional resources in the form of a highly skilled and specialised workforce, a competitive and vibrant environment, and technological capabilities, all of which often cluster around particular regional and urban agglomerations, are deemed to be important. In Europe, in particular, the integration of its market and the growing importance of some of its regional and urban agglomerations are also affecting the internationalisation of firms' R&D.

As companies reorganise their activities globally and countries are integrating within the globalising knowledge-based economy, governments are becoming concerned about devising new technological policies to foster the creation, diffusion and effective use of knowledge. Thus, during the last few years a new paradigm for promoting the knowledge-based economy has emerged, in which investment in science and technology capability is of high priority. Since human resources are the most important determinant of a knowledge-based economy, improvement in educational provision and acquisition of scientific expertise are extremely important.

Aims and objectives

The focus of this comparative study is to identify how corporate governance of high-technology British and German companies in two geographical clusters is preparing itself for the emerging knowledge-based economy in the twenty-first century. The main objectives of the project are to:

- examine through literature the relevance of the knowledge-based economy in theory and practice;
- identify the opportunities available to highly innovative and knowledge-intensive firms;
- analyse how firms' managers are adopting policies that enhance the competitiveness of their companies;
- explore whether a common response can be discerned, given the ever-increasing integration of British and German economies in the European context.

The project will contribute to policy formulation by helping company managers and policy-makers to understand more fully the processes of the emerging knowledge-based economy. We hypothesise that for the European regions and localities, new opportunities – as well as threats – are opening up, as their economies move from traditional 'production' to a new model based on the post-industrial knowledge-based economy. In this 'new economy', the production, diffusion and use of information become the key components of corporate competitiveness and economic performance.

Methodology

These objectives are realised by undertaking a comparative research study in two high-technology regional agglomerations in Britain and Germany. In order to understand knowledge as a contributor to innovative activity, and the extent to which it can be classed as a transferable factor in the development of innovative companies, we will examine the empirical evidence from these two emerging knowledge-based agglomerations, namely the M4/M5 corridors in the West of England and the Hanover–Brunswick–Göttingen economic triangle in Germany.

The M4/M5 corridors in the West of England are a mix of industrial estates, business parks, factories, warehouses and research institutions extending westwards from Swindon to Bristol, and northwards from Bristol to Cheltenham. The growth of high-technology firms, primarily regionally owned, in the 'golden triangle' of Bristol, Swindon and Gloucester (also known as 'Silicon Gorge') has been remarkable. The triangle, according to the *Financial Times* (14 October 1999), is becoming a serious competitor to the Thames Valley, Cambridge and Scotland.

Like the West of England, the Hanover triangle offers a very diverse picture. On the one hand, there is still a heavy economic dependence on the car industry. Volkswagen and its supplier network hold a fairly high share (20%) of the region's manufacturing employment. On the other hand, according to a study by the Niedersächsisches Institut für Wirtschaftsforschung (NIW) and the Norddeutsche Landesbank (NORD/LB), the region is equipped with excellent private and public research facilities, and includes innovative firms in multimedia, biotechnology and environmental engineering (NIW and NORD/LB 1998).

In this report we first present a historical overview of the evolution of the knowledge-based economy, within the macro-environment of the political economy of Europe and then the two sub-regional agglomerations in the South West of England and Lower Saxony. Then we carry out case studies to identify how high-technology companies are preparing, if at all, for the knowledge-based economy. By means of in-depth interviews with top managers of 24 innovative companies (14 in the West of England and 10 in Lower Saxony), complemented by a questionnaire survey (only in the West of England), the study attempts to identify the way in which managers develop strategies for the future, understand how technology can serve those strategies, and utilise the local highly skilled and educated workforce. The assumption made is that high-technology firms normally prepare and implement long-term research and technology development (RTD) policies in the firm's board meetings, and do not normally communicate these policies to the general public. However, by interviewing senior executives we expect to obtain some clues about how firms might develop and what policies might be adopted.

The main task is the exploration of common features of successful high technology companies in Britain and Germany, and the examination of the extent to which these features can be integrated into other contexts (for instance, for the benefit of less innovative companies). In doing so, the two teams take account of the impact of additional factors such as cultural differences, national entrepreneurial practices and attitudes, and the existence of trust in local/regional politico-administrative initiatives which encourage inter-organisational collaboration.

The research draws on some of the recent theoretical arguments (the new economy, knowledge societies, innovative milieux, clusters, networks and learning) put forward in economics, political science, economic geography, sociology and business management with respect to this subject. We employ the most relevant internationally comparable indicators to highlight recent trends in science and technology, and new indicators that can measure innovative performance and other related outputs of a knowledge-based economy. We can effectively analyse and evaluate knowledge capabilities within and across organisations if we apply a framework within which evidence about knowledge capability development can be structured and interpreted. We suggest a structure that draws on our experience in carrying out research on learning for innovation (Konstadakopulos 2000a, 2000b; Revilla Diez 2000a, 2000b, 2001a) and on a search of the literature. An appropriate framework for support comes from previously published reports (Edvinsson and Malone 1997) and particularly from the work of Miller *et al.* (1999) on measuring and reporting intellectual capital.

The combined interview and questionnaire survey covers the following main themes:

- *General information, history and performance*. What are the main characteristics of the firms in terms of size, origins, line of business, and innovative activity?
- *Firms' internal management of intangible assets*. We consider the characteristics of the firms' workforce in terms of skilled employees, labour turnover, skills shortages, and training and retraining activities. In addition, firms' intangible investments, and investment in IT and in particular e-commerce, are examined. What indicators of human knowledge and firm-specific knowledge capital do managers employ?
- *Firms' external reporting of intellectual capital*. Relations with suppliers and customers in knowledge-driven sectors with respect to innovation and technology transfer, and their role in the innovative activity of the firm.
- *Firms' strategies for the future*. How strategy (including long-term R&D strategy) originating from human capital (employees/managers, leader know-how, experience, education, etc.) is translated into working practices and customer capital.

The questionnaire was directed at senior managers of both small and large local knowledge-based companies that have identified knowledge as a vital resource, and companies that consider themselves in transition from capital- to knowledge-intensive organisations. Broadly, the sample included high- and medium- high-technology manufacturing and services in finance, insurance and telecommunications as identified by Keeble *et al.* (1999), as well as technology-based, knowledge-based business services as identified in reports of the OECD (1999a; 1999b; 1999c). The OECD notion of knowledge-based industries and services attempts to bring together sectors with high R&D activity, high use of information and communication technology (ICT) and/or a significant proportion of highly skilled workers. In addition to the commonly identified high-technology industries, activities such as banking, insurance, health and education (in the business sector) are included in our sample. In common with the rest of the OECD countries, knowledge-based industries and services in Britain and Germany have grown from 45% of gross domestic product (GDP) in 1985 to 50% in the late 1990s (OECD 1999c: 43). Similarly, high- and medium high-technology goods represent an increasing share of internationally traded goods.

The selection of company managers was based partly on an existing database compiled from previous surveys and partly on the recommendations of key informants, including company executives themselves.

Overview

The report begins, in Chapter 2, with a literature review on the theoretical and pragmatic foundations of the knowledge-based economy. It continues with an assessment of the gap between the rhetoric and reality regarding the knowledge-based economy.

Chapter 3 introduces some aspects of framework conditions which are currently the focus of regional or local authorities' policies in the West of England and Lower Saxony and which are necessary to meet the challenges of the knowledge-based economy. This includes regional policies for the creation of high-technology clusters, the development of human capital, the improvement of IT and R&D infrastructure, the introduction of financial and fiscal measures, and assistance in achieving networking.

Chapter 4 analyses and compares the results of the empirical surveys. Special attention is paid to the activities adopted by knowledge-driven companies in the West of England and Lower Saxony in order to compete in the knowledge-based economy. These include actions on training and retraining of the workforce, adoption of IT technology (and, in particular, e-commerce), innovation and technology transfer networks, and long-term research and technology development strategies.

Chapter 5 summarises the findings and puts forward some policy recommendations.

2 The theoretical and pragmatic characteristics of the emerging knowledge-based economy

Background

The forces for globalisation of economic activity and the advancement of technology point to the advent of knowledge as the main reason for economic growth. Yet relatively little is known about the knowledge-based economy. The OECD (1996) defines knowledge-based economies as those which are 'directly based on the production, distribution and use of knowledge and information'. The phenomenon of the knowledge-based economy is broadly encompassing, incorporating all the actors from both the public and private sectors of administration, business and education in the development, dissemination and application of knowledge. Most recent literature attempts to elaborate on the role of knowledge in shaping not only the economy but also the whole social system (Thurow 1999; Leadbeater 1999; Kukliński and Orlowski 2000).

The growing knowledge-based economy has important policy implications for all members of the European Union, the European Economic Area and the EU accession countries (Kukliński 2000). European economies are more dependent on knowledge than ever before. As mentioned in the Introduction, knowledge – embodied in the human capital and in technology – is creating new knowledge-driven industries and services. However, the knowledge-based economy is emerging in an era of profound changes in Europe as well as in the rest of the world. These changes are based primarily on technology and are shaping the world economy. Technology, in particular, is becoming the main source of competitive advantage and is associated closely with the regional dynamics of European integration. As European companies reorganise their activities globally, governments are concerned to find new ways of fostering their innovation capacity domestically. However, the European knowledge-based economy will be developed not solely by market forces but also by a set of socio-economic policies designed and implemented at the European, national and, increasingly, the regional and local levels.

It is only recently that the concept of the knowledge-based economy has featured prominently in the strategies for the economic development of national governments and regions/localities, in Europe as well as in the rest of the world. For instance, the economic development policy of the British government is focused on the development of clusters of knowledge-intensive companies (Department for Trade and Industry (DTI) 1998) rather than on pure job creation. The economic policies of Singapore and Malaysia, aimed at developing their respective countries into knowledge-based economies, are rather more detailed, concrete and ambitious. According to Singapore's Economic Development Board (1999), the intention is to develop the city-state into a global hub of the knowledge-based economy. It is devising sectoral policies for sustaining and building on its manufacturing and services sectors, with strong emphasis on technology and

innovation. Malaysia, too, is building an infrastructure for knowledge enhancement in the form of a 'multimedia superhighway corridor' to act as a magnet for knowledge-intensive companies.

Sub-national entities have also undertaken policies to stimulate the development of knowledge through new forms of collaboration. The Canadian province of Nova Scotia is a prominent example of a region in which firms and government have recognised the challenge of the knowledge-based economy and responded promptly (Konstadakopulos *et al.* 2000; Nova Scotia Economic Development 2000). The province has established a partnership programme to take action towards building its knowledge economy. On the other side of the Atlantic, the region of the South West of England, through the newly established South West of England Regional Development Agency (SWERDA), has also started to take new measures for economic success that supplement traditional ones. SWERDA is seeking to establish centres of excellency and knowledge networks necessary for enabling the region's large number of innovative companies and research institutions to exploit innovation, emerging technologies and knowledge-based industries (SWERDA, 2000).

At the supranational level, the European Commission has taken a number of initiatives to expedite the shift towards a knowledge-based economy and society (as the Commission now refers to the concept, reflecting its desire to include the social dimension). In 1997, the European Union adopted a communication document entitled *Towards a Europe of Knowledge*, proposed by the Commission for the creation of a European common response to the challenges of the emerging knowledge-based economy. At the Lisbon extraordinary summit in 2000, the discussion document *Employment, Economic Reforms and Social Cohesion – Towards a Europe Based on Innovation and Knowledge* highlighted the need for Europe to hasten her transition to a knowledge-based economy by investing in people. Many activities for the promotion of the knowledge-based economy and society have been incorporated in the Commission's draft 6th Framework Programme on the creation of a 'European Research Area'.

The OECD has produced a number of studies on the knowledge-based economy, and has originated models to facilitate the measuring and monitoring of the features of successful knowledge-based economies in the developed world. For instance, OECD (199a) contains many standard indicators of economic performance (R&D intensity, export shares and productivity measures), as well as new indicators which reflect the knowledge-based economy (intangible investments in R&D and education, computer penetration and e-commerce activity). In addition, the World Bank – concerned with the slow economic growth of the majority of developing countries – has adopted the concept of knowledge as the centrepiece of its development policy.

Beyond the rhetoric, however, are there any indicators that could confirm the arrival of the knowledge-based economy in the two countries under consideration in this report, namely Britain and Germany? Table 2.1 includes some indicators that on the one hand shed some light on both countries' technological base and on the other measure the penetration of IT (personal computers and Internet hosts).

The data on scientists and engineers are derived from censuses and do not take into account the difference in the quality of education and training between the two countries. Similarly, although public and private R&D expenditure, as shown in Table 2.1, is not a guarantee for technological advancement, nevertheless it increases the

Table 2.1
Selective development indicators for Germany and the United Kingdom

	Scientists and engineers in R&D, 1987–97[a]	Scientific and technical journal articles 1995	Expenditures for R&D, 1987–97[b]	High technology exports, 1998[c]	Patent applications filed by residents 1997	Personal computers, 1998[d]	Internet hosts, July 1999[e]
Germany	2,831	30,654	2.41	14	62,052	304.7	173.96
United Kingdom	2,448	32,980	1.95	28	26,591	263.0	270.60
Europe (euro zone)	2,126	98,365	2.16	15	101,037	228.9	157.53

Source: World Bank (2000).
Notes:
[a] Per million people
[b] % of GNP
[c] % of manufactured exports
[d] Per 1,000 people
[e] Per 10,000 people

accumulation of knowledge. However, pure firm R&D intensity is a better indicator, as it reflects firms' efforts to make technological innovation a basis for their competitiveness. It is higher in Germany than in United Kingdom, which is below the OECD average (OECD 1999a: 13).

The bibliographic indicator in Table 2.1, counting scientific and technical journal articles, may exclude some of regional or local importance and may be biased towards English-language journals. High-technology exports with high R&D intensity are based on high-technology products rather than on industrial sectors, which may produce a mixture of high- as well as low-technology products. These exports include high-technology products such as aerospace, computers, pharmaceuticals, scientific instruments and electrical machinery. The share of firms that have introduced at least one new or improved product or process in the market over a given period of time is an important indicator of innovation. Germany – together with the USA and Japan – is a major patenting country, and has the largest percentage of firms that have introduced a new product or service over a given period. The data on patents indicate that Germany has more than twice as many patented inventions as the United Kingdom or indeed any other European country.

The indicator on personal computers shown in Table 2.1 is the estimated number of self-contained computers designed to be used by a single individual. However, as it is possible that thousands of personal computers may be connected to a single mainframe computer, this indicator may understate the total use of computers. Computer penetration rates are an indicator of IT diffusion in homes and in workplaces. The number of PCs per thousand people is a broad indicator of IT uptake within a country's population. Internet hosts are the number of computers with active Internet protocol addresses connected to the Internet.

A cursory evaluation of the figures shown in Table 2.1 reveals that, from the seven indicators shown, Germany is doing better than the United Kingdom in four indicators, while the United Kingdom is doing better in three. Both countries perform above the European (or euro zone) average.

Certainly much about the knowledge-based economy's rise in popularity is based on vogue. Nonetheless, policy-makers are keeping a watchful eye on the various facets of this phenomenon in order to adopt the necessary conditions for enhancing the development of knowledge-based economies.

Many firms are embracing knowledge in order to achieve world-wide success. Within organisations, knowledge management has gained substantial momentum, and has replaced previously popular concepts in management literature such as re-engineering and information management (Seely Brown and Duguid 2000: 118–119). The majority of such knowledge-intensive firms appear to have the following qualities in common: they have adopted a clear strategy for their future; they have a good understanding of how technology can serve this strategy; they collaborate extensively with their customers and suppliers; and they value and reward handsomely their highly skilled and educated workforce. The management theory of the late 1990s has accepted the idea that successful companies of the future will depend on their ability to harness the know-how and creativity of their employees and more particularly of Peter Drucker's so-called teams of 'knowledge-workers' (Kanter 1995; Leadbeater 1998: 380; Owen 1999: 43).

It is customary for knowledge to be subdivided into technological knowledge and economic competence. According to Clement *et al.* (1998), firms are involved in the acquisition of existing technological knowledge through activities of the first order such as patents, licences, and application software, and of economic competences through activities of the first order such as (basic) training and market research. They are also creating new technological knowledge through activities of the second order, with R&D projects within the firm and cooperation in the R&D field. Furthermore, they are creating new economic competences through activities of the second order such as further education and training, organisational development, and cooperation in the economic field (market identification and market development).

We shall argue that knowledge capability is heterogeneous across firms and develops in incremental, evolutionary, idiosyncratic ways. Knowledge capability is therefore difficult to replicate, as most of it tends to be tacit in nature, localised and firm-specific. It emerges from the interaction between the firm's resources, corporate culture and environments. The production, deployment and exploitation of knowledge develops through an extensive process of learning (and unlearning) as well as knowledge accumulation. The process also involves the deployment, coordination and integration of internal and external skills and resources. Firms do not develop high levels of knowledge capability overnight, and so the history of the firm is important.

We suggest that firms with high knowledge capabilities are more able to deliver high-value products or processes. This is because they can deploy new technologies and use them to create opportunities for growth and competitive advantage. Such firms are more likely to have developed information technology/information systems (IS) infrastructure, human capital, and relationships with external customers/suppliers. More importantly, they are likely to be located near other similar-minded companies.

Regional agglomerations as a focus for the knowledge-based economy

Knowledge-intensive industries in all parts of the world are likely to cluster together and to prosper in growth regions. This implies the elimination of certain political and administrative frontiers and the creation of other boundaries or delimitations related to geographical concentrations or sectoral clustering. The most crucial aspect of such clustering is the opportunity it provides for innovation and creativity through technology spillovers, information sharing, and the exchange of tacit and codified knowledge. California's Silicon Valley – the industrial strip between San Francisco and San Jose in northern California – is the best-known recent example of agglomeration. There are quite a few clusters in Europe that resemble Silicon Valley, from the high-technology agglomeration of Cambridge's Silicon Fen to low-technology ones such as northern Italy's textile and ceramic tile businesses.

Porter (1990, 1996) and Kanter (1995) have argued that the most competitive industries tend to be highly integrated ('clustered'), with favourable consequences for learning, innovation and competitive advantage. The existence of regional clusters[2] is a topic that has been well documented during the last two decades (Feser, 1998). According to Porter (1996: 85), the regionally concentrated cluster, and not the individual industry, is the appropriate unit of analysis on empirical grounds. Regional clusters are often a mixture of mature and emerging industries, as opposed to those which are exclusively high-technology, knowledge-intensive, innovative and newly established (Porter 1996: 87–88).

The attraction of regional clusters is reflected in the cluster policies devised by decision-makers for the development of an area, especially when faced with the threat of globalisation. In Europe, regional policies in several regions are geared to the promotion of sectoral clusters. Some of the German *Länder* (such as North Rhine-Westphalia and Baden-Württemberg) and some of the autonomous communities in Spain (Catalonia and the Basque country) have adopted cluster policies at the regional level (Lagendijk 1998: 319). In the United Kingdom, cluster policies and initiatives emerged out of sectoral policies that were evolved from the Marshallian *'industrial district'* model of development. They are now part of a more comprehensive policy in Scotland, Wales and Northern Ireland, rather than England (Lagendijk, 1998: 328–330). However, more recently the English regions, including the South West, have started to adopt cluster policies, and this will be discussed in greater detail in the following chapter.

[2] There are many terms for denoting clusters, especially in the context of regional development: *agglomerations, growth triangles, industrial districts, innovative milieux, local production systems, metropolitan areas* and *technological districts.*

3 Regional strategies for the knowledge-based economy

The emergence of the knowledge-based economy is taking place in the context of the increasing integration of international and European industrial systems into trading blocs. At the same time, regional and urban agglomerations and their linkage with regional, interregional and transnational networks are gaining in importance. In an integrating Europe, there are not only greater than ever flows of goods and services, but also commercial, financial and technological information exchange of tacit and codified knowledge. There are many examples of successful stories from European regions that are knowledge centres and have become specialised in high technology. The clustering of biotechnology firms in the Cambridge area of the United Kingdom, the grouping of racing car designers outside London, and the concentration of biomedical equipment and software firms in Dublin indicate that regional agglomerations are important aspects of regional growth. The West of England sub-region – part of the administrative region of the South West of England – is also acquiring dominance in niche markets such as aerospace, multimedia and precision engineering, especially in the so-called 'golden triangle' of Bristol, Swindon and Cheltenham. An analysis of research strength and patterns of specialisation, based on bibliometric indicators, ranks the urban agglomeration of Bristol – jointly with that of Cardiff, in neighbouring South Wales – as an outstanding centre of knowledge in Europe after Cambridge, Oxford–Reading, Geneva–Lausanne, and Basel–Mulhouse–Freiburg (Mathiessen and Schwarz 2000: 53–55).

Industrial R&D in Lower Saxony is enjoying an upswing. In comparison with southern German agglomerations, with their high research density, a certain disparity still persists. But the gap between the Hanover region and the leading agglomerations in western Germany has decreased considerably since the 1990s. This catching-up process on the part of the Hanover region has much to do with the growth of the business-oriented service sector as well as with the still dominant automobile sector. Considerable advancements are being made in biotechnology, especially in the field of medical technology, communication technology and multimedia.

In the discussion that follows, and in the context of the emerging knowledge-based economy, we shall try to understand how our two regions have achieved economic success, and consider whether they are making long-term investments in skills, innovation and entrepreneurship.

The innovative milieu of the West of England

The economy of the West of England

The West of England is a vital part of the administrative region of the South West of England,[3] one of the UK's largest and best-performing regions. In order to understand the emerging knowledge-based economy in the sub-region, it is necessary to examine the economy of the South West as a whole. Although the South West is a peripheral region, its economy has been growing steadily over the past two decades. Its GDP per head stands at around 91% of the UK level (provisional figures for 1999: DTI 2001), and 95% of the EU average. However, the region displays high levels of economic activity – 61% compared to the EU average of 55% (SWERDA, 2000). The region is characterised by an extreme divergence of GDP, from 115% in Wiltshire in the north-east to only 70% in the extreme south-western county of Cornwall. Furthermore, its economy is based on a diversity of sectors, such as defence, aerospace, financial services, multimedia and electronics.

The region has a relatively large number of indigenous small and medium-sized enterprises (SMEs), and although business start-up rates are relatively low, their survival rates are above the national average. However, the majority of the region's businesses are either sole traders or partnerships, with only a quarter registered as limited companies (DTI and Department for Education and Employment 2001). Employment growth has been high, with nearly 170,000 jobs created between 1991 and 1997. The South West also has one of the lowest regional unemployment rates in the UK (2.2% in January 2001, compared with 3.5% for the UK as a whole) (DTI 2001). Only a small proportion of its workforce is now employed in manufacturing, and this is concentrated in light manufacturing industries. However, parts of the region are experiencing skills shortages, especially for engineers, technicians and clerical staff.

The economy of the South West is not particularly dependent on foreign investment, as the number of inward investments is lower than in all other British regions except Northern Ireland. Nevertheless, of the companies at the leading edge of technology, more than 1,200 that are foreign-controlled – mostly of North American, Far Eastern and European origin. According to Sir Michael Lickiss, Chairman of SWERDA, he main incentives for relocation in the South West are considered to be the English language and culture, accessibility to the EU's markets, and the region's highly skilled workforce and pristine natural environment (see Braddon and Konstadakopulos 1999: 10). The South West has seven universities and over 40 colleges, and 47% of all economically active adults are qualified to at least NVQ level 3 or equivalent, with 27% to at least level 4 or equivalent (DTI, 2001).

[3] The South West of England consists of the counties and unitary authorities of Gloucestershire, South Gloucestershire, Bristol, Bath and North East Somerset, North Somerset, Somerset, Swindon and Wiltshire, Bournemouth, Dorset and Poole, Devon, Torbay and Plymouth, and Cornwall and the Isles of Scilly.

Regional support for the development of skills, innovation and entrepreneurship

During the 1970s and 1980s it was the policy of central government in London, via the Government Office for the South West, to attract high technology to the region as well as support strategically important national companies. High-technology grants were made available, especially by the Labour government, to the large electronics and defence and aerospace companies, whose R&D departments happened to be situated largely in the South West of England. However, with the arrival of the Conservative government in the late 1970s, a more sophisticated type of policy emerged, which sought to improve the technological performance of local firms and the diffusion of technology. In the 1980s, the central government reduced R&D grant aid and launched instead a number of regionalised technology transfer initiatives. In the 1990s, subsidies in support of technology and innovation were further reduced, and support was only made available for pre-competitive research. For instance, the *Advanced Technology Programmes* sought to promote long-term collaboration between UK companies in advanced technologies, while the *LINK* scheme aimed at assisting companies to undertake joint research with universities. In addition, nationwide projects such as *SMART* and *SPUR* were introduced in 1991 to support single-company innovation and have financially assisted a number of companies that we included in our West of England survey. With the support of Training and Enterprise Councils, and higher and further education institutions, efforts were made around the same time to create a better-skilled workforce and retrain redundant workers.

However, prior to the creation of the Regional Development Agency (RDA) in 1999, most regional technology initiatives were undertaken by the plethora of policy agents in the region, such as the sub-regional development agencies, business support organisations and government departments. As a result, regional policies were largely unfocused, inefficient and uncoordinated (Konstadakopulos 2000c).

The competitive advantage of the South West of England in defence, aerospace and electronics is mainly the result of Ministry of Defence public procurement policies that favoured national defence companies. In addition, the Labour governments of the 1960s and 1970s assisted the establishment of many high-technology companies in the area. Today, the region has an important aerospace cluster that includes well-known multinational companies such as BAe, GKN-Westland, Messier-Dowty and Rolls-Royce, along with many of their most important suppliers and subcontractors. The defence and aerospace industries have also given birth to marine and environmental technologies, as well as to electronics, telecommunications and software industries.

However, the endogenous economic development of the South West of England was greatly assisted by the establishment in late 1970s and 1980s of a number of American high-technology multinational companies (such as Dupont Electronics, Hewlett Packard, Intel, Logica, Lucent Technologies (formerly AT&T) and Motorola). Japanese (such as Honda) and European (mainly French and German) high-technology multinationals soon followed. The majority of foreign multinationals built their plants within the M4 corridor, thereby giving them easy access to London and Heathrow Airport. Initially, many of these plants were production units, or regional sales and servicing centres without significant R&D activity. However, many of the high-technology transnational corporations soon started to establish their own R&D facilities alongside their production plants, and most importantly they began to come into contact with regional research institutions and local firms.

The West of England is a good example to the rest of the region of how to adapt to the knowledge-based economy. The most important outcome of the high-technology clustering of British defence and aerospace companies and transnational corporations in this sub-region, in particular along the M4 corridor, and more recently along the M5, is the opportunity it provides for specialisation, innovation and creativity. The development of the area has been documented and analysed by a number of authors (Boddy *et al.* 1986; Konstadakopulos, 1997, 2000a; University of the West of England 1999).

The most important collective actors that have been operating in the region are the Training and Enterprise Councils, Business Links, Chambers of Commerce, a number of development agencies (all now part of the RDA), and the city and county councils. The area has a good reputation for being innovative, and a culture of innovation exists in its high-technology precision engineering, telecommunications and multimedia sectors. As in the rest of the region, the West of England has a highly qualified and skilled labour force. It has also benefited from being close to London and Oxford, two important centres of high technology and knowledge in the UK. During the last two decades, the area has seen a significant growth of indigenous, highly innovative and knowledge-intensive SMEs. Some of these are the result of a spin-off from large local technology-based companies. A previous survey of such SMEs has identified that a third of them have patented an innovation, and more than a fifth have produced a breakthrough innovation (University of the West of England 1999). Such efficiency is realised through technology spillovers, information sharing, and exchange of tacit and codified knowledge. As a consequence, new patterns of innovative activity have sprung up around the M4 and M5 corridors between the major urban centres of Bristol, Cheltenham and Swindon (the so-called Silicon Gorge). This triangle exhibits a knowledge-based economy characterised by the establishment of innovative and knowledge-intensive firms and knowledge institutions. In addition, a new type of firm and a new business culture are emerging in the knowledge-driven sectors of the local economy. Indigenous companies (such as Dyson Ltd, the most celebrated innovator in the region, Renishaw plc, Rotork plc, the Oscar-winning Aardman Animations, and Science Systems plc) are already on the way to becoming large multinationals. These companies are not only firmly embedded in the region, but also have a long history of innovation, particularly in high technology. In addition, they take advantage of the region's highly skilled and educated workforce.

Unlike the newly devolved Scotland, Wales, Northern Ireland and Greater London, the region does not yet possess an elected parliament or assembly. However, the South West Regional Development Agency was the first in England to launch a technology strategy for the promotion of knowledge-based industries (October 1999). SWERDA, responsible for an area with a population of 5 million, and with a modest annual budget of £76 million, is proceeding with the implementation of its strategy. It is aiming, rather ambitiously, to promote and provide financial assistance, through its Regional Development Fund, to four sectors with the greatest potential for the region's economy, and to encourage the development of four additional ones. The main sectors are: aerospace, automotive, instrumentation production and marine technologies. The sectors to be developed are: multimedia development, ICT hardware production, food processing and environmental technologies.

SWERDA is already supporting a number of incubator sites in order to facilitate the growth of knowledge-intensive companies and encourage the creation of high-technology clusters. For example, the emerging multimedia sector in the sub-region is supported by the Bristol Creative Technology Network, while the medical devices sector is

supported by Gloucestershire Medical School, linked to Cranfield University. SWERDA has promoted high-technology skills through the establishment of two specialised ICT institutions, and the creation of the Learning and Skills Council. Support for innovation has materialised with the establishment of university innovation centres that encourage closer links and joint research between regional universities and industries. Further initiatives are also being undertaken in order to increase awareness and understanding among businesses of e-commerce, and promote a climate of entrepreneurship in the form of risk capital for new start-up companies.

For some time the most important regional actors have been instrumental in the creation of sectoral innovation networks for the transfer of knowledge and technology. SWERDA is supporting the West of England's Aerospace Forum, which includes most of the companies involved in the aerospace supply chain. There is also considerable evidence that a number of entrepreneurs are choosing to settle within the region to take advantage of existing infrastructure facilities, the skilled workforce and the region's amenities.

The adoption of cluster policies and initiatives is important for developing the knowledge-based economy, but in the South West of England it is only during the last few years that attention has been paid to these policies in a comprehensive way. As we note in the following section, the *Land* of Lower Saxony has adopted similar policies in order to develop its own knowledge-driven industries.

It is still too early to assess the effect of such policies. Nevertheless, there are factors that contribute to, and others that mitigate, the development of the region and its path towards knowledge-based economy. The most influential factors are: a historically strong regional specialisation; socio-political embeddedness; effective information and knowledge networks,; existence of knowledge institutions; and strong local and/or regional culture.

A detailed investigation of the patterns of sociability in the South West of England in the past (Konstadakopulos 2000c) reveals a rather limited number of cooperative networks among economic actors such as companies and research institutions. The absence of strong associative order is due to the region's weak regional identity – the exception being the far South West, that is, Cornwall. Inter-group relations among companies have been mostly adversarial, based on the Anglo-Saxon individualistic form of business culture rather than on cooperative spirit. Companies in the South West of England share the same attributes: liberalism, individualism, profit orientation, high mobility of workforce, and low R&D spending. As will be shown in the following sections, these patterns of associative order contrast with the characteristics of the 'Rhine model' of Lower Saxony, symbolised by a cooperative spirit, emphasis on vocational training, respect for excellence, company loyalty, and harmonious labour relations.

The Hanover–Brunswick–Göttingen economic triangle

The Hanover–Brunswick–Göttingen economic triangle has comparatively favourable development prospects for the new decade. The danger – much discussed during the 1980s – of being uncoupled from the development of the growth regions in southern

Germany, and thus finding itself in a losing position in the process of regional structural transformation, seems to have been averted. This increase in development is not only attributable to the stimulation of demand created by German reunification, but is essentially based on a locational advantage brought about by the opening of the inner-German border, which has presented the region with new opportunities as a hub of important trans-European transport axes. Moreover, the region's infrastructure has been radically improved as a result of preparations for EXPO 2000.

Nonetheless, these positive developments in recent years have by no means been able to solve all the region's problems. These include the persistent issue of unemployment. In 1999 it stood at 11.4% in the Hanover region (56,000 registered unemployed), almost a quarter more than the western German average, and also above the average for western German agglomerations. Other major problems are the continuing heavy dependence on the automotive industry, the inadequate locational profile of sunrise technologies, the unmistakable need for modernisation in the domain of SMEs, the structural change in the service sector, and the existing deficits in the field of image policy and locational marketing.

The following description of the economic structure of the agglomeration will focus on the Hanover region, the driving force within the economic triangle and in Lower Saxony itself. The region comprises the state capital of Hanover and the district (*Landkreis*) of Hanover that surrounds it. The per capita income in the region lies slightly above the national average.

Manufacturing sector

The production sector in the Hanover agglomeration has a total labour force of 136,000 (as at 30 June 1999). The major branches are:

- construction (26,000 employees);
- automobiles and components (26,000);
- electrical engineering (13,600);
- food (8,600);
- mechanical engineering (7,500);
- rubber processing (6,600);
- energy (5,700);
- chemicals (4,800).

The automobile industry is particularly strong in the Hanover region, with more than 6% of all jobs belonging to this sector (well above the national average). It is dominated by the commercial vehicle plant of Volkswagen AG. The actual dependence, direct or indirect, of economic development in the region on the demand for vehicles is even higher than the above-mentioned figures indicate: many companies from other branches are suppliers for the national and international automotive industry, among them the rubber industry (tyres), plastics processing (plastic components and films), electrical engineering (starter batteries, etc.), mechanical engineering (brakes and engine parts), and the chemical industry (catalytic converters).

In total, there are 39 companies in the field of automotive and ancillary industries, employing nearly 31,000 persons. This corresponds to 33% of those employed in manufacturing industry and a 7% share of all employment in the Hanover region. During the 1990s, the importance of the automobile industry and its suppliers has remained constant. Against the background of this high degree of dependence, the regional rootedness of decision-makers and the presence of company headquarters in the area is of particular importance for the regional economy. Besides the group headquarters of Continental AG, major companies such as Volkswagen Nutzfahrzeuge and Varta relocated their head offices in the Hanover region during the 1990s. This development has played a considerable part in confirming Hanover as an automobile centre.

Around 40% of the industrial turnover of the region results from sales abroad. The actual dependence on export sales is probably even higher, owing to the specialisation of the supplying industries in the automobile industry. In this respect, it is above all the larger companies, with 500 or more employees, that are significant in terms of exports: four-fifths of all exports from the Hanover region come from such companies. Advance technology products play only a small role. Their share comprises just 9% of exports, although this has noticeably increased in recent years. The majority of exports (around 60%) come from the field of high-grade technology (especially the automobile industry).

The service sector

A total of 298,000 persons are employed in the service sector. The region specialises in the fields of transport and telecommunications, financial services and public services. The largest service branches are:

- wholesale and retail trade (62,000 employees);
- business-oriented services (55,000);
- non-profit organisations and regional authorities (42,000);
- science, education and media (32,000);
- transport and communications sector (30,000);
- health care (27,000);
- financial services (25,000);
- hotel and catering, home and other personal services (25,000).

The development of the service sector in the Hanover region was well below average during the 1980s. The top position among German agglomerations was occupied by Munich, followed by Nuremberg, Stuttgart, and Frankfurt am Main. The Hanover region's specialisation in the transport and telecommunications sector is outstanding, particularly in railways, telecommunications, road transport and other transport branches. Logistics services are becoming an increasingly important locational factor in the achievement of competitive edge at a time of growing market internationalisation and intensification of goods exchange. With its central position in respect of national and international markets and transport flows, and the high-quality logistics enterprises already present locally, the Hanover region satisfies the necessary preconditions for adopting and further developing an important function as a node for the flow of goods and services in the global value-added chains.

Financial services are also represented to an above average degree in comparison with other German agglomerations. For instance, the insurance branch is better represented than the banking industry. Public services are over-represented in the economic structure of the region. The business-oriented service sector has an average weighting in the economic structure compared with other agglomerations.

Of outstanding importance is the trade fair industry. Hanover is one of the world's most important trade fair locations; the five largest capital goods fairs in the world are all staged in the city. According to estimates made in 1997 by Deutsche Messe AG, the company running the trade fair site, these fairs attract an influx of purchasing power of some DM1.2–1.4 billion, and a production effect (including the multiplier effects) of around DM2.5–3.0 billion. They provide around 17,500 full-time jobs.

The most successful international flagship trade fairs are CeBIT and the Hanover Fair. CeBIT – the world's largest trade fair, with more than 7,500 exhibitors – is concerned with IT, software and telecommunications. The Hanover Fair is the world's largest trade fair for industry, automation and innovation.

Weaknesses are apparent in the region in legal and business consultancy, property, and asset management. Business advertising, which is concentrated to a considerable extent in Munich, Hamburg and Düsseldorf, is even less significant.

The regional system of research and development

During the last twenty years, regional authorities in Germany have increasingly moved in the direction of placing new emphases on regional policy, through innovation policies of their own. This recognises the crucial role of R&D in growth and development. Differences in the development level and in economic growth are to a large extent the result of how far a region participates in technological progress. This in turn depends on the innovation potential of the regional economy, which is primarily determined by the R&D activities of companies, its endowment with public and non-public research institutes, the level of education and training levels of the workforce, and the willingness to undergo a structural change at the expense of the 'older' industries and in favour of 'newer', more research-intensive industries, as well as to provide knowledge and innovation transfer services.

The industrial R&D capacities in Germany are concentrated in certain agglomerations. Within Germany, a clear north–south divide is evident. R&D concentrations are increasingly forming in southern German areas, with Munich in top position. Further R&D centres are Stuttgart, Rhine–Neckar and Rhine–Main, Nuremberg, Cologne–Bonn and Hamburg. Strongly placed, too, is Berlin – which acts as a strong magnet for industrial R&D in practically all fields of technology – as well as Brunswick, Ingolstadt, Friedrichshafen, Ulm and Dresden.

A large share of the R&D competence in northern Germany is focused in Brunswick. In contrast, the R&D share of the labour force in the Hanover region lies well below the average for western German agglomerations. During the 1990s, the gap between Hanover and the leading agglomerations in western Germany shortened considerably. Contrary to the overall reduction of R&D personnel in the Hanover region there was a slight expansion of R&D capacities. This has much to do with the sectoral trends, which can be most clearly illustrated by the examples of automobiles and chemicals:

- The automobile industry has been able to double its share in the industrial R&D capacities in Germany over the past 20 years. The automobile sector in Hanover has been revitalised in the wake of the growth of production and R&D in this sector.
- By contrast, the research-intensive regions along the Rhine have lost R&D capacities, due to the diminishing innovative stance of the chemical industry in Germany.

High-technology producer service firms increasingly determine the direction of innovations. The industrial R&D is orienting itself more and more towards their needs (ICT, medical technology, pharmaceuticals). On the other hand, the producer service firms strongly depend on stimuli from the innovative fields of industry. Regarding the Hanover region, it could be said that very little innovation stimulation has emanated from the producer service firms, which have been weak for a long period. The above average intensification of all the producer service sectors during the 1990s led to a considerable increase in R&D activities.

However, some promising factors should be mentioned in respect of innovation output as measured by patents:

- One advantageous feature of the Hanover region is that a considerable number of patent registrations occur in fields that are generally associated with high growth prospects: health care, electronics, communications engineering, information/ acoustics/information storage, measurement/control/surveying, as well as fermentation, sugar, and skins and pelts, which also encompass modern biotechnology.
- Technology in the Hanover region continues to have a relatively strong focus in the somewhat traditional fields of metal working and processing, as well as automotive and mechanical engineering, and mining.
- Ranked in the lower middle field are sections of the chemical-pharmaceutical industry and construction.

The Hanover region is endowed with a wealth of research staff in higher education, for which it is only surpassed by Munich and Aachen. Industrial R&D activities are relatively small. However, a multitude of research institutes – even if they demonstrate high scientific performance – is not sufficient in itself to attract industrial research activities into the region, as has been shown in Aachen. Based on its teaching and research personnel, the Hanover region has a strong specialisation in technical fields.

A particular strength is represented by the medical sciences, engineering sciences, civil engineering and surveying, land-use planning, and environmental management. Mathematical and natural scientific fields are less well represented in the Hanover region.

Knowledge and technology transfer facilities in the Hanover region

Technology and knowledge transfer institutions and agencies serve to promote the innovation activities of firms. Through information, advice and networking they support the faster application of 'new knowledge' in industrial innovation and thus contribute to improving the competitiveness of enterprises in the region. The Hanover region, as the economic and political centre of Lower Saxony, has a large number of such transfer establishments, the most important of which are listed below:

- The Technologie-Centrum Hannover functions as a management and innovation consultancy on the one hand and as a business start-up centre and innovation advisory office on the other.
- The Hanover Chamber of Handicrafts provides specific services in the area of technology transfer, *inter alia* innovation consultancy for companies in the handicraft or skilled trade sector, the coordination of pilot projects, and the active support of cooperation projects with research institutions.
- The Hanover-Hildesheim Chamber of Industry and Commerce, among other services, arranges contacts with experts in companies, universities, colleges and research facilities, promotes innovation-oriented cooperation, and offers consultation for inventors and advice on business promotion funding.
- The RKW Nord Rationalisierungs- und Innovationszentrum der Deutschen Wirtschaft provides SMEs with targeted and achievement-oriented advice and practice-related further training, as well as organising working groups and forums for the exchange of experiences.
- The Erfinderzentrum Norddeutschland (Inventors' Centre of North Germany) provides services in the field of evaluation and expert appraisal of innovations, technologies and inventions, with the aim of realistically assessing their technological and commercial potential.
- The Niedersächsiche Agentur für Technologietransfer und Innovation functions as headquarters of the Lower Saxony innovation network. The services provided include advising and supporting of SMEs in the areas of technology transfer, innovation, information, cooperation, business promotion programmes and European issues.
- Uni Transfer is the research and technology contact office of the University of Hanover. It functions as an interface between science and business, and thus contributes to the translation of application-oriented research findings of the university into business practice.

The Hanover region can thus boast a comprehensive and varied range of transfer facilities. No deficits can be ascertained as regards the breadth of consultation and coordination services on offer. There is, however, room for improvement with regard to cooperation and coordination among the transfer agencies. The impression is frequently given that the activities of the different establishments take place parallel to one another, in an entirely uncoordinated manner.

The promotion of firm start-ups

One strategic goal of the local authorities of the region is to foster structural change via the promotion of firm start-ups. The Existenzgründungsinitiative Hannover Region (EIH), which is run and funded in partnership with the city of Hanover, the Greater Hanover District Association, the Kreissparkasse and the Stadtsparkasse, is one example of combining different forces. The EIH adopts the function of a central port of call for all sub-sections of business start-up consultation. It clarifies the different types of consultation and further training on offer, lends support to young firms in their initial stages, sends start-up entrepreneurs to the relevant experts, and establishes a network to coordinate business start-up activities in Hanover.

The contact office has further established itself by opening up an information point for the Deutsche Ausgleichsbank within the EIH premises; with the help of this service, those

interested in starting up a business have direct access to the bank's information on the Internet.

In order to institutionalise the EIH still further, the core members founded a general association in the legal form of a registered association and a supporting organisation, of which further network partners and sponsors can become members.

The initiatives in start-up promotion are beginning to pay off. According to one analysis of enterprise start-ups in major German cities, Hanover occupies one of the highest positions. During the period from 1990 to 1998, Hamburg, Düsseldorf and Frankfurt were the front-runners. Hanover followed in fourth place, approximately equal to Munich. The start-up intensity within the production sector is well below average, but well above average in the service sector.

4 Knowledge-driven companies in Britain and Germany

This chapter contains the findings from the empirical investigation of the two research teams in the West of England and Lower Saxony. As mentioned earlier, the main aim is to identify how knowledge-intensive companies are preparing for the knowledge-based economy. Before embarking on a more detailed discussion of the findings, it is important to explain some of the terminology used. The *knowledge-based economy* refers to that economy which is directly based on the production, distribution and use of knowledge and information. *Knowledge-intensive companies* in manufacturing and services are those companies that have a high R&D activity, high ICT usage, and/or a significant proportion of highly skilled employees. A major aim of the study is to look at how regional companies generate knowledge in general, and more specifically how they develop, value, measure and report their *intellectual capital*. The latter refers to those intangible assets within an organisation related to information and knowledge, which are not generally measured but contribute to an organisation's success (brands, patents, trade marks, supplier–customer relationships and, most importantly, tacit and codified knowledge). It is now common practice to divide intellectual capital into three main categories:

- *Human knowledge capital* is the human intellectual capacity of skilled and experienced managerial, technical and operational personnel.
- *Firm-specific knowledge capital* is the organisation's internal knowledge and information about markets, products and services, employees, customers, suppliers, competitors, technologies, and other factors.
- *Partnership and linkage relationships knowledge capital* is the organisation's external knowledge gained through its relationships with suppliers and customers, which promotes the exchange of or access to knowledge, skills and services.

The West of England perspective

In this section we try to analyse the responses received from top executives in the West of England during our face-to-face interviews with them. The first issue that we tried to clarify in these interviews is whether our sampled companies had articulated a vision of the role of knowledge, particularly in relation to their intellectual capital, and whether they were developing a strategy for the management of the firm's knowledge that was aligned with their business strategy. An important objective here was to establish how the company's intellectual capital is organised, and which of the company's departments were in charge of it.

The majority of executives stated that they recognise the importance of knowledge. However, their companies do not have a specific strategy for the promotion of knowledge within their organisation, nor have they adopted a systematic way of dealing with it.

Some executives mentioned that they were familiar with terms such as 'knowledge worker', 'knowledge management' and 'knowledge economy'; however, these terms are not yet widely understood within their organisation. Others indicated that their company's core values for treating employees fairly reflect the firm's commitment to its human capital. Characteristically, the executive of one R&D-orientated company commented on the difficulty of managing knowledge and stated:

> information and knowledge resides in our staff's heads. However, we have not yet found a magic way of managing that knowledge. Certainly we cannot do without it. We do not have a systematic methodology or a specific department … I reckon that communication is very important for the diffusion of such knowledge.

Another executive of an R&D-orientated company reported that this company is currently putting forward procedures that will recognise the importance and value of its intellectual capital. An executive of one very large corporation was more specific, and stated that his organisation has developed a strategy for diffusing knowledge among its employees. We have also been able to establish that, for the majority of firms interviewed, responsibility for the management of knowledge mostly lies within just two company departments, namely those of technology/engineering and human resources.

The vast majority of executives reported that their companies have designated staff and adopted regulations, governance structures and processes for the appropriation and reuse within the organisation of accumulated knowledge. This form of knowledge normally takes the form of a database, which is easily accessible to everyone in the organisation. In addition, knowledge is found in the codes of practice, reports, briefs, seminars, and minutes of meetings in which managers from various subsidiaries come together and share their experiences. For example, the executive of one software company noted:

> we do have an internal newsletter, a website, and our own intranet, so information is circulating around the company. Thus, we do disseminate knowledge, through our intranet, about any technical developments taking place. For instance, we now share knowledge for the development of e-commerce.

The majority of company executives stated that knowledge sharing across their organisation is taking place 'often' rather than 'occasionally'. Once more, it is the company's climate and organisational culture that support the development of knowledge. Some executives commented that their employees have access to lessons learned elsewhere in the organisation (including past experience on R&D outcomes) or to information on technical matters. For instance, the technical executive of a knowledge-intensive company described how, after the construction of a large prototype device, the company performed a 'post-mortem', so that everyone could observe the project's outcome and determine what happened during that design process. One chief executive officer (CEO) said that every new product in his organisation is subject to a number of design reviews by a group of in-house peers, well before the product is sent to the market. Thus every lesson learned is codified in the form of a project report, which in turn feeds back into future product designs.

Most executives said that everyone in their organisation had access to adequate information and knowledge in relation to technical developments relevant to their work. An increasingly important medium for such access is the Internet. Others reported that they actively encourage staff to attend international seminars and colloquia in their

specialist fields, as well as to present their own scientific papers. Some executives post up current news, various market statistics and relevant information in their company's intranet. One manager mentioned that his firm is keeping abreast of technical developments in the fast-changing environment of high-technology business by forming strategic partnerships with his customers for joint project development.

When executives were asked whether they and their workforce had access to knowledge about markets, products and services, and what their competitors are doing, some of the responses were unexpected. For instance, one manager noted

> you tend not to have so many competitors these days, you have collaborators instead … so we now find that the people we used to compete with, we actually now work with.

Some executives expressed a similar view, in that they now see other companies in the same line of business more as partners. Industry collaboration is strong in emerging industries because of the high cost of R&D, which obliges companies to form strategic partnerships with other firms in order to share costs as well as expertise and knowledge. Nevertheless, a number of company executives reported that they closely monitor their main competitors' activities.

There are signs that knowledge management is playing an increasingly significant role in guiding the strategy of the companies sampled. For instance, the human resources manager of a European multinational company, in charge of nearly 200 employees, was emphatic that knowledge management is of the utmost importance in his organisation, and stated:

> This is a knowledge-based company. The output from this site is nothing other than electronic files that are sent to our manufacturers [overseas]. We are not making a product here.

Another interviewee conceded that knowledge management within his organisation had been a rather academic, and by implication a difficult, subject of discussion. However, he pointed out that his company is managing knowledge by default, and added that knowledge management is closely related to communication, especially with the outside world. One chief executive in charge of IT highlighted the importance of knowledge management within his organisation, as well as the need to acquire skills for managing knowledge, not only by management but also by the rest of the workforce. Only a very few executives admitted that up to now knowledge management within their organisation had not been well developed, although this was starting to change as their customers asked for more sophisticated and knowledge-intensive products and services.

When executives were asked to specify what could be done in order to improve knowledge management within their organisation, they identified a number of problems hampering them. One interviewee commented that knowledge resides mostly in people's heads and is not easily diffused within the rest of the organisation. Furthermore, the technical executive of a precision engineering company stated:

> There are a number of individuals in our workforce – extremely well qualified and top in their field – who are not the best of people for communicating their knowledge. As a consequence, we do not share all those skills, although we try to. What we do is to organise internal workshops – not totally internal, as we do invite other people – in

> the form of lunch-time lectures, which always go down well. However, this never seems to be enough … It is technical knowledge rather than marketing that is absolutely crucial to us. Unfortunately, we find it difficult to share that knowledge and experience.

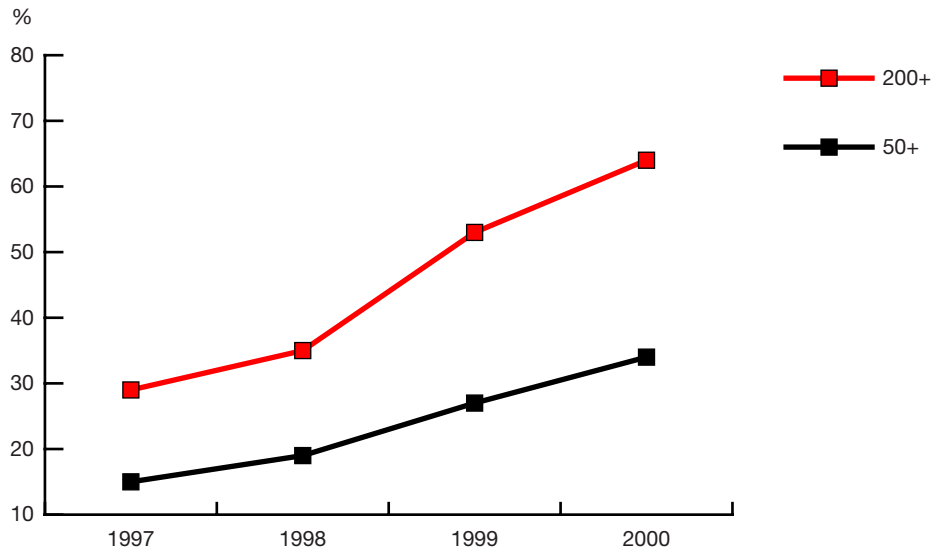
Other interviewees pointed out the need for improvement in disseminating knowledge residing in the minds of skilled workers, and expressed a desire for better coordination in knowledge management and sharing of experience.

In order to measure the effectiveness of accumulated knowledge within organisations, we asked CEOs to rate their company with regard to generating ideas and new applications. The vast majority (75%) described their firm as 'excellent' in this respect. One of the executives stated: 'we are certainly the most innovative company in the world in this sector. As far as our [precision engineering product] is concerned, I think it is difficult not to argue that we are a technological leader.' Another declared: 'I rate us as excellent. We do encourage people to think [outside their spheres of work]. No new idea is scorned.' One proud comment was that 'for new ideas this company is excellent – we have just won a blue-sky research project for the Ministry of Defence'.

Many of the interviewees also stated that their companies are taking measures for the promotion of external relations with suppliers and customers, in order to facilitate the exchange of or access to skills and knowledge. In particular, a number of companies have formed strategic partnerships with their suppliers and customers. The majority of such relationships are defined within a legal framework because of intellectual property rights. Who actually owns intellectual rights and how these rights are shared is a very important issue for companies working together. Some of our sampled companies in the aerospace industry disclosed that they are collaborating with other major companies in the field on projects awarded by the European Space Agency. In a European context, such collaboration among firms is now the norm. However, inter-firm collaboration within projects granted by the UK Ministry of Defence is not yet common, although there is a great deal of subcontracting work involved. The technical executive of one knowledge-intensive multinational providing financial services indicated that his corporation has a number of employees who are dedicated to building close relationships with intermediaries, in order to share and exchange with them information and knowledge about markets. Such intermediaries are also invited to the company's headquarters abroad for meetings with the chief executives. Another service provider reported that they have always been keen on sharing knowledge with the small businesses for which they cater. Interaction and collaboration with other companies is seen to be an important activity for knowledge acquisition and exchange of expertise. One way a company can undertake a project in which it does not possess adequate knowledge and expertise is to invite input from people from other companies, in order to 'put the jigsaw together'.

On the question of how managers rate their organisation's endowment in creating the capacity to undertake the deployment and effective use of knowledge and information, some answers were very informative. The majority of executives were content with the level of personnel training within their organisation, rating it as 'good' or 'excellent'. Some were proud of having achieved the status of 'Investors in People' (see Figure 4.1), and emphasised the ways they value their staff, for example by offering them access to the company's share option scheme.

Figure 4.1
Proportion of organisations (50+ and 200+ employees) in the South West of England with Investors in People recognition



Source: DTI (2001).

An executive of one very large British organisation reported that his company has created a major personnel training centre in the UK. In addition, all members of his staff have been encouraged to put forward their own personal training plans. Every employee can also use the many training packages available on their desktop computer. The human resources executive of a subsidiary of an American company highlighted the importance of her company's central European facilities for training managers. Many other executives reported that their companies provide courses either internally or externally, and for management training they provide a bespoke programme. As one interviewee remarked, in the last ten years the training of his firm's personnel in the handling and dissemination of knowledge has changed dramatically.

Many managers emphasised that their companies rely more than ever before on their highly skilled workforce. For instance, an R&D subsidiary of a multinational reported that, of a total of 310 employees, 290 are qualified to at least undergraduate level in engineering, and many of these have a PhD. One engineering company with 70 employees stated that they have adopted various training schemes. For example, they provide day release for staff to attend classes in one of the region's colleges, and they have on average four or five people taking advantage of this scheme every year. However, being a small company, the employees had to find time for training within the constraints of their job. Regarding investment in IT/IS resources, three-quarters of executives reported that they were either 'excellent' or 'good'.

There are many external factors specific to firms in the West of England agglomeration that are likely to influence an organisation's investment in knowledge-related investment decisions and organisational knowledge capability. One of the most persistent issues preoccupying the majority of executives in the sub-region is that of skills shortage. Such shortage is particularly acute with regard to qualified engineers and technicians. For instance, an executive from a company based in Swindon, where skills shortages are more

profound than elsewhere in the agglomeration, stated: 'It is very difficult to attract appropriate staff … there is a shortage of labour, and certainly this particular problem has to be addressed by the government.' Another executive in Bristol commented that 'skill shortages are absolutely critical. We are short of about 80 electronics designers within this industry.'

The fact that sterling remains outside the euro zone was the second most important issue reported by our sampled companies. This was particularly a concern for aerospace companies, which have to quote their prices and pay their suppliers in euros, while paying their workforce in sterling.

A couple of interviewees commented on the role of technology in shaping their business environment for managing knowledge. One issue raised was that IT in general, and e-commerce in particular, brings changes in consumers' behaviour and their expectation of service. Another factor mentioned was the important role of technology in supporting knowledge management. Until recently, knowledge management was not possible, due to the lack of networks and IT resources.

In a continuously changing environment, firms are faced with considerable uncertainty. We therefore asked CEOs to identify the strategic technological opportunities that could reduce such uncertainty, as well as encourage knowledge development in their organisation. A number of executives reported that new technologies are an important medium for enabling them to sell their products world-wide. The Internet and e-commerce were put forward by some knowledge-intensive service organisations as the most important determinants that have changed the way they relate with their customers and how they deliver their services.

The success of the sampled knowledge-intensive companies is strongly connected to their location. Many interviewees commented favourably on being located in the West of England. The agglomeration is now a significant cluster of high-technology companies. Characteristically, one manager, referring to his company's origins, said:

> We were established in the late 1970s, and were the first company in our field to locate in the area. Now there are at least 50 similar companies, of which ten are as large as we are. Although this is not beneficial in the short term, as they sometimes take our staff from us, in the long-term it will be beneficial, as an important industry cluster is emerging here.

The knowledge indicator questionnaire survey in the West of England

The purpose of the questionnaire survey is to validate the qualitative results obtained from the interviews. Of the 21 organisations (see Appendix A) included in the survey, all but two (Confederation of British Industry and Nationwide Building Society) are profit-making companies. Fourteen top executives were interviewed and asked to complete the questionnaire. Twelve additional questionnaires were received by post, five from managers of companies where one of the managers had already been interviewed. A total of 26 top executives or managers therefore took part in the survey.

Table 4.1 presents a summary of the results of the questionnaire survey with respect to knowledge capital indicators. Company executives consider human knowledge capital to be the most important category of knowledge indicators – this category has both the

Table 4.1
Summary of the questionnaire survey in the West of England

Type of knowledge capital indicators	No. of responses	Aggregate mean	Standard deviation
Human	245	3.78	1.08
Firm-specific	216	2.91	1.54
Partnership	266	3.61	1.18

highest aggregate mean score and the smallest standard deviation. The partnership knowledge capital category is clearly the second most important.

Table 4.2 shows that company executives rated 'Employee motivation' as the most useful indicator of human knowledge capital. However, the low ranking with regard to usage of the indicator (seventh) highlights the difficulty that management faces in developing and using it. 'Employee satisfaction' is considered the second most useful indicator, and is ranked third in terms of usage. Another four human knowledge indicators receive a mean rating of 4 or above on a five-point scale. These are: the information technology literacy of staff; the percentage of employees with university degrees; leadership skills (managers); and years of experience in profession. The quality of human capital is the major factor behind the invention and diffusion of technological knowledge. Measures of educational attainment are the most commonly used proxies for human capital. However, there is no correlation between indicator usefulness and actual usage, highlighting once again the difficulties associated with the development and application of human knowledge capital indicators.

Executives of our sampled companies think that their firm-specific knowledge capital indicators are the least useful of the three indicator categories (See Tables 4.1 and 4.3). None of the firm-specific knowledge capital indicators has a mean above 4 on the five-point scale. The highest ranked indicator (3.37) is the number of multi-functional project teams.

Table 4.2
Relative importance of human knowledge capital indicators

Indicators of human knowledge capital	*N*	Mean	SD	Usefulness ranking	Current usage ranking
Percentage of employees with university degrees	25	3.92	1.07	4	4
Years of experience in profession	25	4.00	1.04	6	2
Employee turnover rate	24	3.81	1.38	7	1
Employee satisfaction	24	4.29	0.90	2	3
Leadership skills (managers)	25	4.00	0.99	5	8
Training expenses per employee	25	3.33	0.96	8	5
Number of innovations per employee	24	3.12	1.26	9	10
Information technology literacy of staff	25	4.16	0.85	3	6
Employee motivation	24	4.37	0.64	1	7
Ratio of managers to employees	24	2.87	0.99	10	9
Total – human knowledge indicators	**245**	**3.78**			

Table 4.3
Relative importance of firm-specific knowledge capital indicators

Indicators of firm-specific knowledge capital	*N*	Mean	SD	Usefulness ranking	Current usage ranking
Percentage of R&D expenses in relation to sales	24	2.83	1.54	6	6
Number of patents or copyrights per employee	24	2.29	1.68	9	9
Volume of ICT	24	2.91	1.47	5	7
Ratio of ICT expense to total revenue	24	2.62	1.46	8	8
Number of computer links to corporate database	24	3.12	1.59	4	5
Number of multi-functional project teams	24	3.37	1.27	1	2
Number of new product (process) introductions	24	3.08	1.47	3	4
Average length of time for product design	24	3.33	1.73	2	3
Number of software licenses	24	2.66	1.70	7	1
Total – firm-specific knowledge indicators	**216**	**2.91**			

Company executives rated highly the usefulness of partnership knowledge capital indicators (Table 4.4). The customer satisfaction indicator emerges as the most important, with a mean of 4.57. This was followed by customer loyalty, growth in business volume, and percentage of sales by repeat customers, all of which were rated above 4. Overall indicator usage closely parallels the usefulness rating (correlation coefficient is 0.72). The exception is the customer loyalty indicator, which is rated eighth in usage but second in usefulness.

Overall knowledge indicator usefulness is shown in Table 4.5. It can be seen that this consists of human and partnership category indicators only. At the individual indicator level, there is no correlation between indicator usefulness and usage. This indicates the difficulty that managers encounter in the development and application of indicators.

Table 4.4
Relative importance of partnership knowledge capital indicators

Indicators of partnership knowledge capital	*N*	Mean	SD	Usefulness ranking	Current usage ranking
Customer satisfaction	26	4.57	0.75	1	2
Percentage of sales to repeat customers	24	4.00	1.44	4	4
Ratio of sales to total customers	24	2.83	1.43	10	9
Customer loyalty	24	4.23	0.90	2	8
Number of customer complaints	25	4.00	0.86	7	3
Growth in business volume	26	4.19	0.89	3	1
Number of networks with suppliers/customers	23	3.04	1.29	9	10
Number of alliances, partnerships and joint ventures	24	3.41	1.41	6	7
Ratio of customers to employees	24	2.12	1.45	11	11
Market share	24	3.80	1.44	5	6
Profits per employee	22	3.54	1.14	8	5
Total – partnership knowledge indicators	**266**	**3.61**			

Table 4.5
Overall knowledge indicator usefulness and usage

All indicators	Category	Mean	Usefulness ranking	Current usage ranking
Customer satisfaction	Partnership	4.57	1	2
Employee motivation	Human	4.29	2	6
Customer loyalty	Partnership	4.23	3	9
Growth in business volume	Partnership	4.19	4	1
Information technology literacy of staff	Human	4.16	5	7
Percentage of sales to repeat customers	Partnership	4.00	6	4
Leadership skills (management)	Human	4.00	7	8
Years of experience in profession	Human	4.00	8	3
Percentage of employees with university degrees	Human	3.92	9	5

Company executives believe that four factors (costs, time, internal communication and inconvenience in usage) are affecting the development and application of knowledge indicators. Overall, the high logistical costs for developing the indicators are perceived to be the greatest barrier (Table 4.6).

The majority of company managers stated that they would use human knowledge indicators extensively for improving operational efficiency, managing human resources, allocating financial resources, improving the quality of their product or service, strategic planning, and gaining a competitive edge (Table 4.7). Furthermore, they were prepared – albeit to a lesser extent – to share some human knowledge indicators with their own employees, board of directors and company managers (Table 4.8).

Relatively few managers felt that they would use their firm's specific knowledge indicators in relation to improving the quality of their product or service and on gaining a competitive edge (Table 4.7). In doing so, they would share these indicators mainly with the board of directors, employees and other company managers, rather than externally (Table 4.8).

Table 4.6
Barriers to the development and application of knowledge indicators

Factors influencing development and/or application of indicators	*N*	Mean	SD	Rank
High logistical costs for developing indicators	25	3.88	1.09	1
Time needed for developing indicators	26	3.87	1.03	2
Inconvenience in using/interpreting indicators	26	3.54	1.06	4
Communicating the importance of indicators (internally)	26	3.53	1.30	3
Communicating the importance of indicators (externally)	26	2.80	1.29	7
Comparability (internally)	24	3.00	1.31	5
Comparability (externally)	24	2.91	1.24	6
Total – all barriers	**177**	**3.36**		

Table 4.7
Preferred knowledge indicator usage

Use knowledge indicators for …	Human (%)	Firm-specific (%)	Partnership (%)
Strategic planning	**57**	**50**	**54**
Management of human resources	**73**	**50**	35
Marketing new product/service	33	46	**54**
Securing investments in ICT infrastructure	42	**50**	**54**
Specialisation and gaining competitive edge	**61**	**61**	**58**
Increasing shareholders' value	38	**50**	**50**
Improving quality of product/service	**61**	**61**	**58**
Improving operational efficiency	**73**	**50**	42
Allocating resources	**65**	35	35
Facilitating financial planning	35	**58**	**50**
Influencing government (including EU) policy	23	42	33
Facilitating partnership relationships	**50**	33	**62**

N = 26.
Note: Reported usage of knowledge indicators at 50% or higher is shown in bold.

Finally, some managers stated that they would use partnership knowledge indicators primarily for facilitating partnership relations and then for strategic planning, securing investment in ICT infrastructure, gaining a competitive edge and improving the quality of their product or service (Table 4.7). Moreover, they were willing to share them not only with their board of directors and other managers, but also with their customers (Table 4.8). However, the general picture emerging is that company managers are not prepared to share knowledge indicators with any of their competitors, or even with government or higher education (HE) institutions.

Table 4.8
Preferred knowledge indicator sharing

Share knowledge indicators with …	Human (%)	Firm-specific (%)	Partnership (%)
Board of directors	**58**	**73**	**71**
Company managers only	**54**	**65**	**63**
All employees within the organisation	**65**	**65**	42
Customers	38	42	**71**
Suppliers/subcontractors and educational partners providing knowledge	42	31	46
Investors and shareholders	27	**54**	46
Competitors	15	3	15
Government (including hi|gher education institutions)	46	46	42

N = 26.
Note: Reported usage of knowledge indicators at 50% or higher is shown in bold.

The Lower Saxony perspective

In this section, we describe some findings on how firms manage their knowledge, as identified by ten case studies. Face-to-face interviews were carried out with ten executives from highly innovative firms in the Hanover region. During the selection process, attention was paid to whether firms were representative of the economic structure of Lower Saxony. Therefore, the main sectors focused on are automotives (including their suppliers), electronic and mechanical engineering, ICT service providers and biotechnology.

One aim in looking at the knowledge management practices of the firms was to establish how they handle their human resources and their internal knowledge. In particular, it was important to find out how exchange of knowledge between the firms' different departments, as well as exchange of knowledge between them and their customers or suppliers, was managed (see also Revilla Diez 2000a; 2000b; 2001a; 2001b; Fischer *et al*. 2001).

Before looking in more detail at the differences of knowledge management practices, some of the general findings concerning all firms are discussed.

Skills shortages

Nearly all firms were concerned about skills shortages in the labour market. In particular, people with qualifications in IT and electronics are not available to a sufficient degree. One of the executives interviewed said he would engage 20 more electrical engineers immediately, if they were available. However, the Hanover region was seen to be in a better position than others with regard to the availability of qualified labour, although the number of graduates with IT qualifications is insufficient. This executive also remarked that the number of companies competing for graduates with the same qualifications is smaller in the Hanover region than in other centres in Germany, for example Munich. He explained that university graduates in the Hanover region are not willing to move away from the area, even though labour mobility is viewed as a necessity in a globalised world. Many graduates do not want to lose their social environment and stay in the Hanover region. A further advantage of the region is seen in the low prices for land. One disadvantage, however, is that it is not so easy to change the location of the firm without changing the living location of its workforce.

Changing demand for qualifications

In many of the interviewed companies, a major shift in the qualifications required can be seen. One of the greatest changes is the replacement of mechanical product components by electronic ones. One executive in an electronic firm said:

> Thirty years ago, 70% of our R&D staff were mechanical engineers and 30% were electrical engineers. Nowadays, 70% of the R&D staff are software developers, 30% are electrical engineers and only 10% are mechanical engineers, and yet we still make the same product.

A second process observed was that different scientific fields, such as mechanics and electronics, inevitably interlink with each other. This leads to changes in the organisation structure. One executive told us:

> We have no head of department in our R&D section any more, but rather two in equal positions. One is responsible for the mechanical division and the other for the electrical division. This is a clear sign of how interlinked different sections in our firm have become.

Knowledge management practices

This section highlights the knowledge management practices of the firms sampled. One of the aims of the research team was to identify differences in such practices. One hypothesis is that resource knowledge is treated differently by the firms sampled. In particular, there are thought to be differences between two distinct groups of firms. One is that of well-established firms with huge production sites. In our sample, firms from the automotive industry, automotive suppliers, and electronic and mechanical engineering belong to this group. The other is of young start-up firms. These firms operate in the fields of IT, multimedia and biotechnology. They are all service providers and their success is entirely based on knowledge. The question is whether these young start-up firms have more advanced knowledge management abilities than the well-established firms, which have not been used to focusing on resource knowledge.

Knowledge management practices in young start-up firms

The firms in this group had a clear knowledge management strategy. Their success is based entirely on intangibles. In none of these firms does production of a product take place. Another significant characteristic of the firms is that time is a very critical factor for them. One executive said: 'If our intangible product is only one month late, its market value decreases rapidly. Every 18 months complexity is doubling'. Therefore, they rely on excellent knowledge management practices to remain competitive. They cannot afford to slow down because of staff sickness or departure to another company. Another reason why these firms have developed excellent knowledge management practices is that there has been an increase in the complexity of the production process. Because of this, the number of employees in project teams has risen. One executive told us that up to 40 engineers are working simultaneously on one project. Without using ICT infrastructures, this would be impossible. However, one firm saw its rapid growth as a major problem. When the firm was still small, knowledge management was not considered necessary, and this attitude has persisted, even though the number of employees has increased significantly.

MANAGING HUMAN CAPITAL

Further vocational training plays a central role in strategies that companies employ to ensure the employees receive new relevant knowledge. This training is either organised by the company itself or by external service providers. In one young firm, project teams receive a global budget for further vocational training. They can then decide autonomously how they want to spend their budget. Furthermore, the company offers each employee further such training in non-technical fields such as project management, leadership qualifications and communication skills. In a small IT company training was less far less formally organised and it was up to the employee to undertake further vocational training. One of its executives said: 'If people want to buy a book, they can buy it; if they

want to participate in a computer course, they can participate; and if they want to travel to a conference, they can travel.' Special incentives to make people participate are not necessary. One executive emphasised: 'People want to take part in further vocational training, and if that is not the case, they are not suitable for the firm. Many engineers are delighted if they can take over new projects, instead of always doing the same routine work.'

MANAGING INTERNAL KNOWLEDGE

The most frequently used methods of sharing knowledge within the firm are via the intranet, regular team meetings in each department and regular meetings between the heads of departments from different sections. Many firms emphasised the importance of project work. For each new project, employees are grouped together in new teams, according to the project requirements. In none of the sampled firms are special incentives given for the development of new knowledge. Many executives told us that they just expect their employees to look out for new knowledge. However, one executive acknowledged that it was necessary to find a better way of managing knowledge but did not know how to go about it.

Another interesting aspect of internal knowledge management could be seen in one small start-up firm from the biotechnology field. In this firm, one employee had the task of searching through scientific databases for relevant information to store in the firm's internal databank. Other employees could feed instructions into this person's search on the type of information which needed to be collected.

MANAGING PARTNERSHIP KNOWLEDGE

The ICT infrastructure is vital for sharing knowledge with other firms. Many of the arrangements during a shared project with another company are made via e-mail. However, at the beginning of a new project face-to-face contact is seen as indispensable.

Cooperation with research institutes was not seen as conducive to strengthening R&D capabilities within the firm. In one executive's view, 'research institutes are too far away from real problems and unable to operate with flexibility and are not oriented to the commercialisation' of their innovations.

Knowledge management practices of well-established firms

This group has also acknowledged the importance of knowledge management. Nevertheless, its implementation into the workplace has not yet taken place. The reasons for this 'knowing–doing gap' are manifold. One executive said that people are too busy with their day-to-day business to think about knowledge management practices. Furthermore, there is a lack of understanding as to how to introduce a knowledge management system. Also, the high cost of maintaining such a system was a hindrance. One firm mentioned the introduction of a new section for knowledge management. The firm has recognised that much of its internal knowledge, gained from R&D projects, could be more beneficially used in other projects than it is at present. Another implementation problem concerns employees' attitudes. One executive stressed that engineers in his firm are very critical of research results that other colleagues have achieved. Many of the engineers would believe a new process or product only when they could test it themselves. This is why it is so important that employees accept a knowledge

management system. It is impossible to build up such a system if people in the firm oppose it.

In another firm, the people responsible are thinking of building up a knowledge management system. However, the motivation for such action has not emerged from the firm itself. Because the firm fulfils certain quality criteria, it has achieved a notable status in the car industry, and in order to maintain this status it must build a knowledge management system in the coming years. A clear knowledge management strategy was identified in only one of the firms interviewed. The main aim of the knowledge management strategy is to support and improve the transfer of know-how within the firm. It is recognised that this is possible by building up an efficient IT infrastructure. In addition, a great emphasis was placed on the development and implementation of knowledge management tools. In order to test the benefits of a knowledge management system, trial projects were implemented aiming at different goals. One objective is to simplify access to expert knowledge. Another is to preserve knowledge from retiring employees.

MANAGING HUMAN CAPITAL

The management of human capital starts before employees commence working in a firm. One executive reported that it is very important for his firm to build up a relationship with students, for example by offering them access and information for their master's theses and dissertations. This becomes even more important when the number of qualified graduates is diminishing. In some firms, the departure of qualified employees is a major concern. One task of human capital management is therefore to limit the drain of such staff as much as possible. 'We are trying to show our employees what excellent career chances the firm offers them', said one executive. He emphasised that it is possible to acquire large responsibilities after a short time of employment. Another advantage, in his view, is that employees can work at a foreign location for a certain period of time. In many of the companies interviewed, both the head of department and the employee set individual advancement targets which should be achieved by the next year.

Further vocational training was also viewed as very important. In comparison to the new start-up companies, it was more formally organised and sometimes less individualistic. In one of the firms, a 'summer university' is organised to which experts are invited. Employees participate voluntarily.

MANAGING INTERNAL FIRM KNOWLEDGE

Some of the companies interviewed have special incentives for the creation of new knowledge. An example is to encourage employees in the process of developing new patents. One executive told us that his staff would receive a bonus payment even if it were not clear whether the firm would benefit from the new patent. The 160 employees of the R&D section are producing 180 patents a year.

Some firms which are adopting knowledge management try to improve and simplify their internal communication channels. One executive said:

> Very often, an employee in the firm does not know whether another employee is working on a similar project. The problem is simple: how to get in contact with that person. Therefore, our firm is currently building up a 'yellow pages' system, in which

each member of the staff can search for other employees who possess a specific expertise and relevant qualifications.

MANAGING PARTNERSHIP KNOWLEDGE

Partnership knowledge plays an important role for the firms sampled, especially among automotive producers and their suppliers. For this reason, employees are exchanged for a period of time between producers and suppliers. One executive of an automotive supplier emphasised the importance of their key account management system, where there is one key person responsible for all matters concerned with each car manufacturer.

Cooperation with universities in the region is viewed as very beneficial for knowledge exchanges. One executive said some former employees are now professors at universities. They offer students the possibility of writing their master's theses within the firm. Many of these students later become employees of the firm.

However, not only universities are important, but also a wide range of network relationships. One executive said: 'It is very important for our company to be present in many different political organisations and committees. Only through continuous work on such committees are you able to shape decisions in your favour.'

The knowledge indicator survey in Lower Saxony

One major problem in the knowledge management field is that knowledge is difficult to measure. Therefore, one other aim of the research was to determine whether certain indicators could be developed to enable firms to evaluate their knowledge management practices.

Human capital

The indicators for human capital were focused on the qualifications and attitudes of the employees. Average employment time in the firm was valued as a very useful indicator, and is already used by half of the companies. The cost of further vocational training, and leadership qualities for human resource development, were also viewed positively, although they were used less as indicators. The average employment time in any one department was considered unimportant. One executive pointed out that this indicator would need to be more precise. This is due to the fact that remaining for a certain time in one division is viewed positively, but becomes a disadvantage if the period of time becomes too long. Therefore, an exact period would need to be set in order to make such an indicator meaningful. The proportion of employees with further education qualifications was considered a useful indicator by only half of the interviewees.

Another problematic indicator is the measurement of employees' IT competence. Nearly all those asked placed it at 3 on the five-point scale (see questionnaire in Appendix B, adapted from Miller *et al.* 1999). In many firms, IT competence was viewed as absolutely necessary. 'Without IT abilities, employees could not do any work at all', said one executive. A further problem is the wide range of IT competences. In one firm, such competence is already achieved when the employees can use a normal Microsoft Office program, while in an IT firm, profound competence is required in highly specific programs.

The attitude of employees was considered a very important indicator by all. Measuring motivation, as well as the employees' contentedness, was seen as very helpful for managing human resources. However, although viewed highly positively, only two out of the ten firms use such indicators. In these two cases, the firms regularly checked on their employees' satisfaction by questionnaire. The reason why only a small number of firms measure the satisfaction of their employees is attributed to the difficulties in measuring such satisfaction. One executive said he prefers indirect indicators for measuring the contentedness of his employees such as the percentage of sickness leave.

Internal firm knowledge

The indicators for internal firm knowledge were focused on R&D and the ICT infrastructure. The most frequently used indicator for R&D is the percentage of R&D expenses in relation to sales.

The number of product (process) innovations in the last three years, and the average time between product idea and introduction to the market, were indicators that were viewed positively. Their high evaluation reflects how great the pressure is for innovations to be made within a short period of time.

The number of patents per employee was also viewed as very useful. Only the small firms in our sample did not agree. The number of project teams including employees from more than one division was also evaluated positively by the majority of those asked.

Most indicators of the ICT infrastructure were considered only moderately important. Only those for IT provision were generally viewed positively. Less well viewed were the indicators measuring Internet and intranet provision within the firm. This is probably due to the fact that all sampled firms – at least their offices – were equipped with PCs connected to the Internet and intranet. The problem is therefore quite similar to that of IT competences in the human resource indicators. Because all the survey firms offer their employees access to the intranet and Internet, the indicator is unable to distinguish knowledge management practices. More promising for further research will be to look not at whether these media are used, but how they are used. Who has permission to put material on to the intranet, and what information is shared?

The number of software licences per employee was rated moderately. One of the executives mentioned the need to have as few licences as possible, in order to reduce costs.

Further useful R&D indicators, which were not included in our questionnaire, are cultural competence, the detection of trends and the use of pre-warning systems. These were pointed out by the executive of a large firm. This multinational company has to manage the production of different brands and the operation of large production sites simultaneously around the globe. The executive noted: 'Cultural competence is vital for our company to master the production and sales of our products in order to fulfil our customers' demand'.

Partnership knowledge

The indicators for external firm knowledge were focused on customer relationships and other forms of cooperation with research institutes or service providers. Customer

relations, customer satisfaction, customer loyalty, after-sales service and management of customer complaints were all rated highly. Furthermore, no other group of indicators was considered more homogeneous. One executive stressed the importance of the way of measuring the above indicators in order to make them more accurate and comparable. For instance, for the measurement of 'customer complaints' he suggested that it could appropriate to measure the response time the company needs to handle complaints. A similar picture emerged regarding cooperation relationships. The number of supplier–customer relationships, and the number of relationships with research institutes, are seen as quite meaningful. The number of relationships with service providers was only rated moderately, as was the number of alliances and joint ventures. This is probably due to the difficulties encountered in measuring these relationships as a company may have different types of service providers. For example, an executive in the car industry mentioned that one of his company's service providers supplies brochures, while another supplies automotive components. The two service providers are not seen as equally important. The brochure could be printed easily by another printing firm, while the automotive parts could be only supplied by a particular supplier with which the company has developed a long-term relationship based on trust, and this cannot be easily be replicated with another supplier.

The number of supervised master's theses was also viewed positively. There are good opportunities for firms to recruit new and skilled employees this way.

A further recommended indicator is that of the 'image of the firm'. The opinion that customers have formed of a particular firm appears to be highly important. In the words of one executive: 'once you have lost a customer because he/she is dissatisfied, it is becoming nearly impossible to win him/her back'.

Development and application

A further issue was to determine which factors are the ones hindering the development and application of knowledge indicators. The most influential factors were the enormous amount of time needed to develop such indicators, the difficulties in interpreting them, and their acceptance within and outside the firm. Less value was put on the difficulties of comparability. This is true for internal comparability, for example between two different divisions of the firm, as well as for external comparability, for example for benchmarking between two firms.

Further factors were mentioned by the interviewees. One highlighted a lack of knowledge about the development of indicators. Another was concerned about the high maintenance cost of such indicator-based knowledge management.

Usage

The research team also tried to establish which of three knowledge indicator groups (human capital, firm-specific and partnership) would be particularly helpful in improving specific business processes. Firstly, all three groups were viewed as very helpful for a number of business processes. Those most frequently indicated were strategic planning, gaining competitive edge, and improving operational efficiency. Secondly, and not surprisingly, the human capital indicators were viewed as most beneficial for improving the management of human resources. Similarly, the partnership indicators were considered most beneficial in facilitating network-specific relationships. Further business

goals were added in which all groups of indicators could be very helpful. Innovation leadership, market monitoring and product development were mentioned.

Accessibility

Executives were asked which persons or institutions should have access to such an indicator system. They all considered it beneficial to make all indicator results accessible to the board of directors and to heads of department. Nearly everyone viewed it appropriate to make all indicator results accessible to all employees.

With the partnership indicators there was less concern about making them accessible to a wide range of people and institutions. Half of the companies sampled could imagine making indicators available to clients, suppliers, further vocational training providers, investors and shareholders. Only competitors should not have access to them.

With regard to human capital indicators, most of the executives were in favour of more restrictions. Besides the above-mentioned groups of persons, the majority of executives accepted that further vocational training providers should have access to these groups of indicators. Only a minority supported the idea of also making these indicators available to clients, investors and shareholders.

The majority of executives wanted to make the group of firm-specific indicators accessible to investors and shareholders. A minority also included suppliers, research institutes and competitors.

Conclusion

All of the firms recognised the importance of their human capital, especially with regard to skills shortages in the labour market. However, differences can be identified between the two groups of firms in our German sample. Further vocational training seems to be less formally organised in the group of new start-up firms than in the group of well-established firms. With regard to internal knowledge management, no clear differences can be seen. Regular team meetings, changing team arrangements and working in projects are the most important processes in sharing knowledge within the firm. For the management of external knowledge, links to universities and supplier–buyer relationships are very important. The ICT infrastructure is vital for supporting both internal and external knowledge exchanges.

With respect to the development of an indicator system, the most beneficial would be one that evaluates and monitors the motivation and satisfaction of employees. Furthermore, it is viewed as a very helpful tool for monitoring R&D activities and customer relationships. Factors hindering the development of an indicator system are development time and the difficulties of interpreting results. Concerning accessibility, human capital knowledge indicators are shared less openly than internal and partnership knowledge indicators.

5 Conclusions and policy implications

The above analysis suggests a substantially similar economic situation in the West of England and Lower Saxony. It has also been possible to identify a set of generic factors that contribute to the economic development of both European regions and their path towards a knowledge-based economy. The most influential factors are: a historically strong regional specialisation; the existence of an effective information and knowledge network system; the concentration of a critical mass of research institutions and universities; and the availability of a skilled and well-qualified workforce.

However, the context in which regional policies support the production, utilisation and diffusion of knowledge is markedly different. Policy challenges and responses are therefore regionally specific and depend on each region's technology base, historical experiences and institutional structure. The South West of England has only recently been able to formulate a coherent regional cluster-based policy, through SWERDA. In the federal system of Germany, Lower Saxony has rather more competences, a plethora of support institutions, and flexibility in accomplishing its policy aims. Nevertheless, both regions face similar challenges, namely to alleviate skills shortages and maintain (or even increase) the existing R&D capacity.

Knowledge-driven companies in both the West of England and Lower Saxony are involved in a complex knowledge acquisition process, in which not only internal R&D is important but also the gathering of collective and proprietary know-how through recruitment of skilled labour, training, inter-firm collaborative agreements and strategic alliances and links with research institutions.

The vast majority of company executives interviewed in both Britain and Germany recognised the importance of knowledge for their firm's competitiveness. There is strong evidence that knowledge management is playing an increasingly significant role in guiding the strategy of high-technology and start-up firms in particular. However, the study found a number of well-established companies in both Britain and Germany (especially in the traditional manufacturing sectors) which have not yet developed a specific strategy for the promotion and diffusion of knowledge within their organisation, nor adopted a systematic way of dealing with it.

The competitiveness of knowledge-intensive firms in both regional agglomerations studied depends to a large extent on having sufficient numbers of skilled and experienced managerial, technical and operational staff to carry out the organisation's strategic objectives. The fast pace of technological innovation also increases the need for not only a better-educated workforce but also a particular type of vocational qualification. For instance, the growing demand for electronic and software engineers in both regions is attributed to the fact that such professionals have the capability to implement new technologies fairly quickly.

There is one external factor specific to firms in both agglomerations which is currently influencing their knowledge-related investment decisions and the development of their organisational knowledge capability. Skills shortage is one of the most persistent

problems preoccupying the majority of executives in both the West of England and Lower Saxony. Such skills shortage is particularly acute with regard to qualified engineers and technicians.

From both the British and German case studies, it is clear that firms' managers devote significant resources and employ a variety of knowledge indicators (human capital, firm-specific and partnership) in order to improve their specific business processes. The most popular indicators anticipate and measure the needs of customers, employee motivation, employee performance, and the creation of national and international networks and partnerships. However, the time needed for their introduction, the logistical costs involved, the presence of internal communication problems and inconvenience in using them are all affecting the development and application of knowledge indicators. Furthermore, relatively few executives of our sampled companies were prepared to share these knowledge indicators with other people from outside their organisation.

However, there is evidence of fundamental changes in company attitudes in the West of England. A shift from competition towards collaboration was observed. The increasing technological alliances between firms, and particularly between those from different countries, enable each partner to reduce its research costs, extend its range of products and knowledge sources, and access new markets. Such alliances, especially under the aegis of the EU, range from simple partnerships (cross-licensing) to the establishment of common research subsidiaries.

The above discussion indicates that knowledge-intensive companies in both Britain and Germany respond in a similar way in managing their human, firm-specific and partnership knowledge capital. However, human knowledge and partnership knowledge capital appear to be the most important assets for knowledge-intensive companies.

Table 5.1 provides examples of best practices adopted by knowledge-intensive firms in the two regions as a response to the challenge of the emerging knowledge-based economy.

Table 5.1
Best practices and means for the development of knowledge in enterprises

Best practices	Means
Knowledge management for the diffusion of knowledge among a company's employees	Use of a wide array of knowledge indicators.
	Designated staff and adopted regulations, governance structures and processes for the appropriation and reuse within the organisation of accumulated knowledge
	Dissemination of knowledge through reports, briefs and minutes of meetings in which managers from various subsidiaries come together and share their experiences
	Codification of knowledge in the form of a project report, which in turn feeds back into future product designs
	Use of intranet and the Internet
Developing partnerships for the acquisition of knowledge	Forming strategic partnerships with customers/suppliers for joint project development
	Establishing links with universities and other research institutions
Encouraging the generation of new ideas and new applications within the firm	Bonus payments to employees; staff share options; presentation of findings in international symposia and conferences
Personnel training within the organisation	Investors in People recognition; time relief for attending courses, etc.; in-house bespoke training

It is important to emphasise that the findings of the study come from a relatively small sample of firms, in just two regional agglomerations in Britain and Germany. If they are representative of other agglomerations, however, then they suggest that policies oriented towards supporting education and training, and facilitating collaborative networks among enterprises, are of great importance. Given the fact that the majority of companies in Europe are not yet knowledge-intensive, a great deal of research remains to be done, in both empirical and theoretical terms. Nevertheless, it is hoped that this report provides a useful perspective on how companies in Britain and Germany are preparing for the global knowledge-based economy.

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Appendix A
List of firms

West of England

Apex Computers	Gloucester
AXA Sun Life plc	Bristol
Confederation of British Industry	Bristol and London
Corin Medical	Stroud
Elixent	Bristol
GKN-Westland plc	Yeovil
Halcrow Gilbert	Swindon
Hewlett Packard	Bristol
Integraph	Swindon
Isotron	Swindon
Lloyds TSB	Bristol
Molypress	Swindon
Nationwide Building Society	Swindon
PixelFusion	Bristol
Redcliffe Magtronics	Bristol
Rotork plc	Bath
Science Systems	Bristol
SEA	Bristol
STMicroelectronics	Bristol
TigerRedi	Bristol
Wireless Systems International	Bristol

Lower Saxony

AdnaGen AG	Hannover
Continental AG	Hannover
PONTON-LAB GmbH	Hannover
Robert Bosch GmbH	Hildesheim
Sartorius AG	Göttingen
sci-worx GmbH	Hannover
Sennheiser electronic GmbH & Co. KG	Wedemark
TVN mbH & Co. KG	Hannover
Varta AG	Hannover
Volkswagen AG	Wolfsburg

Appendix B
Interview/questionnaire

In collaboration with the University of Hanover, Germany

Knowledge companies in Britain and Germany: A common response to the challenges of the emerging knowledge-based economy?

With the support of the
Anglo-German Foundation for the Study of Industrial Society

The Centre for European Studies at the University of the West of England, Bristol, and the Department of Economic Geography at the University of Hanover are participating in a project to investigate how knowledge-intensive companies are preparing themselves for the so-called knowledge-based economy. A **knowledge-based economy** refers to that economy which is directly based on the production, distribution and use of knowledge and information. **Knowledge-intensive companies** in manufacturing and services are those companies that have a high research and development (R&D) activity, high information and communication technology (ICT) usage and/or a significant proportion of highly skilled employees. A major aim of this study is to look at how regional companies generate knowledge in general, and more specifically how they develop, value, measure and report their intellectual capital. **Intellectual capital** refers to those intangible assets within an organisation related to information and knowledge that are not generally measured but contribute to an organisation's success (i.e. brands, patents, trade marks, supplier–customer relationships and, most importantly, tacit and codified knowledge). It is now common practice to divide intellectual capital into three main categories:

Human knowledge capital is the human intellectual capacity of skilled and experienced managerial, technical and operational personnel.

Firm-specific knowledge capital is the organisation's internal knowledge and information about markets, products and services, employees, customers, suppliers, competitors, technologies, and other factors.

Partnership and linkage relationships knowledge capital is the organisation's external knowledge, gained through its relationships with suppliers and customers, that promotes the exchange of or access to knowledge, skills and services.

General information, history and performance

1.1 Name of company Postal code

1.2 Main line(s) of business

1.3 Name of interviewee Position:

1.4 Size of company (number of employees) Revenue (millions £)

1.5 Business vision

1.6 Strategic business focus

1.7 Strategic knowledge/intangible capital focus

No. Questions

1. Has your company articulated a vision of the role of knowledge (intellectual capital) in the organisation, and is it developing a strategy that is aligned with business strategy? If so, why? How is the work with intellectual capital organised (which department is in charge)?

2. What type of rules, governance structures, processes, and staff composition exist for reusing knowledge effectively across the company?

3 How often does knowledge-sharing across the boundaries of your organisation take place? Please state how your organisational culture and climate supports knowledge development.

(a) Often ❑ (b) Occasionally ❑ (c) Never ❑

4. Do you have access to lessons learned elsewhere in your organisation or to information on technical and operational competences, gained through project implementation experience and R&D? What is the main advantage of having such access?

5. Do you have access to good information about technical developments relevant to your work? How useful is this access?

6. Is there a structure for accessing knowledge about markets, products, services, and what your competitors are doing? If so, please describe it.

7. Is knowledge management playing a role in guiding company strategy? What can be done to improve knowledge management within your company?

8. How do you rate your company in generating ideas and applications?

(a) excellent ❑ (b) good ❑ (c) reasonable ❑ (d) poor ❑

9. What measures are in action for the promotion of external relations with suppliers and customers, facilitating the exchange or access to skills and knowledge?

10. How do you rate the following organisational endowments that create the capacity to undertake the deployment and effective use of knowledge and information?

A. Personnel training:
(a) excellent ❑ (b) good ❑ (c) reasonable ❑ (d) inadequate ❑

B. Investment in IT/IS resources
(a) excellent ❑ (b) good ❑ (c) reasonable ❑ (d) inadequate ❑

11. Which general environmental factors are influencing organisational investment in knowledge-related investment decisions and organisational knowledge capability development (political e.g. euro; economic e.g. high value of sterling; social e.g. skills shortage; regulatory e.g. taxes; technological e.g. new technologies)?

12. Which strategic and technological opportunities and challenges within your industry environment are currently driving knowledge development in your organisation?

Evaluating and gauging the organisation

Respondents are invited to reply from the perspective of their area of responsibility.

Part A: Firm's management of intangible assets

The following three knowledge capital indicators, human, firm-specific and partnership relationships, employed by experts in organisational management represent some of the measures that can be used to evaluate the development of knowledge in your company. Which of the following indicators would be useful to you? Which ones do you already use?

A.1 Indicators of human knowledge capital	Very useful				Not useful or N/A	Which indicators do you currently use? Please '✓'
Percentage of employees with university degrees	5	4	3	2	1	❑
Years of experience in profession	5	4	3	2	1	❑
Employee turnover rate	5	4	3	2	1	❑
Employee satisfaction	5	4	3	2	1	❑
Leadership skills (managers)	5	4	3	2	1	❑
Training expenses per employee	5	4	3	2	1	❑
Number of innovations per employee	5	4	3	2	1	❑
Information technology literacy of staff	5	4	3	2	1	❑
Employee motivation	5	4	3	2	1	❑
Ratio of managers to employees	5	4	3	2	1	❑

Are there any other indicators you feel would be useful? .....

.....

A.2 Indicators of firm-specific knowledge capital	Very useful				Not useful or N/A	Which indicators do you currently use? Please '✓'
Percentage of R&D expenses in relation to sales	5	4	3	2	1	❑
Number of patents or copyrights per employee	5	4	3	2	1	❑
Volume of information and communication technology (ICT)	5	4	3	2	1	❑
Ratio of ICT expense to total revenue	5	4	3	2	1	❑
Number of computer links to corporate database	5	4	3	2	1	❑
Number of multi-functional project teams	5	4	3	2	1	❑
Number of new product (process) introductions	5	4	3	2	1	❑
Average length of time for product design	5	4	3	2	1	❑
Number of software licenses	5	4	3	2	1	❑

Are there any other indicators you feel would be useful? .....

.....

A.3. Indicators of partnership knowledge capital	Very useful				Not useful or N/A	Which indicators do you currently use? Please '✓'
Customer satisfaction	5	4	3	2	1	❑
Percentage of sales to repeat customers	5	4	3	2	1	❑
Ratio of sales to total customers	5	4	3	2	1	❑
Customer loyalty	5	4	3	2	1	❑
Number of customer complaints	5	4	3	2	1	❑
Growth in business volume	5	4	3	2	1	❑
Number of networks with suppliers/customers	5	4	3	2	1	❑
Number of alliances, partnerships and joint ventures	5	4	3	2	1	❑
Ratio of customers to employees	5	4	3	2	1	❑
Market share	5	4	3	2	1	❑
Profits per employee	5	4	3	2	1	❑

Are there any other indicators you feel would be useful? .....

.....

Part B: Barriers to the development and application of knowledge indicators

B.1 To what extent would the following factors impact on your ability to develop and apply these knowledge indicators?

	Strong impact				No impact
High logistical costs for developing indicators	5	4	3	2	1
Time needed for developing indicators	5	4	3	2	1
Inconvenience in using/interpreting indicators	5	4	3	2	1
Communicating the importance of indicators (internally)	5	4	3	2	1
Communicating the importance of indicators (externally)	5	4	3	2	1
Comparability (internally)	5	4	3	2	1
Comparability (externally)	5	4	3	2	1
Other (please specify)	5	4	3	2	1
Other (please specify)	5	4	3	2	1

Part C: Firm's strategies for the future

C.1. Would you use in the near future any of the above-mentioned indicators in relation to the following activities?

	Human knowledge indicators	Firm-specific knowledge indicators	Partnership knowledge indicators
Strategic planning	❑	❑	❑
Management of human resources	❑	❑	❑
Marketing new product/service	❑	❑	❑
Securing investments in ICT infrastructure	❑	❑	❑
Specialisation and gaining competitive edge	❑	❑	❑
Increasing shareholders' value	❑	❑	❑
Improving quality of product/service	❑	❑	❑
Improving operational efficiency	❑	❑	❑
Allocating resources	❑	❑	❑
Facilitating financial planning	❑	❑	❑
Influencing government (including EU) policy	❑	❑	❑
Facilitating partnership relationships	❑	❑	❑
Other activity (please specify).....	❑	❑	❑

C.2. Please indicate the groups with whom your organisations should share the above-mentioned indicators:

	Human knowledge indicators	**Firm-specific knowledge indicators**	**Partnership knowledge indicators**
Board of directors	❑	❑	❑
Company managers only	❑	❑	❑
All employees within your organisation	❑	❑	❑
Customers	❑	❑	❑
Suppliers/subcontractors and educational partners providing knowledge	❑	❑	❑
Investors and shareholders	❑	❑	❑
Competitors	❑	❑	❑
Government (including HE institutions)	❑	❑	❑
Other (please specify).....	❑	❑	❑