1. Introduction

1.1 INTRODUCTION

The nature of universities in Europe has changed dramatically since the mid-1990s. A number of events have precipitated this change. First, following the drop of federal funding for research at universities in the US, the public research funding of research at universities in Europe has also decreased (Etzkowitz, 1983). Second, a public debate has emerged about the role which universities have to play in society. Third, many countries in Europe have adopted a Bayh–Dole type of Act on university patenting activity. These environmental changes are believed to increase the pressure and incentives to commercialize university research (Bank of England, 1996; Confederation of British Industry, 1997; Siegel, et al., 2003). Traditional emphasis has been upon the licensing of innovations (for example, Thursby and Thursby, 2002) but greater attention is now being addressed internationally to the creation of new ventures that involve the spinning-off of technology and knowledge generated by universities (Table 1.1).

According to the Association of University Technology Managers (AUTM), US universities spun out 4543 start-ups between 1980 and 2003 (AUTM, 2005). In the 1980s, US universities created fewer than 100 start-ups per year. In 2004 they created 462 start-ups, taking equity in 240 of them. For many analysts, this growth is explained by the passage of the Bayh–Dole Patent and Trademark Amendments Act of 1980 which permitted performers of federally funded research to file for patents on the results of this research and to grant licences for these patents, including exclusive licences, to firms. Although there is some debate about the direct effects of the Act (Mowery, 2001), patent activity in academia has seen exceptional growth, for example from 1584 patent applications in 1991 to 10,517 in 2004. During the same period, university revenue from patents licences jumped from $200 million to $1.3 billion (AUTM, 2004). This Act made it easier for universities to license and commercialize inventions, facilitating the creation of spin-off firms interested in licensing and developing these inventions (Mowery et al., 2004). More generally, the Bayh–Dole Act legitimated the involvement of universities in technology commercialization and spin-off activities at US universities.
Within Europe, there is some debate about whether too many (Lambert, 2003) or too few (Williams, 2005) spin-offs from universities are being created. As in the US (O’Shea et al., 2005), university spin-off activity in Europe is highly skewed. UK evidence (Wright et al., 2003) shows, for example, that 57 per cent of 124 responding universities did not create any spin-offs in 2002 and only nine universities created five or more. Similarly, a pan-European survey covering 172 universities in 17 countries found that 103 provided spin-off services. Only half of the universities providing spin-off services created one or more spin-offs in 2004 (Proton, 2005).

In principle, university spin-offs benefit society and universities in a variety of ways, including their effects on local economic development, their ability to produce income for universities, their tendency to commercialize technology that otherwise would be undeveloped, and their usefulness in helping universities with their core missions of research and teaching (Shane, 2004). There is clear evidence that some university spin-offs are highly successful. For example, in the US, 18 per cent of all spin-offs from the Massachusetts Institute of Technology (MIT) in the period 1980–86 went public (Shane and Stuart, 2002) and in the UK there were 20 public listings of spin-offs in the period 2003–04 (UNICO, 2005). In Belgium, the InterUniversity Institute for MicroElectronics has realized a multiple of 36 on a trade sale of a ten-year old spin-off sold for 50 million

<table>
<thead>
<tr>
<th>Country</th>
<th>Period</th>
<th>Number of spin-offs</th>
</tr>
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<tbody>
<tr>
<td>US</td>
<td>1980–2003</td>
<td>4543*</td>
</tr>
<tr>
<td>Canada</td>
<td>1962–2003</td>
<td>1100</td>
</tr>
<tr>
<td>France</td>
<td>1984–2005</td>
<td>1230</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1980–1990s</td>
<td>300</td>
</tr>
<tr>
<td>Australia</td>
<td>1984–1999</td>
<td>97</td>
</tr>
<tr>
<td>UK</td>
<td>1981–2003</td>
<td>1650+</td>
</tr>
<tr>
<td>Belgium</td>
<td>1980–2005</td>
<td>320</td>
</tr>
<tr>
<td>Sweden</td>
<td>Up to 1990s</td>
<td>3000–5000+</td>
</tr>
<tr>
<td></td>
<td>2001</td>
<td>900–8000</td>
</tr>
</tbody>
</table>

Notes:  
* Includes 462 for 2004 relating to US and Canada.  
+ Different number of respondents in different years.  
** Estimates vary depending on definition and methodology.  
+++ For Sweden and Germany estimates difficult due to IP ownership residing with the academic rather than the university.

Source: Authors’ review.

Table 1.1 University spin-offs internationally (selected countries)
euros, while the first spin-off from the University of Gent was sold in 1994 for slightly over 2 billion euros after an initial investment of 75 million euros over a ten-year period. Yet, many spin-offs are not successful and they do not generate substantial wealth even though they appear to have high survival rates (Nerkar and Shane, 2003). While it is relatively straightforward to create a legal entity, the act of creating a company does not necessarily mean that it will subsequently create capital gains or income. There is, therefore, a major need to understand the spin-off creation process and, in particular, how wealth can be generated in the traditionally non-commercial environment of universities.

The focus of research and policy attention has predominately been on a small number of successful US institutions such as MIT and Stanford (Colyvas et al., 2002; Shane and Stuart, 2002). These cases are atypical even in the US because of the resources they can command and because they are located in regions that are effectively quasi-incubators. Although cases such as Cambridge, Leuven, Heidelberg and Chalmers may be considered successful high-tech centres by European standards, the geographical context of MIT and Stanford is not replicated in any part of Europe. Rather, many universities and public research organizations (PROs) in Europe have traditionally operated in an environment where high-tech entrepreneurship is relatively new or undeveloped. The spin-off process in such contexts is likely to be very different from that in more developed high-tech entrepreneurial environments such as Boston or Silicon Valley (Roberts, 1991; Roberts and Malone, 1996; Saxenian, 1994a, 1994b) where the capability to select the best projects and allocate resources to them already exists. Here the spin-off process can follow a ‘business pull’ strategy that is not dependent on the activities of the PRO, but benefits from high levels of innovation within the surrounding region. In contrast, in environments with less demand for innovation, characterized by a weak entrepreneurial community and few other key resources, PROs may need to play a more proactive incubation role. This strategy is best described as ‘technology push’, where the PRO exercises selection and provides venture creation and development support throughout the stages in the spin-off process.

The purpose of this book is to examine the spin-off venture creation process in a European context. We encompass a range of institutional environments both in terms of different countries and in respect of different regions and universities within individual countries. Our analysis adopts a multi-level approach. We focus on evidence from spin-offs in Belgium, France, Germany, Sweden and the UK. These countries provide a range of institutional environments within the European context in which there is variation in the general institutional context (La Porta et al., 1998; Reynolds et al., 2003), the ownership of intellectual property (IP) in universities
and the processes and policies relating to the stimulation and funding of spin-offs.

The structure of this chapter is as follows. First, we outline the definition of spin-offs used in this book. Second, we review key indicators of institutional differences between the US and European countries. As the institutional context may impact the nature of commercialization activities and processes, we are particularly interested in how the elements of countries’ national innovation systems, research activity and funding, structure and management of public sector research, entrepreneurial and business environments, and availability of private equity capital may differ.

1.2 DEFINITION OF UNIVERSITY SPIN-OFFS

Our study includes a wide range of companies that originate from universities. We define university spin-offs as new ventures that are dependent upon licensing or assignment of an institution’s IP for initiation. This definition is consistent with that used by the AUTM in the US. In some cases, where permitted, a university may own equity in the spin-off in exchange for patent rights it has assigned or in lieu of licence for fees. This is a narrow definition of a spin-off, but also the one which is most often used in empirical studies, although not every researcher clearly specifies that his/her study exclusively looks at these spin-offs. The reason for this is that in general these spin-offs are the easiest to keep track of for the Technology Transfer Office (TTO) since they are by definition based upon university IP.

However, if we only focus on spin-offs using the first part of the definition, we would miss a substantial part of the reality. At some universities in some institutional contexts, IP is not necessarily owned by the university. Moreover, many companies are created that do not build upon formal, codified knowledge embodied in patents. Therefore, we also include start-ups by faculty based in universities which do not involve formal assignment of the institution’s IP but which may draw on the individual’s own IP or knowledge. It is hard to assess how many of these academic start-ups exist in comparison to the number of spin-offs. The relative proportion of both categories will depend upon the research composition at the university, the institutional context, the university policy with regards to IP rights and, finally, the entrepreneurial activity of the academics themselves. Some evidence from our Belgian sample suggests that in that specific context about half of the companies created by university faculty are spin-offs; the other half are academic start-ups.

However, we exclude companies that may be established by graduates after they have left the university and companies established by outsiders.
that may draw on IP created by universities. The former are only loosely connected to the university and are very difficult to identify in empirical studies. Most universities do not have an idea about the companies that were created by graduates from their undergraduate or master programmes. Even if they do, it is usually not clear whether the start-up can be linked to specific knowledge created and transferred in the university setting or whether it is based on knowledge which the graduate cumulated outside the university. Although we do not include them in this book, their number should not be underestimated. Some empirical evidence collected by the University of Twente suggests that companies created by graduates might outnumber the spin-offs by 20 per cent.

1.3 INSTITUTIONAL DIFFERENCES

Institutional differences between the US and European countries may have a general contextual bearing on the extent and nature of university spin-off activity in Europe. In this section, we examine different indicators of these contextual differences. First, we explain how the European Innovation Paradox forms the basis of the recent changes in Europe’s innovation policy. Second, we discuss the intensity of research and development (R&D) in each of the countries in the study and pay particular attention to the so-called 3 per cent norm in terms of gross expenditure on research and development as a percentage of gross domestic product (GDP). Third, we analyse how the university system differs in each of the countries included in the book with a particular focus on differences between Europe and the US. Fourth, we discuss briefly the legal-institutional framework within which professors operate. This framework, which encompasses the regulation of IP and the public status of professors, differentiates Europe from the US. Fifth, we outline differences in entrepreneurial and the national business environment, which are relevant to explain the academic spin-off activity. Finally, we discuss differences in the availability of equity capital.

The European Innovation Paradox

In Europe, a discussion about spin-offs cannot take place without having a look at the innovation system in which these spin-offs are created. This innovation system comprises all the actors that play a role in the development and commercialization of knowledge. The innovation system in Europe started to change after the European Commission introduced its famous concept of a ‘European Innovation Paradox’ (Caracostas and Muldur, 1998). In their seminal work, Caracostas and Muldur have shown
that the productivity rate of academics in terms of scientific papers is higher than that of their US colleagues, when we take language-related issues into account. However, in terms of patents per capita, all European countries lag significantly behind the US. The European Union plays a leading role in top-level scientific output, but lags behind in the ability to transform this strength into wealth-generating innovations. In other words, Europe performs well in science but badly in innovation. This idea of a technology gap with the US is however not new in Europe. In France, it appeared for the first time in 1964 in a publication of the Direction Générale à la Recherche Scientifique et Technique. It shows how Europe perceives the US innovation system.

The US innovation system is expected to have a strong ability to convert its scientific research into technologies and practical applications through the creation of high-tech start-ups. The strengths of the US innovation system have been identified as: a favourable IP system, universities as a source of a large number of spin-off firms, strong links between university and industry, strong relationships between large companies and new firms, the availability of venture capital and of business angels, and last but not least, public policies to support these new spin-offs through the Small Business Administration (SBA) and the Small Business and Innovation Research (SBIR) programme. Seen through a European lens, the US has created world leaders such as Intel (created in 1968), Microsoft (1975), Cisco (1984) and Dell (1984) who appear among the 25 larger American companies, whereas SAP (created in 1987) is the only ‘young’ firm to appear among the top 25 European companies. If one looks at the companies created after 1980 among the 1000 larger companies in the world, 64 are American and only nine are European (Worms, 2005). Since 1980, American small and medium-sized enterprises (SMEs) generated seven times more new world-leading companies than the SMEs from the whole of the European Union (CEC, 2004).

In Europe, the national systems of innovation seem traditionally to have been much more unfriendly to new firms. The weaknesses of these systems are explained largely in terms of institutional, organizational and cultural factors. Intellectual property regulation is still quite weak and the single European Patent is blocked by ethnic minorities in the European Union. This results in high translation costs and expensive court trials. Most universities are publicly owned and thus embedded in the bureaucratic nature of any national administration. They have to overcome a number of legal barriers in order to be even allowed to spin-off companies. Collaboration between small and large firms is hindered by the absence of technology agglomerations such as Silicon Valley and Route 128 (Saxenian, 1994a, 1994b). The financial markets experienced a strong growth in the mid-1990s with different alternative markets such as the European
Association of Securities Dealers Automatic Quotation System (EASDAQ), the Alternative Investment Market (AIM), Neuer Market, le Nouveau Marché being launched in different countries, but each of these markets – except maybe AIM – suffered from illiquidity of the small cap stocks that were quoted on these markets, and the secondary markets in Germany and France as well as the Brussels-based EASDAQ simply collapsed after the dotcom bubble. On top of this, some of Europe's flagships in the new economy, such as BAAN Company and Lernout & Hauspie, both successfully quoted on the New York Stock Exchange (NYSE) at a certain point in their lifetime, experienced fraud and eventually went bankrupt in very spectacular ways, receiving lots of adverse media attention in most of Europe.

However, European policy-makers are increasingly aware that economic growth depends strongly on the development of technology transfer from public research to industry, especially through the creation of new knowledge-based firms. As a result, policy-makers clearly have perceived a need to develop new policy instruments and change the legal and institutional environment of the mid-1990s to develop a system of innovation in which new technology-based firms (NTBFs) and particularly spin-offs or start-ups from public research play a crucial role in new technologies. Because these changes are so numerous, we devote a chapter to them. Chapter 2 describes the development of policy priorities and instruments in this area in European countries.

Research Input and Output and the 3 Per Cent Norm

Within the context of the European Innovation Paradox, the European policy-makers have agreed that not only the system of innovation should be transformed, but also that the intensity of innovation efforts should be increased in each of the member states. Since a simple metric to quantify the innovation intensity in a country does not exist, the general idea was to turn back to a widespread and very objective measure: gross domestic expenditure on R&D (GERD). Through consensus building, the key goal in Europe for European Union (EU) member countries is to achieve a target ratio of GERD to GDP of 3 per cent by 2010. There are large structural differences, both between European economies and the US and within European countries in terms of the extent of R&D funding in relation to national income, who funds the expenditure and who performs the research.

Comparing GERD to GDP, there is a substantial gap between the US and the EU: 2.66 per cent for the former and only 1.86 per cent for the latter (Table 1.2, column 3). As the ratio was relatively stable between 1999 to 2002 (respectively 21 per cent and 20 per cent), this gap seems likely to persist, with Europe still having much to do to catch up with the US.
In 2002, EU member states spent $202 billion on R&D. Nearly two-thirds was spent by three countries: Germany ($54.2 million), France ($37.9 million) and the UK ($31.1 million). In absolute amounts, Sweden ($10.2 millions) and Belgium ($6.4 millions) are some distance behind (Table 1.2, column 1). But, when research spending is expressed in terms of each country’s GDP, Sweden, with 4.27 per cent of its GDP devoted to R&D, becomes the leading European country. When ranked by this indicator, the gap between Germany, France and Belgium is notable (2.53 per cent compared to 2.26 per cent and 2.24 per cent, respectively). But the depth of activity in these three countries is markedly greater than that of the UK (1.87 per cent).

In 2002, nearly two-thirds of European R&D effort was carried out by the private sector (63.8 per cent) and one-third (36.2 per cent) by the public sector (Table 1.2, columns 4 and 5). Looking at how the national R&D effort of the five countries studied in this book is distributed between the private sector and the public sector notable differences appear. In Sweden and Belgium, R&D is chiefly carried out by the private sector (77.6 per cent and 73.3 per cent, respectively). In Germany and the UK, the role of the private sector is a little less strong (69.2 per cent and 67 per cent, respectively). France is the country where the private sector activity (63.3 per cent) is the closest to the EU average.

There are about 5.3 million full-time-equivalent researchers in the world: 1.26 million of them work in the US and 1.13 million in the EU. When this

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**Table 1.2 R&D expenditure**

<table>
<thead>
<tr>
<th></th>
<th>Gross domestic expenditure on R&amp;D (billion $) (2002)</th>
<th>Gross domestic expenditure on R&amp;D Evolution % 1997/2002</th>
<th>Gross domestic expenditure on R&amp;D as % of GDP (2002)</th>
<th>% of GERD carried out by the public sector</th>
<th>% of GERD carried out by the private sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>6.4</td>
<td>+ 33</td>
<td>2.24</td>
<td>26.7</td>
<td>73.3</td>
</tr>
<tr>
<td>France</td>
<td>37.9</td>
<td>+ 17</td>
<td>2.26</td>
<td>36.7</td>
<td>63.3</td>
</tr>
<tr>
<td>Germany</td>
<td>54.2</td>
<td>+ 19</td>
<td>2.53</td>
<td>30.8</td>
<td>69.2</td>
</tr>
<tr>
<td>Sweden</td>
<td>10.2</td>
<td>+ 36</td>
<td>4.27</td>
<td>22.4</td>
<td>77.6</td>
</tr>
<tr>
<td>UK</td>
<td>31.1</td>
<td>+ 19</td>
<td>1.87</td>
<td>33.0</td>
<td>67.0</td>
</tr>
<tr>
<td>EU</td>
<td>202.0</td>
<td>+ 21</td>
<td>2.66</td>
<td>28.0</td>
<td>72.0</td>
</tr>
<tr>
<td>US</td>
<td>277.0</td>
<td>+ 20</td>
<td>2.66</td>
<td>28.0</td>
<td>72.0</td>
</tr>
</tbody>
</table>

**Source:** Data OECD, Eurostat, OST estimations and computation (OST, 2006).
number of scientists is expressed as a ratio of the labour force, a major
difference emerges, with the density of researchers in the US (8.62
researchers per thousand workers) being considerably ahead of that in the
EU (5.39) (Table 1.3, column 1).

The distribution of researchers between the private (laboratories of
private firms and enterprises) and public sectors (laboratories funded by the
state, universities and other institutions of higher education, and not-for-
profit organizations) varies greatly from country to country.

In the US, less than a fifth of researchers work in the public sector (17.7
per cent), while in Europe this figure is around a half (50.6 per cent) (Table
1.3, column 2). Among the five European Union member states studied in
this volume, a disparity exists but is less important ranging from France,
where 48.9 per cent of researchers work in the public sector, to the UK and
Sweden, where 39.8 per cent and 39.4 per cent of researchers, respectively,
are in the public sector.

Scientific publications are one of the main products of research activity.
By using the information contained in bibliographic databases that record
all articles published in a selected set of scientific journals, it is possible to
count articles by country (as well as by the discipline, region or institution).
In 2003, nearly 35 per cent of world publications were produced by the EU
and 27.5 per cent by the US (Table 1.3, column 3). The EU’s scientific
output is concentrated in a small number of member states: Germany,
France and the UK account for over half of EU scientific production. The
UK is the EU member country with the largest publication share at 6.9 per
cent of the world total, followed closely by Germany with 6.7 per cent. The
share accounted for by France is noticeably smaller at 4.8 per cent but this
figure is some way ahead of Sweden and Belgium (1.4 per cent and 0.9 per
cent, respectively).

Last but not least, even though they have their limits, patent data are the
best available basis for indicators of the technological activity of a country
or set of countries. Two very different patent systems coexist: the European
system and the American system. In the European patent system, patent
requests are published after 18 months. Under the American system, only
successful applications are published, after a variable waiting period. In the
European patent system, EU members states’ patent share dominates,
unsurprisingly, accounting for 40.2 per cent of all applications (Table 1.3,
column 4). The US accounts for less than one-third of the patents in this
system (31.7 per cent). Germany leads all European member states with a
world share of 16.7 per cent, compared with 5.6 per cent for France, 5 per
cent for the UK, 2 per cent for Sweden and 1 per cent for Belgium. In the
US Patent and Trademark Office, the US accounts for 47.9 per cent of
filings, and Europe for only 17.6 per cent (Table 1.3, column 5). Here also,
### Table 1.3  Science and technology indicators

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</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>7.39</td>
<td>44.9</td>
<td>0.9</td>
<td>1.0</td>
<td>0.5</td>
<td>131</td>
<td>117</td>
</tr>
<tr>
<td>Germany</td>
<td>6.71</td>
<td>41.5</td>
<td>6.7</td>
<td>16.7</td>
<td>7.4</td>
<td>102</td>
<td>222</td>
</tr>
<tr>
<td>France</td>
<td>6.90</td>
<td>48.9</td>
<td>4.8</td>
<td>5.6</td>
<td>2.6</td>
<td>109</td>
<td>110</td>
</tr>
<tr>
<td>Sweden</td>
<td>10.27</td>
<td>39.4</td>
<td>1.4</td>
<td>2.0</td>
<td>1.1</td>
<td>192</td>
<td>230</td>
</tr>
<tr>
<td>UK</td>
<td>5.80</td>
<td>39.8</td>
<td>6.9</td>
<td>5.0</td>
<td>2.5</td>
<td>141</td>
<td>87</td>
</tr>
<tr>
<td>EU</td>
<td>5.39</td>
<td>50.6</td>
<td>34.8</td>
<td>40.2</td>
<td>17.6</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>US</td>
<td>8.62</td>
<td>17.7</td>
<td>27.5</td>
<td>31.7</td>
<td>47.9</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

Notes:

[3] Data ISI-Thomson Scientific, OST computing; world publication share is determined using fractional count based on the bibliometric version of the Web of Science.
[6] Data ISI-Thomson Scientific, OST computing; relative scientific density is calculated as the ratio of the quantity of a nation’s publications to the size of its labour force, normalized to 100 for the European Union.
[7] Data INPI, EPO and Eurostat, OST computing; technological density is calculated as the ratio of the quantity of a nation’s patents to the size of its labour force, normalized to 100 for the European Union.

Germany largely dominates its EU partners, with a world share of 7.4 per cent, nearly three times that of France and the UK. Sweden and Belgium account for 1.1 per cent and 0.5 per cent, respectively.

Morgan et al. (2001) find in the US that the patent success rate for academic researchers was lower than for those from industry but that a significant fraction of patent activity in universities results in commercialized outputs. Comparative estimates of the number of patents issued by academic establishments suggest that the UK performs less well than the US when gross patenting numbers are deflated for differences in the size of the countries (Wright et al., 2003). For example, while in 2002 the US universities generated 31.4 patents per $100 billion GDP, the comparative figure in the UK was 23.0 patents per $100 billion GDP.

The ranking of the countries looks quite different when one looks at their world shares of scientific production and at their world share of patents. For example, the UK led the other countries in scientific production, with a world share of 6.9 per cent ahead of Germany (6.7 per cent) and France (4.8 per cent). However, its ranking looks quite different when world shares of patent applications are considered, with Germany dominating and the UK in third place. This demonstrates that there is no automatic relationship between scientific output and technological capacity of the countries.

The above data have shown that the five countries differ widely by size and R&D potential. Using indicators of scientific and technological density is a way of counteracting the effect of country size. The scientific density (Table 1.3, column 6), which relates the number of scientific publications to the size of the labour force, is higher for Sweden (192), the UK (141) and Belgium (131) than for France (109) and Germany (102). The Sweden performance is remarkable: its density is nearly double the European average (100).

When technological density – that is, the number of European patent applications by a nation compared to its labour force – is calculated for the five countries (Table 1.3, column 7), once again Sweden (230) is at the top, followed by Germany (222). France, Belgium and particularly the UK trail at some distance.

In conclusion, the figures show that most European countries perform very well in terms of publication and patent output. So, the innovation paradox in these measures seems to disappear. However, this has not yet translated into growth-orientated spin-offs. It remains questionable whether the actions taken will accomplish the 3 per cent target or result in the desired objective increasing spin-offs. A lot of effort seems to be put in to subsidizing research which is mainly performed by the industry sector. However, innovation efforts in terms of commercialization tend to be overlooked, although some countries like Belgium consider public venture
capital as part of the R&D budget. Belgium has set up a public pre-seed capital fund with an almost 7 million euros budget to invest in spin-offs and other technology-based start-ups. This amount of money is considered to be R&D budget. The structure of the R&D sector will also determine the extent to which spin-offs can be realized. In the next paragraph we discuss these structural differences.

**Structure of the Public Research Sector**

The structure of the public research sector varies considerably between the US and Europe and within Europe. The US is differentiated from Europe by the higher percentage of private universities, among which commercialization activity may be quite significant (Owen-Smith and Powell, 2001).

In Germany, the public research sector consists of two main types of PROs: universities and research institutes. Of the 350 universities, 271 are state owned with many private universities not having research bases. Within the state sector, the technical universities have historically had close connections to industry, notably engineering. The 63 general universities comprise all higher education institutions without a clear engineering background that offer a broad variety of disciplines. The 144 universities of applied sciences (in German, Fachhochschulen) have a strong orientation towards practical needs with a disciplinary focus of engineering, computer sciences and business administration. A further 128 universities specialize in specific disciplines such as the arts, medicine, education sciences, business administration, public administration, sports or theology. Outside the university sector are several hundred individual public research institutes (PRIs) the vast majority of which belong to one of four large trade organizations. First, the Hermann von Helmholtz Gemeinschaft Deutscher Forschungszentren (HGF) comprises 15 large research centres mainly engaged in natural science and engineering, including nuclear research and space research. Second, the Max Planck Gesellschaft zur Förderung der Wissenschaft (MPG) runs 77 Max Planck Institutes (MPIs, including two institutes outside Germany). Third, the Fraunhofer Gesellschaft zur Förderung der angewandten Forschung (FhG) consists of 58 research institutes mainly engaged in applied research in engineering, a few of which carry out military-related R&D. Fourth, the Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz (WGL) unites 80 research institutes that cover a range of disciplines and types of research, including some institutes with service function (such as museums and scientific libraries). These institutes receive a greater proportion of their funding from government than the universities. In addition to direct state funding, a major funding body is the German Research Foundation (DFG) financed jointly by the Federal and
the local state (Länder) governments and providing grants for scientific research based on a peer review system (both for small projects and long-term research networks and centres of excellence). Funding by companies is almost entirely project based, either in the course of contract research or collaborative projects. Funding for scientific research is provided by company foundations such as Volkswagen-Stiftung, Fritz-Thyssen-Stiftung, Bosch-Stiftung, Bertelsmann-Stiftung and hundreds of other private foundations. Until the 1990s, public funding severely restricted investment by universities into spin-offs. Latterly, the environment has changed as more universities are becoming subject to global budgeting, enabling university managers to decide where to allocate the institutional funding received from the state government.

In Sweden, only 11 out of 39 higher education establishments have a university status. Two are broadly diversified in the field of science, the remainder being more or less specialized. Three are private: Chalmers University of Technology, Stockholm School of Economics and Jönköping University. Ten out of the 39 dominate the R&D carried out. The 30 public research institutes and industrial R&D institutes cover diverse fields of science. Two-thirds of the institutes’ finances come from individual companies. The state, through such bodies as NUTEK and VINNOVA, provides an important one-third of the finances.

The public research sector in the UK consists of 167 organizations that have university status (there are three additional private universities), though not all are engaged in research. There are also 85 government laboratories/public research institutes. Financing for university research is provided by seven discipline-based autonomous state-funded research councils which are part of the Office for Science and Technology (OST) and the Higher Education Funding Councils (HEFCs), which finance the main operating costs of universities. The allocation of HEFCE money is influenced by the (approximately) five-yearly Research Assessment Exercise (RAE) under which a range of discipline-based panels of peers rates the research of each university department. Falling Higher Education Funding Council for England (HEFCE) funding for research universities has contributed to increased fund-raising from the commercial sector. In addition, major foundations like the Wellcome Trust and other charities finance research, in particular in the medical field.

At the extremes, the management of universities may be centralized or decentralized. In the decentralized model, universities retain a high degree of autonomy and effectively compete against one another (Goldfarb and Henrekson, 2003). It has been argued that as a result of the highly decentralized system in the US, where there are proportionately more private universities than in European countries, universities have been more able to
become responsive to the economic needs of society (Argyes and Liebeskind, 1998). In the centralized model, the state plays an important, and highly visible, role in managing the overwhelmingly public university sector, such as in mainland European countries. Under this system academics have traditionally been civil servants with high degrees of pay uniformity. The UK is probably best described as a hybrid model, a mixture of both the decentralized and centralized systems. In particular, competition has been encouraged within the state sector for research funding through the RAE and the Research Councils. Although the academic labour market has become relatively flexible, rigid pay scales are still imposed at all levels below full professor.

In France, the public research sector consists of three main types of PROs: 90 universities, 25 public research organizations and around 180 grandes écoles (public engineering or agronomic schools and management schools). The main public research organization is the CNRS (Centre national de la recherche scientifique – the National Centre for Scientific Research), a multidisciplinary institution with a mission to undertake fundamental research. The other main important PROs are the CEA (Commissariat à l'énergie atomique – research on nuclear energy), INRA (Institut national de la recherche agronomique – agricultural research), INSERM (Institut national de la santé et de la recherche – Health and medical research) and INRIA (Institut national de la recherche en informatique et automatique – research on computer science and artificial intelligence). All these public research organizations have autonomy in decision-making and research strategy. In contrast, the universities lack autonomy both in recruiting (which depends upon a national competition) or managing their personnel or in implementing a strategy. The universities, the CNRS and the grandes écoles represent academic research activity, while the other PROs represent what is referred to as ‘la recherche finalisée’ (OST, 2004).

Recent years have seen the disappearance of dualism, the separation between the CNRS and the universities, and the existence of the grandes écoles without research activities, which had been a particular feature of the Colbertist model in France (Mustar and Larédo, 2002). The CNRS could now be considered, following the example of the Anglo-Saxon research councils or the National Science Foundation (NSF), as a research support agency or, more specifically, an agency concerned with structures, which makes its contributions in the form of human potential and large technical rather than financial resources. For example, CNRS staff and university staff collaborate closely, since 90 per cent of CNRS personnel are employed in laboratories located in the universities. Traditionally, the universities have weaker links with industry. Most of the best PhD graduates traditionally obtain positions in the public sector. The grandes écoles have
strong links with industry and most of their graduates obtain high-level positions in industry. Currently, across all disciplines, one in every five PhD theses in France is produced in the research centres of these schools, although they only contain barely 6 per cent of all teacher-researchers.

These changes have occurred in the wider context of governments increasingly disengaging from large military and civil programmes, and looking towards the support of SMEs and high-tech firms, using public sector research as a major vehicle. In 2005, two new agencies were created. The first is the Agence de l’Innovation Industrielle (AII), which will finance the new Programme Mobilisateurs pour l’Innovation Industrielle. The first six large research programmes involving 600 million euros of funding, 236 million euros of which are to be provided by AII, were launched in April 2006. These programmes focus on the Internet (Quaero), biotech (BioHub), telecommunications (TVMSL), the built environment (Homes), transport (NeoVal) and the green car. The second agency is the Agence Nationale de la Recherche (ANR), whose objective is to increase the number of research projects across the scientific community, which will be financed after peer evaluation of competitive bids. The main idea behind the creation of this agency is that project-based research funding is widespread in many foreign countries and constitutes a factor of dynamism to explore the borders of science. The ANR is effectively envisaged as a French NSF, with a budget for 2006 of 800 million euros for research projects of a duration of four years maximum.

In Belgium, there are 17 universities and 59 polytechnic schools active in the field of research and education. These universities have increasingly suffered from budgetary cuts. The result of this unfavourable policy is that research has increasingly become financed by external sources, which in turn leads to difficulties in attracting permanent staff. However, in the mean-time the number of students is increasing annually. For example, the two largest Dutch-speaking universities Katholieke Universiteit Leuven (KUL) and Universiteit Gent (UG) saw their number of students increase from, respectively, 23 659 and 19 920 in the academic year 1997–98 to 28 058 (+18 per cent) and 22 052 (+11 per cent), in the academic year 2000–2001. Conversely, the personnel at the KUL decreased over the same period from 5720 to 5038 (–12 per cent) while it increased only slightly at Ghent University from 3562 to 3772 (+6 per cent).

The legal framework for industry science relations is particularly complicated since the country is divided into three ‘regions’ (Brussels, Flanders and Wallonia), that are delegated to organize industry matters such as R&D subsidies (including joint R&D–university projects) or issues concerning intellectual property. In a kind of matrix structure, the country is divided
into two ‘communities’: the Flemish and the French (Walloon) community. Each of these regions and/or communities has its own policy and regulations. In this book, we will examine the situation in Flanders.

In addition to the universities and polytechnics, there are four important independent Flemish research institutes: the Flanders Interuniversity Institute for Biotechnology (VIB), the Interuniversity Institute for Microelectronics (IMEC), the Flemish Institute for Technology Research (VITO) and IBBT. The VIB specializes in biotechnology research, the IMEC specializes in microelectronics, and the VITO conducts orientated contract research and develops innovative products and processes in the fields of energy, environment and materials. The IBBT is the recently created Institute in Broad Band Technology. The importance of these institutes for spin-offs is great since they cumulate research efforts across universities. In other words, the Flemish government has chosen to build a critical mass across universities in particular technological domains. The IMEC, for instance, unites research groups from four different universities and also has its own campus. In total it employs over 1000 researchers. The VIB and the recently created IBBT follow a model of virtual cooperation. This means that the research groups stay within the different universities but a holding structure coordinates their efforts.

In conclusion, we can state that the university system in Europe is mainly dominated by the government, both in terms of management and research funding. This will have severe consequences for the way in which the universities are managed and, relatedly, on their degrees of freedom in terms of recruitment, promotion, commercialization efforts, and so on. In addition, in some countries such as France, Germany and Belgium, public research has been concentrated in government-based research laboratories, which cannot be neglected in a study on spin-offs. These research laboratories are created by government to concentrate the research efforts and build up a critical mass. Often, they compete with the universities in terms of research funding and employees or, as in Belgium, they simply draw resources from the different universities.

One of the most important environmental changes in Europe which is supposed to have had an impact on the way in which spin-offs are conceived is change in legislation relating to IP rights. This is the topic of the next section.

Management of IP

The ownership of IP has important implications in terms of the creation of incentives for academics, and other related parties, to commercialize technology. Where property rights are weak and knowledge is tacit, the transfer of technology can be highly problematic due to the problems of hold up. As
licensing may be problematical in such circumstances, it may be preferable to create a spin-off company and incentivize the academic through the provision of an equity stake (Shane, 2001).

The Bayh–Dole Act (BDA) in the US played an important role in the development of policy relating to IP. Proponents of the BDA argue that by granting universities control over their own IP they effectively gave incentives to universities to invest in their own technology. Mowery et al. (2001) argue that the rise of the biotechnology industry, the legal change that made it possible to patent ‘engineered molecules’ and the general policy for the strengthening of property rights for IP in the US, have also been important influences on the commercialization of technology developed in universities.

Belgium adopted a Bayh–Dole-type of Act in the second half of the 1990s, while France has had this type of regulation for a long time. Although the UK has no formal Bayh–Dole-type Act, in public research organizations the IP strictly belongs to the university who will commonly grant the academic inventor a right to a proportion of the income stream from it. As a result there is no formal requirement to disclose inventions. In contrast, in both Sweden and Germany the academic has traditionally been the sole owner of the IP. This position changed in Germany in 2003 and a system more similar to that of the US has been introduced. In Sweden, however, this position prevails and is thought to be a major impediment in technology transfer occurring from Swedish universities, as the universities have nothing to gain from commercializing IP if all the gains accrue to the individual scientist. Although the position has not yet changed in Sweden, it is subject to considerable debate. The relatively recent changes in Germany and Sweden also imply that the universities did not keep track of the spin-off activity.

Next to the regulation of IP, an important determinant of the success of spin-off companies concerns the involvement of the academic scientist in the company (Jensen and Thursby, 2001). This creates interesting issues relating to the structure of academic careers and the extent to which universities can/will be willing to be flexible in terms of the career progressions of academic entrepreneurs. Academic entrepreneurs, who are expected to spend time commercializing their IP, will not be able to dedicate the same amount of time to the traditional areas of teaching, research and administration. There is a need to ensure that the right financial incentives for the academic are present on the upside and a need to accommodate the problems associated with the potential downside for the entrepreneur’s academic career (Goldfarb and Henrekson, 2003).

The US and the UK both have much more fluid labour markets than the top-down countries. In the US, where salary levels are much more market driven, there is a greater dispersion of academic salaries compared with other countries. In Sweden, Belgium, Germany and France rigid pay scales
have meant that it has often been in the interest of universities to discourage interaction between academics and industry.

Although academic labour markets are much more flexible in the US and the UK than many other countries, technology transfer may still create its own tensions for university management. A particular concern is the extent to which involvement with commercial projects such as spin-off companies is valued in terms of the promotion system. In the US and the UK, the focus of academic tenure and promotion decisions has historically been on the basis of publication (and citation) records and research funding. Similarly, the academic labour market is more fluid in terms of mobility, with academic faculty competing for posts on an individual basis.

In Germany, France and Belgium staff at state-owned universities are either civil servants (that is, with a permanent contract, including all professors) or administrative employees of the state government. In Germany, professors are recruited based upon a central quota system. For instance, the whole of Germany employs 46 marketing professors. One can only become a marketing professor after one of these 46 leaves the cohort and a position becomes available. Hence, there is extreme competition among young graduates to become a professor. Once one reaches the level of a professor, one has research funds and young researchers at one’s disposition and a central institute such as Steinbeisch regulates all kinds of consulting activities that might render an extra income to the professor. In contrast, young researchers have non-permanent contracts (typically running for five or six years) and are urged to quit the universities after finishing their PhD or their Habilitation (post-doctoral degree). It is not surprising that in this context it is extremely difficult to create spin-offs.

In both France and Germany, there is a central recruitment system organized by government. Only the candidates who pass the ‘concours’ can be employed in a French university.

In Belgium, recruitment is decentralized to the individual universities as well as the promotion decisions. However, salaries are fixed by government. Professors are evaluated based upon their scientific output, their teaching qualities and, finally, their involvement with society.

Again, the spin-off activity discussed in the remaining chapters of this book has to be seen in the context of these different legal and institutional environments.

Entrepreneurial Activity

Renault (2006) showed in a study of 98 professors in 12 universities in the US that the entrepreneurial attitude of the academics had most explanatory power in predicting their commercialization activities, including their
involvement in licensing out technology, spinning off companies and being involved in contract research. The general entrepreneurial attitude of people is an indicator which is known to vary between countries within Europe and between Europe and the US in particular. Without going into the details on what drives entrepreneurial activity, we describe in this paragraph how entrepreneurial activity differs, using data drawn from the Global Enterprise Monitor (GEM). This monitor collects data on the total entrepreneurial activity (TEA) in a country. This is an index that measures the degree to which adults are involved in nascent or new firms with growth ambitions. It indicates that entrepreneurial activity is considerably greater in the US than in Europe, especially in relation to continental European countries (Table 1.4, Panel A). There are several reasons, given in the General Entrepreneurship Monitor, about why entrepreneurial activity is so low in many European countries. A rigid social security system and inflexibility on the job market are two main reasons, the relevance of this for academics having already been discussed above.

In addition to these constraints, the administrative difficulty in actually setting up a business is also considered to be an indicator of entrepreneurial activity. The US is ranked the world’s third easiest economy in which to start a business. The UK economy is ranked ninth, whereas the German economy is only ranked at forty-seventh. Other secondary indicators have to do with the easiness of running a business in each of these countries. Differences between countries with respect to enforcing contracts may be particularly important in the case of high-tech companies which are based on legally protectable IP. The US is the highest ranked of the countries we have highlighted, ranked tenth in the world. The lowest ranked country we focus on is the UK, which is ranked thirtieth. The US and UK have far more flexible labour market laws compared to Germany and France. There are also big differences in terms of businesses’ ability to raise credit (Table 1.4, Panel B). In particular, the UK and German economy rank highly with first and fifth place respectively, while the French economy lags considerably.

We can conclude with the observation that creating spin-offs or academic start-ups in Europe will be a much more laborious process than in the US, and may not render the same kind of social esteem as in the US. In continental Europe, the number of people simply starting up a business is much lower than in the US or the UK. So, it seems less generally accepted to get involved in this kind of activity. Academics who still want to start up a company not only face resistance within the university system but also have to convince their friends and family about such a career move. As the idea develops, in countries such as France, Germany and Belgium they will also encounter a rather complex process administratively. So, they will need an
Table 1.4  Entrepreneurial indicators

<table>
<thead>
<tr>
<th></th>
<th>US</th>
<th>UK</th>
<th>Sweden</th>
<th>Germany</th>
<th>France</th>
<th>Belgium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel A</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>No. adults per 10 000 in nascent/new firm expecting ≥19 jobs in 5 yrs</td>
<td>No. adults per 10 000 in nascent/new firm expecting ≥19 jobs in 5 yrs</td>
<td>No. adults per 10 000 in nascent/new firm expecting ≥19 jobs in 5 yrs</td>
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<td>No. adults per 10 000 in nascent/new firm expecting ≥19 jobs in 5 yrs</td>
<td>No. adults per 10 000 in nascent/new firm expecting ≥19 jobs in 5 yrs</td>
<td></td>
</tr>
<tr>
<td>Total entrepreneurial activity with growth ambitions 2005</td>
<td>141.36</td>
<td>70.60</td>
<td>49.30</td>
<td>46.11</td>
<td>37.71</td>
<td>16.32</td>
</tr>
<tr>
<td>Doing business (overall)</td>
<td>3</td>
<td>9</td>
<td>14</td>
<td>19</td>
<td>44</td>
<td>18</td>
</tr>
<tr>
<td>Starting a business</td>
<td>3</td>
<td>9</td>
<td>20</td>
<td>47</td>
<td>13</td>
<td>34</td>
</tr>
<tr>
<td>Dealing with licences</td>
<td>17</td>
<td>29</td>
<td>13</td>
<td>20</td>
<td>23</td>
<td>31</td>
</tr>
<tr>
<td>Hiring and firing</td>
<td>6</td>
<td>15</td>
<td>86</td>
<td>131</td>
<td>142</td>
<td>43</td>
</tr>
<tr>
<td>Getting credit</td>
<td>15</td>
<td>1</td>
<td>30</td>
<td>5</td>
<td>115</td>
<td>45</td>
</tr>
<tr>
<td>Activity</td>
<td>7</td>
<td>9</td>
<td>95</td>
<td>57</td>
<td>56</td>
<td>13</td>
</tr>
<tr>
<td>--------------------------</td>
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<td>---</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>Protecting investors</td>
<td>10</td>
<td>30</td>
<td>14</td>
<td>25</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>Enforcing contracts</td>
<td>17</td>
<td>10</td>
<td>18</td>
<td>30</td>
<td>32</td>
<td>9</td>
</tr>
<tr>
<td>Closing a business</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: The ease of doing business index ranks economies from 1 to 155. The index is calculated as the ranking on the simple average of country percentile rankings on each of the ten topics covered in Doing Business in 2006. The ranking on each topic is the simple average of the percentile rankings on its component indicators.

accountant and other advisers to help them in this start-up process, which creates both a psychological and a financial barrier to starting up a venture. The financial part is exactly the topic of the next paragraph.

**Availability of Finance**

Wright et al. (2006b) have shown that a lack of venture capital is often seen as a major barrier to start-up activity by technology transfer office (TTO) managers. This kind of equity finance is used to finance concept-testing activities and to value the IP at start up. In addition to the rational explanation of a need for equity finance, starting up a company with a substantial amount of capital might also be seen as a more solid basis for a career than bearing all the entrepreneurial risk as an academic.

Again, marked differences are evident between the US and Europe in the availability of personal capital to start businesses. The personal capital of young entrepreneurs is generally higher in the US, with funding from ‘family, friends and fools’ (3F) being more in evidence than in Europe. High-tech entrepreneurs in the US stress the importance of networking as a source of finance prior to seeking venture capital finance (Roberts, 1991). In the US education system, there also appear to be greater opportunities to encounter individuals from a variety of backgrounds. In particular, scientists and people with a financial or Master of Business Administration (MBA) background may get to know each other more easily, forming a basis for a willingness to invest in high-tech ventures.

In addition to personal funds and so-called 3F money, the US model of technical entrepreneurship is linked to the availability of venture capital to select and to finance the best projects (DiGregorio and Shane, 2003; von Burg and Kenney, 2000). A major premise for the introduction of policies to stimulate the development of venture capital in European countries was that the gap in high-tech entrepreneurship between European countries and the US was a financial one (Edwards, 1999; European Commission, 2000a). These developments have had mixed success.

In the UK, whose financial system most closely resembles that of the US, a venture capital sector developed ahead of those elsewhere in Europe. Although there were long established venture capitalists (VCs) such as 3i, the VC sector began to develop in earnest at the end of the 1970s following the Wilson Committee inquiry into the role of financial institutions (Wilson, 1979; Wright and Robbie, 1999). However, the greater emphasis of the UK venture capital market has been on later-stage and management buy-out investments. Evidence from the early 1990s suggested that new high-tech firms had to meet more rigorous selection criteria than equivalent non-technology projects (Murray and Lott, 1995). While there had
been some improvement by the late 1990s, the problem still persisted (Lockett et al., 2002a).

In Germany, the public authorities attempted to foster a venture capital market from the 1970s by mobilizing banks’ investment. However, the first German venture capital fund created in 1975, the Deutsche Wagnisfinanzierungsgesellschaft (WFG) never succeeded in inducing larger market development (Becker and Hellmann, 2003). Creating a venture capital market in a bank-based financial system proved particularly difficult and slow (Black and Gilson, 1998; Wright et al., 2005).

A number of venture capital initiatives were introduced in France from the early 1970s, such as the creation of Sociétés financières d’innovation (innovation finance companies) to facilitate the industrial application in France of technological research and the promotion and exploitation of inventions, the establishment of the Société Française de Garantie des Financements des PME (SOFARIS) as a fund to guarantee the risks relating to their equity investment in innovative SMEs, and measures to enable the creation of Sociétés de Capital Risque (venture capital companies) with attractive tax benefits for shareholders. Following only modest development of the venture capital industry up to the mid-1990s, it came to be recognized that there was a need to create a new and specific stock market for high-growth firms that would contribute to the development of venture capital by improving the liquidity of the shareholders in innovative growth companies. In 1996, le Nouveau Marché was created. A year before, the AIM had been created in London with the same objective, some months after the EASDAQ was created in Brussels. At this time a consortium was created with the French Nouveau Marché, the EASDAQ and the German Neuer Markt and the Belgian New Market (the latter two both created in 1997). In Sweden, two new markets established for small technology companies the Stockholm Bourse Information (SBI) and the Innovationsmarknaden (IM) were merged in 1998 (OECD, 2003). These markets enabled innovative firms to raise capital to accelerate their growth, and venture capitalists to make their equity capital in these firms more accessible. However, the success of these markets has been mixed with, for example, the Neuer Markt closing in the aftermath of the bursting of the dotcom bubble.

Focusing on the provision of venture capital for new and early stage ventures, it is not surprising that the US has the highest formal venture capital to GDP ratio (Table 1.5). Reflecting their emphasis on later-stage and buy-out investments, although the UK and France are the most developed private equity and venture capital markets in Europe, they have considerably lower levels of early stage VC investment per percentage of GDP. Sweden’s early stage formal venture capital markets figure relatively highly, while those in Germany and Belgium are very low. However, a remarkable
difference is that the informal venture capital industry appears highly developed in Germany in relation to GDP. In contrast, both France and the UK have the lowest involvement from informal VC investment per percentage of GDP capita, with 0.62 and 0.66 respectively.

1.4 THE ISSUES AND STRUCTURE OF THE BOOK

Our examination of the issues involved in developing spin-offs is based on several levels of analysis – the policy context, the types of spin-off firms, the incubation processes involved in developing spin-offs at the university and public research organization level, the processes involved at the spin-off firm level, the role of individual entrepreneurs and entrepreneurial teams, and the role of financiers.

In Chapter 2, more specific policies relating to the promotion of innovation and the development of spin-offs in universities and public research organizations are examined.

Understanding of the nature of spin-offs is important in designing approaches to address the challenges in their creation and development. The heterogeneity of spin-offs is analysed in Chapter 3. The chapter maps the literature on spin-offs through the development of a matrix aimed at identifying general dimensions of the typologies of research-based spin-offs. Three broad conceptual perspectives are identified which relate to differences in the resource endowments, institutional links, and business models of spin-offs. A distinction is made between the process of spin-off creation and the process of spin-off development.

In addition to heterogeneity in the nature of spin-offs, there may also be variety in the incubation processes adopted in order to develop these ventures. Chapter 4 presents a systematic analysis of the different approaches.

Table 1.5 Formal and informal venture capital 2003

<table>
<thead>
<tr>
<th>Country</th>
<th>Informal investment per GDP %</th>
<th>Formal VC per GDP %</th>
<th>VC and informal investment per GDP %</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>0.62</td>
<td>0.082</td>
<td>0.71</td>
</tr>
<tr>
<td>UK</td>
<td>0.66</td>
<td>0.089</td>
<td>0.75</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.86</td>
<td>0.039</td>
<td>0.90</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.80</td>
<td>0.118</td>
<td>0.92</td>
</tr>
<tr>
<td>US</td>
<td>0.96</td>
<td>0.164</td>
<td>1.12</td>
</tr>
<tr>
<td>Germany</td>
<td>1.09</td>
<td>0.028</td>
<td>1.12</td>
</tr>
</tbody>
</table>

The chapter uses evidence from 50 universities and public research organizations across Europe to identify five incubator models. Three of these, identified as Low Selective, Supportive and Incubator models, involve approaches where the organization has the resources and activities to meet their objectives but with distinctly different types of spin-offs and levels of involvement. The other two models, labelled as Resource Deficient and Competence Deficient, are unable to meet their objectives because of shortcomings in their resources and activities, respectively.

Chapter 5 examines the phases that spin-offs go through in their development, and analyses the key challenges these ventures face. The analysis indicates that spin-offs pass through a number of different distinct phases of activity in their development and that, between the different phases, ventures face critical junctures that need to be addressed before they can progress to the next phase. Each phase can be characterized as an iterative process of development. The phases are identified as the research phase, the opportunity framing phase, the pre-organization phase, the reorientation phase and the sustainability phase. The critical junctures that are encountered in moving between each of these phases are identified as the opportunity recognition juncture, the entrepreneurial commitment juncture, the credibility juncture and the sustainability juncture.

Chapter 6 examines the key issues in identifying individual entrepreneurs and entrepreneurial teams who can create and develop the spin-off. More specifically, we focus on how teams are created in the pre-start-up phase. The role of the TTO officer, who is often some sort of privileged witness, is highlighted. Further, we discuss the team composition in spin-offs and link it to the possibility of being successful in terms of growth in revenues and employees. Teams that are artificially composed at the moment a business opportunity is spotted by the TTO seem to be very fragile. They are able to attract venture capital at start-up because the team fits the criteria used by the VC, but this early growth is seldom sustainable. This is in contrast to companies that are created by teams who have both shared social or working experience and a heterogeneity in terms of skills and/or backgrounds. Finally, solo entrepreneurs or teams that have no heterogeneous composition seem to be the least successful in terms of growth.

Accessing finance to establish and grow the spin-off poses major challenges. Chapter 7 examines issues relating to accessing finance for spin-offs. We triangulate evidence from spin-off companies, university TTOs and venture capital firms in the UK and continental Europe to identify the problems in accessing this form of finance. We compare perceptions of high-tech venture capital firms that invest in spin-offs with those that do not, and also consider VCs’ views on spin-offs versus other high-tech firms. We identify a mismatch between the demand and supply side of the market.
In line with the pecking-order theory, venture capitalists prefer to invest after the seed stage. However, in contrast to the pecking-order theory, TTOs see venture capital as more important than internal funds early on.

Finally, Chapter 8 presents some conclusions and policy implications.

1.5 DATA AND METHODOLOGY

The analysis in this book is based on a multi-level programme of studies of spin-offs carried out across Europe. The programme covers issues relating to universities, technology transfer offices, spin-off firms, academic entrepreneurs, financiers and government policy. As a result, the programme involved a set of interrelated studies using different research approaches. The research posed major challenges in data collection in terms of identifying appropriate universities, firms and individuals as well as persuading appropriate respondents to take part in the study.

In order to identify trends and developments in the policy context, we used archival data from a number of sources. To review the heterogeneity of spin-offs we conducted a detailed review of the relevant literature.

Data relating to the activities of technology transfer offices were identified using both quantitative and qualitative means. In March 2002, a survey of university technology transfer activities comprising quantitative and qualitative questionnaires was sent to the top universities in the UK as ranked by research income, accounting for 99.8 per cent of this revenue. As the survey was conducted with the support of the two associations of technology transfer officers in the UK, the Universities’ Companies Association (UNICO) and the Association of Universities Research and Industrial Liaison officers (AURIL), we were able to identify the most suitable respondent through their membership. We conducted an initial telephone exercise to identify the most suitable person to complete the questionnaire. This person was typically the head of the TTO or their designate. We received information from 98 of these universities. We returned to these institutions in the spring of 2003, and obtained full data on the level of their spin-off activity in financial year 2002 from 124 universities. Tests showed that the respondents were representative of the population of universities that are active in commercialization of university research.

This quantitative survey of TTOs was followed in 2003 and 2004 by a series of detailed interviews with a selection of TTOs in order to enable insights to be gained regarding the processes used to get projects investor ready. We approached TTOs in institutions within the context of maintaining coverage that reflected a range of age, experience, geographical spread and size. The universities in our sample are drawn from a wide range of
geographic regions across Europe. The universities also display a substantial age range. The sample includes both some of the longest-established universities as well as more recent technologically focused universities.

To examine the different incubation processes in universities and public research institutes we adopted a two-stage process. First, we identified 13 regions at the EU NUTS2 level, that is, the regional classification system adopted by Eurostat, which according to the European Report on Science and Technology Indicators (1994, p. 152; 1997) contained 80 per cent of all research laboratories and enterprises of the EU at that time:4 Île de France and Centre-Est (Rhône-Alpes) in France, Vlaams Gewest and Région Wallonne in Belgium, Eastern (East Anglia) and East Midlands in the UK, Oost-Nederland and Zuid-Nederland in the Netherlands, Bayern, Baden-Württemberg and Hessen in Germany, Northern Italy (Nord Ovest, Lombardia, Nord Est and Centro) in Italy, and Southern and Eastern Ireland (see Table 1.6).

For each region, a university researcher based in the region was asked to identify, for their region, technology transfer units according to the following criteria: (1) they needed to be founded before 1997, (2) they needed to

### Table 1.6  Research institutions and regional economic data

<table>
<thead>
<tr>
<th>Name of Scientific Regions of Excellence in Europe</th>
<th>GERD as a percentage of GDP, 1998</th>
<th>Number of patents applications per capita, 2000</th>
<th>Number of high-tech patents applications per capita, 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vlaams Gewest</td>
<td>1.9</td>
<td>159.6</td>
<td>26.8</td>
</tr>
<tr>
<td>Région Wallonne</td>
<td>1.9</td>
<td>134.9</td>
<td>12.6</td>
</tr>
<tr>
<td>Baden-Württemberg</td>
<td>3.8</td>
<td>527.4</td>
<td>57.5</td>
</tr>
<tr>
<td>Bayern</td>
<td>2.7</td>
<td>480.6</td>
<td>124.0</td>
</tr>
<tr>
<td>Hessen</td>
<td>2.2</td>
<td>350.4</td>
<td>31.5</td>
</tr>
<tr>
<td>Île-de-France (Rhône-Alpes)</td>
<td>3.4</td>
<td>296.3</td>
<td>68.1</td>
</tr>
<tr>
<td>Centre-Est (Rhône-Alpes)</td>
<td>2.3 (2.3)</td>
<td>197.2 (221.3)</td>
<td>32.7 (39.5)</td>
</tr>
<tr>
<td>Northern Italy (Nord Ovest, Lombardia, Nord Est, Centro)</td>
<td>1.4</td>
<td>104.6</td>
<td>8.0</td>
</tr>
<tr>
<td>Oost-Nederland</td>
<td>2.0</td>
<td>136.3</td>
<td>17.2</td>
</tr>
<tr>
<td>Zuid-Nederland</td>
<td>2.3</td>
<td>521.7</td>
<td>192.9</td>
</tr>
<tr>
<td>East Midlands</td>
<td>1.8</td>
<td>114.3</td>
<td>15.5</td>
</tr>
<tr>
<td>Eastern (East Anglia)</td>
<td>3.6</td>
<td>238.8 (309.9)</td>
<td>77.1 (120.2)</td>
</tr>
<tr>
<td>Southern and Eastern Ireland</td>
<td>1.4</td>
<td>103.6</td>
<td>28.8</td>
</tr>
</tbody>
</table>
have a documented record of spin-offs and (3) the local researchers had to consider them as examples of processes of spin-off activity that were successfully achieving their objectives. Seven cases matched the criteria: Scientific Generics and TTP in the UK, Leuven R&D and IMEC in Belgium, BioM in Germany, University of Twente in the Netherlands and Crealys in France.

Data on each case was collected through personal interviews with several persons in the institutes and secondary data sources such as annual reports, websites and descriptions of the institutes in the local press. Using a structured questionnaire, we assessed to what extent and how each spin-off service was organized or was engaged in the particular activity. We also analysed the resources developed to organize these activities on the bases identified by Brush et al. (2001): human, social, financial, physical, technological and organizational. We examined to what extent the resources that were present were crucial to organize the activities described above.

To validate the models developed in stage 1, we selected a range of different cases from the regions identified in stage 1. First, we identified a sample frame of universities and research organizations in these regions. Second, the universities and research institutes (RIs) were screened for the existence of a spin-off service. Third, a preliminary analysis of the effectiveness of the initiatives set up by the spin-off service took place. Based on this analysis, the most active spin-off services in each region were selected. This analysis produced a sample of 43 RIs. The selected cases were actively pursuing a spin-off strategy, but did not necessarily meet the three different criteria used as selection conditions in stage 1. Data were collected on each RI as for stage 1.

To examine university spin-off (USO) development, qualitative data were collected using in-depth face-to-face and telephone interviews with representatives from 12 USOs in the UK, as well as each of their financial investors and seven associated universities over the period July 2001 to July 2002. These universities were selected on the basis that they are among the top ten research elite universities in the UK and that they are actively pursuing a programme of university technology transfer. Each university was at a different point in transforming its policies, routines and incentive mechanisms towards commercialization through USOs. We selected a range of different ventures in terms of their technology and stage of development. Interviews were carried out with the head of the TTO – or equivalent – business development managers (BDMs) and the members of a spin-off company who had taken the venture through the process, including both the academic entrepreneur and the ‘surrogate’ entrepreneur where applicable. We also gained access to the seed-stage investors in each of the USOs. In addition, we interviewed the head of each department from which the
USO originated. The interviews lasted from one to two hours and were openly recorded and transcribed afterwards.

For the analysis of the spin-off team processes, a detailed field study was carried out of ten academic spin-offs located in Flanders, Belgium. These spin-offs were stratified in particular stages of their development. A longitudinal process approach was adopted (Burgelman, 1983). Cases were selected on the basis of at least two spin-offs being present in each of four stages: research commercialization and opportunity screening, organization-in-gestation, proof of viability and the maturity phase. The projects in the first two stages were selected based on contacts with TTOs, which helped us to obtain some understanding of which seemed to be potential spin-off opportunities. Teams that had got in touch with the TTO in order to protect their IP and that had recently filed or obtained a patent were selected. At the time of the study, the teams at the first stage were considering the options they had to commercialize their IP, of which a spin-off was only one possibility. The teams in the second phase had identified a market opportunity and had decided to create a spin-off. The companies in the last two stages were selected from a list of spin-offs in Flanders, with founders/chief executive officers (CEOs) being contacted to identify their stage of development. Those in the third stage had founded a legal entity and had brought together the necessary resources to develop it. Ventures showing persistence were identified as cases in the fourth, maturity phase. Data relating to teams were collected using a number of methods. First, for projects still located at the university, the head of the research team was contacted to provide data on the research and the team involved. For each selected formally incorporated venture, either the founder or the CEO was asked about the start-up history of the firm and particularly how the team evolved over time. During these interviews, we also asked for the exit/entry dates of individuals involved. For both the head of the research team and the founders/CEOs, the questionnaire was handed to the head of the research team and appointments made to collect the questionnaire. Second, for those teams still in the project stage, all members of the research team were asked to fill out the questionnaire. Each member of the management team of the formally incorporated ventures was asked to fill out the questionnaire. This questionnaire consisted of a part asking for background information on education and experience, and a part aimed at identifying the personal orientation required to realize venture success based on Van Muijen et al. (1999). Third, we collected background information on all individuals entering and exiting the team to allow us to evaluate the experiential diversity of the team at different stages during the spin-off process. The number of persons filling out the questionnaires ranged from two to eight per firm, depending on the phase in which the project/venture was
positioned. In all cases, all the members of the entrepreneurial team were involved in the study. Persuading team members to complete the questionnaire posed major challenges for the researchers.

To examine issues relating to the perspective of *financiers*, a questionnaire was sent in November 2003 to the 56 venture capital funds in the UK that identified themselves as being active investors in technology-based small firms according to the British Venture Capital Association (BVCA) definition of technology (BVCA, 2004). We aimed to examine the attitudes and perceptions of venture capital investors and to analyse the factors affecting the supply of finance from venture capital funds for spin-offs. The questionnaire sought both quantitative and qualitative information as well as presenting the opportunity for respondents to offer ‘write-in’ comments. We received 27 fully completed questionnaires plus nine nil responses/partly completed returns; that is, 50 per cent of the active VCs in the high-tech market. This response rate is in line with other surveys of VCs in the UK and very encouraging for a mail survey. To supplement the UK data, we conducted face-to-face interviews with 65 VC firms located in six European countries which mentioned in their local venture capital association directories that they invested in high-tech start-ups. To maximize the intra-sample variety of these VC firms, the sample frame of VC firms was divided into four groups: funds with more than 50 per cent public capital, captives which belong 100 per cent to a financial institute, multinational VC firms and local VC firms. In each category a random selection of four firms was made. From the 96 identified VC firms, 65 (60 per cent) agreed to participate in the study.

NOTES

1. NUTEK, the Swedish Business Development Agency, is a national agency under the charge of the Ministry of Industry, Employment and Communication that handles issues concerning industrial policies.
2. VINNOVA, the Swedish Agency for Innovation Systems, integrates research and development in technology, transport and working life. VINNOVA’s mission is to promote sustainable growth by financing R&D and developing effective innovation systems.
3. Medical Research Council (MRC), Biotechnology and Biological Sciences Research Council (BBSRC), Natural Environment Research Council (NERC), Engineering and Physical Sciences Research Council (EPSRC), Particle Physics and Astronomy Research Council (PPARC), Economic and Social Research Council (ESRC), Council for the Central Laboratory of the Research Councils (CLRC) and the Arts and Humanities Research Board (AHRB).
4. EU refers only to the 12 original EU member states. The Northern European countries – Sweden, Finland and Denmark – joined the EU much later and were not included in the *European Report* due to lack of regional R&D statistics compiled by Eurostat.