1. Introduction: aims of the book

The research on which this book was based aimed to establish the extent to which firms performed better when co-located within clusters than outside them. The research projects in Austria and the UK also sought to throw comparative light on this issue in economies often thought to represent versions of the two classical European models of industry organization; the first, corporatist or ‘coordinated market’, the second ‘liberal market’ after Hall and Soskice’s widely cited classification of ‘varieties of capitalism’ (Hall and Soskice, 2001) and, in particular, their associated business systems.[1] The precise way in which these issues were tackled involved the use in both countries of an identical set of research instruments and questions inquiring about relative firm performance in two modern, advanced technology industries, information and communication technology (ICT) and biotechnology. The research questions therefore sought to tease out, for both settings, the extent to which innovative milieux (after Maillat, 1998) or markets were the most performance-enhancing settings for such high-technology businesses. This question had particular salience because of the following. Many continental European economies, from Austria to Germany, Switzerland and the Nordic countries operate a ‘social partnership’ model of economic organization in which interaction occurs by negotiation across boundaries between otherwise divergent interests associated with government, industry and labour. At a lower scale than the national economy, this resonates with the ‘networking propensity’ associated with regional milieux of innovative small firms as analysed in Maillat’s pioneering work in the Swiss Jura region of watchmakers.

Contrariwise, a liberal market regime of economic governance might be hypothesized to have few of these milieu effects, being more associated with economic individualism and a competitive ethos than the ‘networking propensity’. Indeed, books such as that of Best (1990) showed in detail that this characterized the distinctive furniture and other comparable industries of Italy, a variant on the coordinated market type of economy, and the UK. The Italian furniture industry prospered from its industrial district, small firm milieux while the UK one fared less well in pursuit of scale economies amid cutthroat competition.[2] Despite this, and returning to the Austria–UK comparison, for the industries under investigation, the overall UK performance is significantly better. For example, keeping in mind the fact that Austria is about one-sixth the demographic size of the UK, its ICT and biotechnology shares in economic activity are weaker.

As elaborated in more detail elsewhere Austria's share of knowledge-intensive services (including software, research, media, and so on) was 27 per cent of total employment in 2001, while in the UK it was 49 per cent. This echoes Peneder (1999) who showed Austrian high-technology industry to contribute 14 per cent of Austrian value-added compared to 24 per cent in the UK. In biotechnology, the UK in 2004 had nearly 200 'pipeline' products in various trialling stages, whereas Austria had none. Having said that, Austria had in 2003 some 30 dedicated biotechnology firms (DBFs), 64 per cent of them located in Vienna (Tödtling and Trippl, 2005), whereas the UK had in 2003 some 455, down from 494 in 2002 due to firm closures and merger and acquisition activity in the sector (DTI, 2005). A comparable proportion of the UK's DBFs are located within a 50-mile radius of London but, unlike Vienna, most are concentrated in university towns like Cambridge and Oxford, and in the Guildford area. The university towns host what are officially denoted 'biotechnology industry clusters'; Guildford is known as a 'biotechnology agglomeration'. Whereas leading edge bioscientific research and talent support 'academic entrepreneurship' in the university towns, Guildford is a case of 'localization economies' spatial concentration due mainly to experienced technical labour and excellent transportation links to London and internationally, something the research reported here sought further to test (DTI, 1999; Cooke, 2001).

Thus the aims of the book are fivefold, involving first, conducting comparative research in the UK and Austria as instances of, respectively, liberal market and coordinated market economies. Second, comparing the two countries in respect of high-technology industry performance and whether market or milieu emphases in firm practices predominated in explaining firm performance. Performance is measured in terms of growth measures of revenues, profitability, innovation and employment. Third, the book explores the extent to which the regulatory context affects the ways economic spillovers, especially those related to knowledge diffusion, operate. Particular attention is devoted to testing claims in the literature of the advantages accruing to firms located in proximity to sectoral neighbours and whether sector or spatial location is the salient factor in firm performance. Fourth, continuing the theoretical interest of the authors in knowledge transfer, especially considering the role of propinquity in facilitating this, the book aims to investigate the processes by which tacit knowledge becomes codified. It is hypothesized that the binary relation between these 'senses of knowing' (Orlikowski, 2002) are more complex than suggested in the literature begun by Polanyi (1966). As hinted by Zitt et al. (2003: 296):

> in many cases both tacit and codified information are linked in a number of ways. For example tacit information may act as a facilitator for the transmission of codified knowledge. If direct information flows matter then the availability of skilled manpower (universities as recruitment base, mobility of researchers) also plays an important role in localised dissemination of knowledge.[3]

A broad conceptual model of the intermediary cognitive and institutional steps from implicit to explicit knowledge in bioscience, referred to as distinct kinds of *complicit* knowledge, identified at least 15 of these (Cooke, 2005). More detailed empirical analysis would undoubtedly yield more. Harmaakorpi (2005) further identifies the role of pre-tacit and self-transcending knowledge as a crucial element in the knowledge creation process.[4] Some light will be shed also on variations among ICT and biotechnology knowledge in exploring these complex developmental issues. Finally, the book aims to explore the influence of different sub-national economic governance regimes upon sector and firm performance, including economic development policies, academic entrepreneurship and outsourcing client–supplier interactions. Accordingly, we hope to illuminate numerous currently hidden corners of the knowledge exploration to innovation exploitation process in distinctive advanced technology industries and varying governance contexts: a robust test of current conventional wisdom about markets, proximity and the leveraging of value from knowledge, we believe.

EUROPE AND THE INNOVATION CHALLENGE IN ICT AND BIOTECHNOLOGY

While as recently as 1995 the European Commission's *Green Paper on Innovation* (EC, 1995) bemoaned the European Union's industrial innovation performance compared with those of Japan and the USA, nowadays the exemplar role of Japan has receded due to its modest performance in biotechnology and failure to innovate around the Internet, two spheres in which the USA predominates globally. The technology stocks boom of the 1990s ended with the crash of 2000–01, spurred, it has been argued, by the injunction to rein back on aspects of 'irrational exuberance'. United States (US) Federal Reserve Bank Chairman, Alan Greenspan, observed this questionable spirit in the momentum built by his and other US commentators' postulation that a 'new economy' had been born. This was fantasized as a self-refuelling 'ideas market' that meant conventional dogma about the importance of profitability in stock valuation could be jettisoned in favour of reliance largely upon investor gambling instincts, sometimes interlarded with fraudulent advice from self-interested market advisers and other 'experts'. Despite the legal fallout and wrecked hopes of easy riches that ensued from the bursting of the tech-stocks bubble, ICT and to a lesser extent biotechnology have by no means gone away. The main change in the ten years since 1995 is that Japan has, in relative terms, disappeared from the innovation radar to be replaced by the new and different development challenges to both Europe and the USA, let alone the rest of the world's economies, by the rise of the sleeping economic giants of India and China.

Europe has slipped back in some ways against its main surviving innovation benchmark, the USA, since 1995. This is despite the European Union (EU) Commission's injunctions, formulated at the Lisbon and Barcelona summits, to make Europe the world's most competitive knowledge-based economy by 2010. Consider the data for recent biotechnologically derived innovations in Table 1.1. These were researched for the UK Department of Trade and Industry's biotechnology monitoring assessments and represent most of the significant commercial innovations for 2003. A number of points arise from these entries. First, some 76 per cent had a US involvement in the origination of the drug, usually but not always by a dedicated biotechnology firm. Second, where the originator or partner was from outside the USA, it was 30 per cent from Switzerland, a non-EU member, though of course a European country. Third, the UK was the leading EU company source, at 30 per cent, with one entrant, Celltech, entering Belgian ownership shortly after. Finally, the 15 per cent Food and Drug Administration (FDA) approvals from wholly non-US partnerships involved one UK-German and one UK-French alliance, while Serono from Switzerland was the only non-US singleton originator. In some respects this is a less forbidding performance than might be imagined from inspection of other data (BIGT, 2004) that shows the USA far ahead of Europe in the number of drugs in the pipeline. So much so that a new model of commercial exploitation from globally leading UK bioscientific research called the 'conveyor belt' is emerging, the basic idea being that commercialization of UK discoveries will increasingly be conducted in the USA through cooperative licensing deals with US DBFs.[5]

Thus it may generally be concluded that for biotechnology, US DBFs are far more innovative and commercially successful than those of the rest of the world, including Europe and that the technological lead, while showing some slight signs of being eroded since Bioscience Innovation and Growth Team (BIGT, 2004) shows Europe has marginally more drugs in late stage trials than does the USA, the acid test is how many, comparatively speaking, receive FDA approval to enter the market. Thus far, US firms have proved superior in that respect.

With regard to innovation in ICT, Table 1.2 summarizes key indicators that show the scale of the US lead. Thus US ICT patents registered at the

Table 1.1 Selected US Food and Drug Administration drug approvals 2003

Company	Drug	Approval body	Indication
Actelion (Switzerland)/ Celltech (UK now USA)	Zavesca	FDA	Gaucher's disease
Cubist Pharma (USA)	Cubicin	FDA	Psoriasis
Genentech (US)/ Novartis (Switzerland)/ Tanox (USA)	Xolair	FDA	Asthma
Genzyme (USA)/ BioMarin (USA)	Aldurazyme	FDA/EMEA	MPS1 deformity
Genzyme (USA)	Fabrazyme	FDA	Fabry disease
Gilead (USA)	Emtriva	FDA/EMEA	HIV
GSK (UK)/ Bayer (Germany)	Levitra	FDA/EMEA	Erectile dysfunction
GSK (UK)/ Corixa (USA)	Bexxar	FDA	Non-Hodgkin's lymphoma
Medimmune (USA)/ Wyeth (USA)	Filumist	FDA	Influenza vaccine
Millennium (USA)	Velcade	FDA	Bone cancer (multiple myeloma)
Roche (Switzerland)/ Trimeris (USA)	Fuzeon	FDA/EMEA/ Swissmedic	HIV
Serono (Switzerland)	Serosotin	FDA	HIV
SkyePharma (UK)/ Sanofi-Synthélabo (France)	Uroxatral	FDA	Prostate

Note: EMEA – European Medicines Evaluation Authority; Swissmedic – Swiss equivalent.

Source: DTI (2005).

European Patent Office rose during the 1990s by 43 per cent to 20 per cent of total US EPO patenting. At 62 per cent the increase was greater in the EU albeit from a lower base, rising to 13 per cent of total European Patent Office (EPO) patents registered. The UK increase was higher at 157 per cent but from a yet lower base than the EU and half the 1990 share of the US.

Table 1.2 Shares of ICT in total patent and value-added shares

Country	ICT patent share (EPO) %		Value-added share %		Business sector value-added share %	
	1990	1998	1995	2001	1995	2000
USA	14.0	20.0	2.1	2.3	10.0	12.0
EU	8.0	13.0	1.3	1.2	7.0	8.0
UK	7.0	18.0	1.7	1.4	10.0	11.0
Austria	5.0	7.0	NA	NA	NA	8.0

Sources: European Patent Office (EPO); Organisation for Economic Co-operation and Development (OECD) STAN (Structural Analysis) Indicators, 2004.

The UK catch-up in ICT patenting in the 1990s was accordingly somewhat spectacular. This could not be said for Austria, whose 40 per cent rise rivalled that of the USA but from one-third the US base.

The value-added shares in the broader economies and specifically their business services sectors also betray a better US than EU performance, though the US gap with the UK in business services share is much less. Here it may be said that the UK shows some similarity with its 'liberal market' counterpart in ICT business service value-added, while Austria, at least in 2000, mimicked a more continental profile. Either way, utilizing different indicators from the biotechnology data, where the US lead is more pronounced,[6] these confirm also that it has a substantially higher ICT patent share and a marginally growing economy-wide value-added share over the EU. The latter contains divergent trends, well represented by the UK and Austria, with the former displaying strong catch-up performance towards the USA in ICT patenting and Austria improving marginally from a low base. The implications of this for economic growth and particularly the role of total factor productivity in explaining growth are the subject of significant policy and academic interest.

Two views on the importance of ICT production and, crucially, *utilization* in economic activity are representative of attempts to place ICT's contribution in perspective. The results, from somewhat divergent starting points tend towards convergence regarding the contribution of ICT to productivity growth and the recently widening gap between the USA and EU. An approach that seeks to place the contribution of ICT to growth in perspective is offered by Kaloudis et al. (2005). In line with the narrower ICT share in value-added shown for both EU and the USA in Table 1.2, the broader group of high-technology (high-tech) manufacturing industries utilizing OECD categorizations[7] reveal high-tech manufacturing for leading OECD countries to contribute less than 10 per cent of total value-added in

1980 and almost exactly 10 per cent in 2002, a slight narrowing of the gap, affected notably by the ICT downturn in 2000–01. It rose to 13 per cent of *manufacturing* value-added by 2002 from less than 10 per cent in 1980. However, in correlating gross domestic product (GDP) growth rates with high-tech shares in manufacturing value-added, the USA is at the leading edge of the upwardly sloping regression line, with Sweden, Finland, Japan and the UK following. Co-ordinated market stalwarts like Germany, Austria and Italy follow some way behind.

So the data tend to support the high ICT and high GDP growth argument. However, the authors also show high-tech to have contributed only slightly more to overall *manufacturing* growth 1980–98 than OECD-defined medium-tech sectors.[8] Moreover, when annual compound growth rates for the 1991–2001 period are examined the correlations lose significance and lower-tech economies like Spain and medium-higher smaller economies like Norway show better growth. Meanwhile, the large coordinated group of Germany, Italy and France rival Japan in the low-growth performance category with those EU countries also displaying only middle-ranking high-tech shares in manufacturing value-added. The authors conclude that different economic strokes work for different manufacturing folks, namely an economy like Norway, rich in oil and gas resources and the upstream marine engineering associated with it can show a better yearly compound growth than higher-tech economies like the UK, the USA and, massively, Japan. In this analysis Austria performs more like Denmark, Finland and Canada – showing a better high-tech share of manufacturing value-added and yearly growth rate than Germany, Italy or France.

A different take on the important question of the extent to which high-tech intensity in manufacturing value-added is positively associated with productivity and GDP growth is provided by Van Ark and Inklaar (2005). The authors first show comparative GDP and labour productivity change between the USA and EU 15 between 1987 and 2004 (Table 1.3). This shows that the USA displayed a consistently higher GDP growth rate than the EU over the 1987–2004 period, and a growing if fluctuating labour productivity improvement over the same period. Meanwhile labour productivity in the EU declined significantly and seems to be structural. In contrast, US labour productivity grew after the slump in technology stock markets around 2000, improving by +0.8 per cent from 2000 to 2004, while that of the EU declined by the same magnitude as the USA grew in that period. Unit labour cost reductions and more efficient use of labour through investment in equipment and skills account for most labour productivity gains. In the US large-scale job-shedding in high value-adding sectors and greater use of, for example, e-commerce, largely account for this. Thus, for instance, in the ICT heartland of Silicon Valley some 400 000 jobs disappeared

Table 1.3 US and EU comparative real GDP and labour productivity change, 1987–2004

	Real GDP (%)		Labour productivity (%)	
	USA	EU	USA	EU
1987–1995	2.7	2.2	1.1	2.3
1995–2004	3.4	2.2	2.5	1.5
Of which:				
1995–2000	4.1	2.7	2.1	1.8
2000–2004	2.5	1.4	2.9	1.0
Of which:				
2004	4.4	2.5	3.0	1.3
Change 2000–04				
Over 1995–2000	−1.6	−1.3	+0.8	−0.8

Source: Based on Van Ark and Inkelaan (2005).

between 2000 and 2003 (Bazdarich and Hurd, 2003). This was the largest peacetime metropolitan job-loss aggregate in US history. In the EU, such labour market carnage was unknown, although recessions were registered, but labour market rigidities probably accounted for most of the decline in labour productivity after 2000.

Moving on, the key question of relevance to this analysis is the extent to which ICT contributed to productivity growth in the US and moderated its decline in the EU. These effects may occur in three ways: ICT investment deepening ICT capital;[9] significant ICT equipment innovation; and knowledge spillovers for intensive ICT user industries. In the EU 1987–2004 non-ICT capital deepening far outweighed that in ICT, though the two came into greater balance between 1995 and 2004. However in the USA there was a greater ICT capital deepening and a miniscule non-ICT capital deepening process, especially in the 1987–95 period. Concomitantly, *total* factor productivity in ICT production grew in the USA at more than double the EU rate in both periods. Also non-ICT total factor productivity was vestigial after 1995 in the EU, while it more than doubled in the USA. After 2000 ICT innovation fell back markedly in the EU and to a lesser extent in the USA, while only the USA, UK and Sweden showed improvement in non-ICT total factor productivity. Austria showed none, in contrast to the pre-2000 period. Finally, since 2000, knowledge spillovers have begun to show an effect upon total factor productivity from ICT use. In other words, *service* industry is the key to faster productivity growth in the USA compared with the EU. This is so in both the pre- and post-2000 periods, especially the latter when, in the EU, banking productivity declined absolutely and it halved in retail. By contrast, in the USA it grew across the key economic sectors, but especially in *business services*. Europe's much vaunted productivity advantage in telecommunications had largely disappeared by the post-2000 period, the USA having caught up, primarily through the contribution of ICT capital deepening. In *business services*, productivity growth is strongly negative in many EU countries. Where it is not, as in the UK, ICT explains a large part of growth, as it does in the USA. Business services productivity growth largely explains total services productivity growth in the USA post-2000 whereas in the EU it peaked in 1996.

To summarize, the advantages accruing from biotechnology and ICT excellence in the USA compared to the EU work in distinctive ways. In biotechnology, the DBFs and their 'big pharma' partners produce far more innovative biotechnology products and services on the health-care market. In the USA more drugs are in trials, though in the EU (plus Switzerland) in 2004 there were more in late-stage trials than in the USA, with what likely success is currently unknown. The US lead in this sector is nevertheless decisive. In ICT the EU problem appears to be complex, involving absolute declines in ICT investment in services, especially the value-adding producer services. These have witnessed a great surge of ICT capital deepening and spread of knowledge spillovers but less actual innovation in the USA since 2000. In particular, the important and burgeoning *business services* sector in the USA has been the key beneficiary of non-ICT industry investment in ICT hardware and software. Business services are many and varied, ranging from varieties of consultancy to e-commerce. This may resonate with the remarkable switch by large US enterprises towards research and development (R&D) outsourcing to such 'knowledge entrepreneurs' to be discussed later in this chapter. Whether it is happening belatedly in the EU seems anecdotally to be the case but if so it may be largely a post-2004 phenomenon and one that increasingly involves Asian host companies.

LIBERAL AND COORDINATED MARKETS: IDEAS, DEFINITIONS AND EXEMPLARS

At this point of this introduction to the book, we wish to offer a little more justification and explain why the 'varieties of capitalism' thesis attracted us more than any other institutionalist approach to analysing the influence of governance regimes upon the evolution of space economies.[10] Recall we are studying generic phenomena – innovative high-technology firms and their specific economic geographies – seeking explanation for performance variance that are both internal to the firm and sector, and external to both. As a key focus of this kind of research is *innovation* and the premier theoretical and empirical work in the field is neo-Schumpeterian innovation systems theory, set within an evolutionary economics macro-framework. Accordingly, we are naturally seeking theoretical compatibilities rather than choosing two or three theoretical frameworks from a portfolio to see which offers the most persuasive explanation of the empirical patterns observed. In this field of research there is no such portfolio. Business systems research is a compatible candidate but all its emphases lean towards the study of large firms, especially multinational companies and their intersections with the regulatory regimes at the macro-level. A striking feature of *innovation* systems theory and empirical research is that it has never been especially exercised about large firms per se but rather with institutions that originate and support the origination of innovation. Accordingly, while the R&D laboratory practices of large firms might be of interest, it is increasingly the case that interest equally falls upon non-profit public research institute laboratories, or university research laboratories, and increasingly the research activities of small and medium-size enterprises (SMEs) as they *interact* with each other and with the *innovation* environment of specialist consultants, incubator facilities, patent lawyers, venture capitalists, innovation *users*, and so on, since it is the system as much as, say, the firm that motivates the quest for understanding.

A different, though again compatible perspective, on regulatory regime comparisons is the now rather dated work that arose more from political sociology than evolutionary economics associated with the study of 'corporatism'[11] or in the USA 'trilateralism'. That terminology instantly takes us back to the pre-Thatcher, pre-Reagan era when corporatism, with its institutional consensus mechanisms involving 'social partnership' and 'social contracts' was often associated with economic success and market economies like the UK and even, to some extent, the USA, were seen to be flagging. But again, as well as concentrating heavily upon political institutions, more than even large corporations which were seldom objects of study, it too concerned itself with the macro-ecology of institutional accommodation and stabilization rather than the wellsprings of techno-economic networks and the sometimes disruptive innovations they brought forth as forms of Schumpeterian 'creative destruction'. Uniquely, therefore, 'varieties of capitalism' overcomes these drawbacks, and indeed research from its perspective even accommodates study of the kind with which this book is concerned, as testified to in, for example, the work of Casper et al. (1999) published in one of the house journals of the neo-Schumpeterian innovation studies community.[12]

Hence, for these reasons we feel the macro-framework we have chosen to help organize the comparative dimension of our work is the most appropriate. It now remains to expostulate its main elements and show how it is made to work on empirical material of the kind we will be presenting in Chapters 7 and 8 in Part II. We may begin by paraphrasing Casper et al. (1999) contrasting economic performance on grounds of innovative performance in high-technology industry between Germany as a coordinated market economy and the USA as a liberal market economy, something we attempt to do similarly for Austria and the UK. Thus Germany is characterized as a coordinated market economy by virtue of the following characteristics. First, the economy is underpinned by a private law system that regulates business and labour contracts. Business itself is organized in ways that embed large firms within networks of trade and industry associations, industrial relations and stakeholder or interest group rules and conventions. These associations are lobbyists for business with government and they often supply useful business services such as research, overseas representation and advice. Government policy relies on the legal system to maintain collective industry agreements between firms and regarding, for example, wage-bargaining, delegating some specific rights to self-managing unions or stakeholder groups. Workforce training is apprenticeship based, focused on specific skill-formation and organized through chambers of industry and commerce. The financial system is primarily bank based with stakeholder corporate governance and banks as major shareholders in larger firms. In Germany market regulation and non-market firm-level modes of business coordination predominate. Hence Germany's market is coordinated.

The USA is a liberal market economy with business organization managed through market interactions supported by a flexible and facilitative legal system. However, in itself it does not rule on the content of legal contracts, this being the responsibility of the contract partners. It has a shareholder not a stakeholder business culture, with minimal legal constraints on firm organization. Different historic and sectoral patterns of market regulation mean business coordination varies across different sectors, historically ranging from legal monopoly to relatively unregulated arrangements. Wage-bargaining is unionized in some industries, and negotiated individual compensation packages in others, with effectively no government intervention. Workforce training is not systematized and not apprenticeship based. The financial system is primarily one of capital markets and historically comparatively weak and regionalized banking. Hence most aspects of economic interaction are largely deregulated with markets coordinating business activity. Accordingly, the USA has a liberal market form of economic regulation.

We will see shortly how accurate a description of regulatory norms these are for, respectively, Austria and the UK. Before that, however, we wish (Table 1.4) to relate the positions of Germany and the USA to innovation

Table 1.4 Coordinated and liberal market structures for innovation in Germany and the USA

	Germany	USA
Science and technology (S&T) labour market	Long-term employment, often with a single employer. Formal rights under co-determination to training, work organization and unlimited employment contracts	Labour markets are deregulated and mobile. Limited, often individual employment contracts. Widespread labour poaching and 'head-hunting'
Firm organization	Consensus decisions, few individual employee incentives. Stock options uncommon, (illegal to 1998). Group reward schemes. Careers well defined and not short-term performance based	Financial 'property rights' ownership structures. No co-determination rules. Strong incentive structures and performance-based compensation. Rapidly shifting firm competencies
Financial ownership	Strong corporate governance rules. Bank not equity firm financing. Bank representatives on boards. Long-term, low-risk investment	Large capital markets (e.g. NASDAQ) fund investment. Equity-based financing, short term. Venture capital
Innovation	Banks do not fund R&D. Incremental innovation the norm. Niche competition. Few radical innovations. These rigidities hamper high-tech start-ups	Investment profile favours novelty and radical innovation. Disruptive technologies create broad, new global markets. Start-up friendly

Source: Based on Casper et al. (2003).

according to their distinctive regulatory regimes, stylizing the findings of Casper et al. (1999) on this. The stylization guides the analysis of comparative innovative performance of Austria and the UK in equivalent industries that are analysed and reported in the rest of this book. Commenting upon these contrasts, it can be said with confidence that these regulatory regimes differ markedly and that this appears to have a determinate effect upon variations in their respective software and biotechnology innovation profiles.

Thus, biotechnology marked a revolution in industrial organization whereby the R&D epicentre shifted from the internal R&D laboratories of large pharmaceuticals firms to university research centres of excellence, foundation-funded research institutes and DBFs. This echoed the shift in scientific primacy from chemistry to biology and the methodology of research from 'chance discovery', classically as with penicillin, to 'rational drug design'. Germany was the home of in-house chance discovery R&D, the paradigm case being Bayer's nineteenth-century breakthrough in synthesizing aspirin from coal tar, the first effective, affordable modern drug. In more recent times German pharmaceutical firms proved particularly incapable of coping with this disruptive triple break in the innovation trajectory of their industry. They responded by seeking aid from government programmes that simultaneously denied such funding to DBFs. Failing to master biotechnology, they later acquired or made alliances with US DBFs but gradually these proved a disappointment as 'star' scientists pocketed the investments and left to form new businesses as serial entrepreneurs. Hence German pharmaceuticals dominance that was pronounced in 1970s had by the 2000s disappeared, with Bayer suffering numerous technological setbacks and Hoechst ultimately being absorbed, along with its French merger partner (Rhone-Poulenc) that created Aventis, into the ownership in 2004 of successful French DBF Sanofi-Synthélabo. Table 1.5 shows some effects of the belated attempt by the federal government to stimulate DBF start-ups through the BioRegio innovative cluster support programme.

This more than doubled the population of German DBFs, but as the substance, content and performance of these admittedly youthful firms shows, this still leaves Germany orders of magnitude behind other, sometimes smaller, European economies let alone the USA. This comparison (Table 1.5) is notable in a number of ways. First, it shows just how effective, at least on the input side of the process, a specialized policy can be in creating firms, indeed in the German case BioRegio aimed expressly to create clusters of biotechnology firms in Munich, Heidelberg and the Rhineland. This is by no means an easy task and the 1995–2000 achievement was a significant boost to those who recognize the important role of policy faced with a

Table 1.5 Main international bioscience competitors, 2003

Country	Companies	Public cos	Market cap.*	Revenues*	Employees*	Pipeline*
USA	1457	307	€205.0 bn	€27.0 bn	191000	872
UK	331	46	€9.4 bn	€3.0 bn	22000	194
Switzerland	129	5	€7.3 bn	€2.0 bn	8000	79
France	239	6	€0.5 bn	€0.3 bn	9655	31
Germany	369	13	€0.5 bn	€0.5 bn	13386	15

Note: * Public company data only.

Source: BIGT (2004).

situation of major market failure. Second, moreover, this occurred in a strong coordinated market economy where such achievements are supposed to be extra difficult. However, third, in biotechnology it is unusual even under a liberal market regulatory regime for growth to be rapid. So Germany's weak performance regarding number and value of public companies, the latter an acid test of achievement of, at least potential, revenues and products in the trialling 'pipeline' bears witness to the possible artificiality of the achievement. After the stock market downturn and the ending of BioRegio many German firms disappeared – 14 alone in Munich in 2004.[13] In conclusion the analysis confirms the association between innovative performance in biotechnology and regulatory regime since the USA and the UK are way ahead of the coordinated markets in Table 1.5.

For ICT, specifically software, the analysis produces comparable though larger-scale discrepancies in performance by high-tech businesses as between the liberal and coordinated regimes. In Germany software is strong in applications, notably customer-specific solutions in engineering processes, particularly automotive. Backed again by large federal government programmes, this niche was to be strengthened further still by knowledge transfer into industry from advanced university and institution research in software. So, as in biotechnology there are many very small firms (some 5000 according to Casper et al., 1999) with fragmented capabilities. Meanwhile one firm, SAP, bucked that market profile by becoming a global leader in enterprise resource planning (ERP), meaning generic programs for efficient reorganization of large companies around standardized integrated software solutions. Software AG is another such standardized German firm, indeed all others in the global top 20 are US firms. One reason why few service-providing German firms are prominent is because most large German firms meet their own software service requirements in-house. It is in standardized markets that innovation is more disruptive and, though Germany challenges the USA on a narrow corporate front, it is massively outweighed by the likes of Microsoft, Oracle, JD Edwards and Peoplesoft, the leading ERP providers. The rest of German software is an adjunct to the German engineering tradition to a large extent, and locked-in to the fortunes of that globally strong but not unchallenged sector. So to conclude, in this analysis of the interaction between ICT and biotechnology in distinctive regulatory regimes, the postulated outcomes are fairly well predicted from the two stylizations. That is, German institutional arrangements tend to sustain incremental, not breakthrough, innovation. These also tend to favour the emergence of a few large, globally successful corporations with flotillas of state-dependent and fragmentary smaller firms and start-ups. Policy can be effective in augmenting numbers of the latter but their small scale and immaturity in Germany's regulatory context mean they do not grow swiftly as many US 'breakthrough' innovators often do.

KNOWLEDGE FLOWS AND THEIR ECONOMIC GEOGRAPHY: INNOVATIVE CLUSTERS

We come now to a brief overview of a key dimension of the book that will feature strongly in later chapters. This concerns a new and by no means totally clear reconfiguration of key global knowledge flows and their new economic geography. This arises from some of the issues already raised regarding the context for this book, notably global outsourcing and specifically *R&D outsourcing*. Of particular interest here is the extent this may have *metamorphosed* global knowledge interactions.[14] We are interested in how its realization evolves institutionally under the two master regulatory narratives with which we are here exercised, and to what extent, hypothetically, they are influenced by this. The policy dimensions of this analysis are briefly highlighted for Austria and the UK in the final section of this introductory chapter. The implications of what has been discussed already for knowledge flows of the kind in which we are interested, are the following. Foremost is the changing status of multinational corporations with respect to the origination of knowledge arising from *exploration* activity in their in-house R&D laboratories. It has recently become clear that the degree to which this happens nowadays has declined, at least for US industrial R&D, from around 71 per cent of all R&D being in-house in 1981 to only 39 per cent being so performed by 2001. This massive shift in R&D outsourcing has benefited overwhelmingly knowledge entrepreneurs, notably DBFs, but also their clustered equivalents in ICT, and university research centres of excellence that are often co-located with the aforementioned.

In these two industries, in particular, R&D outsourcing is very high and increasingly international. Thus from 1994 to 2000 there was a fivefold

Table 1.6 Growth in R&D expenditures by small US companies, 1997–2001

Size of firm	1997	1998	1999	2000*	2001*	% change
<25	2536	3804	5579	6176	4346	71
25 to 49	2455	2525	3824	4507	3375	37
50 to 99	3415	5155	5779	6533	7382	116
100 to 249	5907	6622	5707	8118	11634	114
250 to 499	5229	5522	6463	6731	7832	50
Total	19542	23628	27352	32065	34569	77

Note: Millions of constant $1992/ *$1996.

Source: NSF (2005).

increase in R&D outsourcing to the rest of the world from the USA and a tenfold increase to China and Singapore (up from roughly $50–$500 million in both). The data in Table 1.6 reveal the massive increase in R&D outsourcing as a key knowledge flow under redirection towards SMEs in the USA alone. Moreover, other data from the same source show such knowledge-intensive SMEs to be far larger recipients in share of the total for ICT and biotechnology than, for example, universities.[15] This means that for an increasingly large share of exploration[16] knowledge in two sectors that are high R&D spenders, possibly accounting for half the $198.5 billion US total listed for 2001, SMEs and universities along with other independent research institutes are nowadays major providers. In fact NSF data on this show the relationship between firm and university recipients of R&D outsourcing to be in the ratio of 4:1. Clearly, from Table 1.6, firms in the USA employing fewer than 500 people account for some 18 per cent of US industrial R&D across all industrial sectors, a virtual doubling in five years. Such high-grade data are not available for European countries, but close reading of anecdotally based research such as that provided by the European Association of Contract Research Organisations (EACRO, 2005) shows a consistent trend. The hypothesis that this activity locates in the leading clusters for ICT and biotechnology is intimated in a study by Chesbrough (2003) and this is consistent with work by the likes of Norton (2000) and Florida (2002) who identify such R&D megacentres[17] as Boston, San Francisco, San Jose and San Diego as America's most entrepreneurial, most knowledge-intensive and most culturally talented and innovative of locations. For the present, space does not permit much more to be said although we shall return with further evidence about this *metamorphosis* in the control of exploration knowledge through R&D

outsourcing. The most that can be said about differences between our two stylized kinds of economy and economic governance is that large firms seem equally prone to R&D outsourcing in both regimes but that in, for example, Germany where Fraunhofers, Max Plancks and varieties of research centres from Helmholz to 'Blue List' have for long conducted industrial as well as publicly funded R&D, the most notable 'branching' is that which sees corporations like Siemens outsourcing to affiliates or simply opening internal R&D laboratories in Asia, notably China and India.[18]

POLICY SHIFTS IN INNOVATION GOVERNANCE: AUSTRIA AND UK

We come now to the final segment of the introduction to this book. Here we are interested in alerting ourselves and the reader to signs that the changes alluded to in the foregoing have been or are in the process of influencing the institutional and regulatory arrangements of economic governance in the two types of regime. We switch attention now from the larger stereotypes, Germany and the USA, to their smaller brethren, Austria and the UK. Clearly the last two are by no means carbon copies of the others although, as we shall see, the overlaps are striking. Let us perform a stylization (Table 1.7) around innovation system environments comparable to that performed for Germany and the USA in Table 1.4. Since this research involves a *regional* dimension in the analysis, a summary of key regional innovation support characteristics is also inserted.

Three things are immediately apparent regarding the contrasting institutional and regulatory regimes in question. The first is that Austria and the UK are by no means carbon copies of the stylized portrayals of German and US varieties of capitalism. However, the similarities outweigh the differences. The main difference is the predominance of bank-based funding and 'steering' of companies in Austria and of equity-based funding in the UK. Of course there are differences, depending on scale and nature of firms in question under each regime, but probably in no way do UK firms have bank-based control as in coordinated market economies, and a minority of Austrian firms would traditionally have been mainly equity based, though this is changing. Political change, dismantling of the social partnership, consensus-based public-private 'Austrian model' has occurred, removing from power the once hegemonic conservative and socialist coalitions of the past. Privatization of many public utilities and other holdings has occurred and a new impulse given to innovation, against the kind of economic stability, some would say stagnation, typical of the old model and its associated conventions.

Table 1.7 Coordinated and liberal market structures for innovation in Austria and the UK

	Austria	UK
S&T labour market	University-led; some large firms public-private R&D organizations. Until recently: long-term employment, collective contracts rights to training. Now: more workforce flexibilization and segmentation.	S&T labour markets are university-led, some government R&D, some corporate. Contracts national and local. Increasing 'headhunting'.
Firm organization	Large firms: consensus decisions, union bargaining. Small firms; paternalistic. Careers well defined and not short term and performance based. Few individual employee incentives, stock-options not common. Recently: more flexible incentive schemes.	Equity-based ownership structures. Weak union bargaining. Incentive schemes, performance-related pay. Flexible, global supply-chain configurations.
Financial ownership	Bank not equity firm financing. Bank representatives on boards. Strong corporate governance rules. Long-term, low-risk investment. Some role of public funds.	Large capital markets (e.g. AIM) fund investment. Equity-based financing, short term. Venture capital.
Innovation	Large firms: R&D investment internal. Small firms: little R, some D. Niche competition and incremental innovation. Few radical innovations. Public funds innovation support R&D, innovation collaboration and high-tech start-ups.	Investment profile favours incremental and radical innovation. Research strong, commercialization weak. Moderately start-up friendly.
Regions	Federal system, innovation part of *Land* brief. Corporatist management of services. Unions run labour	Asymmetric devolution. Economic development agencies common. They manage much innovation

Table 1.7 (continued)

	Austria	UK
	market service, industry runs Chambers. Regional economic development agencies.	support, regional venture funds, cluster strategies.

The second point of note is that Austria has a distinctive science and technology infrastructure and associated career path for scientists. It differs even from the German system in the following ways. Key here is the large Austrian Research Centre (ARC) network of national technological institutes such as Seibersdorf, where research, knowledge and technology transfer to firms is conducted. The ARC covers *inter alia* systems, nuclear, weaponry, rail, metallic, electrochemical, and computer vision research. Other research is naturally conducted in firms and universities especially, for industry-related research, in Austria's technical universities, which also frequently have technology parks and start-up programmes. In the UK most leading research is conducted in universities. There are few independent foundations and no research institute network comparable to the ARC. Government research and establishment research is not generally advanced or innovative, while business-funded research budgets have, in recent years, been in decline and/or increasingly outsourced to university laboratories or 'knowledge entrepreneur' research, design and engineering businesses.

Finally, regarding innovation and regions: innovation is prized in both countries but neither is particularly outstanding at commercialization of new knowledge. We have seen how UK biotechnological research of world class is likely to be exploited more in future by US DBFs. In this respect the Austrian and the UK innovation profiles may be closer than those between the USA and the UK. Having said that, the UK has many elements that are also found in the USA, namely, entrepreneurially minded university policies, abundant venture capital, patent lawyers, management accountants and specialist consultancies. However Austria's more publicly funded innovation system may in some respects be superior, given scale differences, to that of the UK. If we move to the regional level of governance, a region like Styria in Austria has excellent technical universities such as the one at Graz, producing numerous start-ups from its graduating PhD candidates, housing them on its technology park and linking them through collaborative activities connected to development agency cluster programmes. However, these innovators are often focused in medium-technology rather than high-technology sectors. Nevertheless a similar 'region' like Scotland or Wales finds many barriers to forming such a seamless innovation system effect. Moreover, in those cases, most of the innovation support activity is public in origin owing to market weaknesses and failures. So, in conclusion, the UK is a markedly 'European' variety of liberal market institutional capitalism with its weak commercialization performance, while Austria is, as we shall see, in Chapter 8 in greater detail, moving away from its stylization as a coordinated market model. Both have solid regional institutional support for innovation – a point at which their divergences are possibly less marked than in other spheres. However, with the establishment of regional development agencies for the regions of England – but not Scotland or Wales – this was itself an economic governance innovation dating only from 1999.

This concludes the introductory chapter. All the issues raised are addressed in some depth in the chapters that follow. Immediately following are two that comprise conceptual and methodological reviews of key concepts from economics and contemporary regional science such as the changing nature of the 'knowledge economy', the role of asymmetric knowledge in regional uneven development, clustering theory and practice, and how we researched comparatively the same industries in two such different regulatory regimes. The various models for commercialization of new knowledge and the mediating influences among markets, knowledge and other spillovers, networks and milieux are then assessed prior to an in-depth analysis of some of the global–local/regional knowledge flows issues informing current debate, such as that touched upon in relation to R&D outsourcing in this introduction. Part I of the book concludes with a chapter reviewing the contribution of an *innovation systems* perspective to understanding the complexities involved in the kind of regional research dealt with in this book, considering varieties of these in line with the general tenor of the book. Part II then moves into empirical analyses of the key research results for the two sectors and countries emphasizing sub-national innovation practices and economic governance interactions, again highlighting the varieties of regional innovation system effects observable from the data. The experiences of the two countries are compared in some analytical and empirical detail before a final chapters draws out the book's key lessons and conclusions for both theory and policy in respect of the issues raised by the research that has been reported.

NOTES

1. On 'national business systems' there is a copious literature from Europe, see for example, Whitley (2002), and from the USA, Hollingsworth and Boyer (1997). These are

'institutionalist' socio-economic analyses and compatible in conceptual terms with the approach taken in this book.

2. It is worth noting, in passing, the significant contribution made to the Italian economy in the post-war years by such small and medium enterprise industrial districts. In a historical analysis by Becattini and Dei Ottati (2006), it is shown that from 1951 to 2001 manufacturing districts grew in employment from 72 000 to over 2 million while provinces dominated by larger enterprises remained at 1.8 million, having peaked at 2.2 million in 1961 and again in 1981. On most other performance indicators, such as value-added, export value, unemployment rates and, even, demographics, small firm districts outperformed large enterprises by a factor of at least two to one.
3. Despite the important insight regarding the practical and conceptual content between tacit (implicit) and codified (explicit) knowledge, these authors badly mix up 'information' and 'knowledge' as if they were identical, a problem by no means confined to them. In this book we will generally refer to 'knowledge' in relation to 'information' according to the following: *information* is a passive resource given *meaning* by the application of *knowledge*, which facilitates *action*. Thus if the actor has *knowledge* of her destination, *meaning* is given to the *information* in the train timetable, enabling appropriate travel *action* to be taken.
4. See also Scharmer (2001). This can take many forms, some no doubt deeply embedded and culturally as well as psychologically shaped. But an instance, discussed by Metcalfe (2005), might be the sense of unease, dissatisfaction or disagreement with the status quo that must be the first step in the knowledge-creation process that may result in a commercial innovation.
5. Foley (2005). A quote from Sir Chris Evans, head of Merlin Biosciences, envisaging a way out of the UK's entrepreneurship deficit in biotechnology. This is a good example of the rise of a specialist 'research industry' in an economy that is modest in its biotechnology commercialization achievements. Of course, time will tell if this happens and whether it is confined only to biotechnology.
6. Further data supporting this contention are provided in Chapter 6.
7. Aerospace, computers and office machinery, electronics-communications and pharmaceuticals.
8. Automotives, chemicals, machinery and scientific instruments.
9. Capital deepening means that in a growing economy, it raises capital per worker for all workers.
10. The approach is not immune from criticism. There are at least three dimensions of this. The first is that it is manufacturing-centric; second that, as we have noted, there is a great deal of variety within the two types; and third, that it postulates no sense of how coordinated market economies can compete in the long run against the 'monetarist assault' of the liberal market economies. Cogent answers, mostly showing how these points are dealt with in the perspective already, are supplied in Hall and Soskice (2003).
11. See, for example, Crouch and Streeck (1996).
12. Casper et al. (1999).
13. This statistic given verbally by BioM, the Munich BioRegio policy vehicle, in a meeting of the EU-BioLink bioincubation project at Genopole, Evry, Paris in January 2005. See www.cordis.lu/paxis/src/val_projec.htm.
14. This term is used in the preface to Penrose (1995) in reference to the manner in which innovation demands the mobilization of growth firms in global knowledge and innovation networks, something she suggests is metamorphosing what we might think of in terms of the structures of globalization. Prominent amongst these restructurings are geographical hierarchies of research accomplishment (see Cantwell and Iammarino, 2003).
15. The data source is the report by the US National Science Foundation (NSF, 2005).
16. This terminology of *exploration* and *exploitation* knowledge originated with March (1991).
17. For a definition of the French concept of *megacentres* as more than mere market-driven clusters because they embody also localized exploration research and talent formation institutions that are mostly publicly funded, see Cooke (2004).

18. See for example, Merchant (2005) on Siemens' investment of $500 million in an Indian export hub. The article notes this is 'to expand research and development, raising its force of Indian software engineers to 4,000'. The move followed similar announcements by Swedish/Swiss rival ABB, Finland's Nokia and pharmaceuticals companies Novartis and AstraZeneca to India in 2005.

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