



Observatory of European SMEs
2002 / No 6

High-tech SMEs in Europe



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This report has been prepared from information provided by all partners of the European Network for SME Research ENSR (see Annex II) and was coordinated by Ms. Ulla Hytti, and D.Sc. Jarna Heinonen from the Small Business Institute, Turku School of Economics and Business Administration, the Finish partner and Mr. Thomas Oberholzner from the Austrian Institute for Small Business Research (IfGH), the Austrian partner.

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OBSERVATORY OF EUROPEAN SMEs

A series of reports submitted to the Enterprise Directorate-General of the European Commission (see also Annex II to this report) by:

KPMG Special Services and EIM Business & Policy Research in the Netherlands

in co-operation with:

European Network for SME Research (ENSR), and Intomart

For more information on the current series of reports in the framework of The Observatory of European SMEs, see the website of the Enterprise DG at <http://europa.eu.int/comm/enterprise>.

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The report published in July 2000 (6th Observatory Report) focused for instance on the markets for products and services, labour market issues, access to both finance and Community programmes, electronic commerce, and associations and foundations in the social economy. It also contained in-depth studies on vocational training for SMEs and new services.

The 6th Observatory Report is published in English, French and German. The report is currently out of print, but a limited number of copies are still available. Please send your request to: ENTR-COMPETIT-BENCHMARK@cec.eu.int.

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These are the abbreviations used in this report for the Europe-19

A	Austria	NL	Netherlands
B	Belgium	P	Portugal
DK	Denmark	S	Sweden
D	Germany	UK	United Kingdom
EL	Greece	EU	European Union
E	Spain	IS	Iceland
F	France	LI	Liechtenstein
FIN	Finland	NO	Norway
IRL	Ireland	EEA	European Economic Area
I	Italy	CH	Switzerland
L	Luxembourg	Europe-19	EEA plus Switzerland

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Preface

Enterprises are at the heart of the strategy launched by the European Council in Lisbon in March 2000. Reaching the objective of becoming the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth, more and better jobs and greater social cohesion will ultimately depend on how successful enterprises, especially small- and medium-sized ones, are.

The *Observatory of European SMEs* was established by the Commission in December 1992 in order to improve monitoring of the economic performance of SMEs in Europe. Its task is to provide information on SMEs to policy-makers at the national and European level, researchers, SME organisations and to SMEs themselves.

The reports of the Observatory provide an overview of the current situation in the SME sector in Europe through statistics on the number of enterprises, on total employment and on production by size of enterprise. In addition, the Observatory reports cover a range of thematic issues.

The *Observatory of European SMEs* covers 19 countries: the 15 countries of the EU, plus Iceland, Liechtenstein, Norway and Switzerland.

During 2002, the following reports are planned to be published:

- Highlights from the 2001 Survey
- SMEs in Europe, including a first glance at EU Candidate Countries
- Regional Clusters in Europe
- European SMEs and Social and Environmental Responsibility
- Business Demography in Europe
- High Tech SMEs in Europe
- Recruitment of Employees: Administrative Burdens on SMEs in Europe
- Tax incentives for SMEs in Europe
- Highlights from the 2002 Survey

The research for the Observatory reports is carried out on behalf of the Enterprise Directorate-General of the European Commission by ENSR, the European Network for SME Research, co-ordinated by EIM Business & Policy Research from the Netherlands in a consortium led by KPMG Special Services from the Netherlands.

For a description of the activities of the Enterprise DG, see the website of the European Commission: <http://europa.eu.int/comm/dgs/enterprise>. For more information on the Observatory of European SMEs, including how to access or order the reports, see: http://europa.eu.int/comm/enterprise/enterprise_policy/analysis/observatory.htm. Information on previous reports of the Observatory may be found there as well.

Summary

The wealth of today's modern economies depends heavily on their performance in generating new knowledge, innovation and technological progress. High-tech SMEs are creating and implementing technological innovations and are therefore playing an important role by increasing living standards, employment, productivity and competitiveness. However, in comparison with its main competitors, Europe is lagging behind with respect to business innovation and R&D. In this context, the present report aims at contributing to the understanding of the general situation of European high-tech SMEs and of the factors limiting their prosperous development.

Definition of high-tech SMEs

A clear-cut and broadly accepted definition for high-tech SMEs does not exist and related concepts and indicators are either too broad, or too narrow, or both at the same time. This report follows a rather broad conceptual approach without elaborating a very stringent definition or set of indicators. Small and medium-sized enterprises being the subject of this study are highly innovative and/or R&D intensive companies and/or use sophisticated and complex production technologies.

The economic importance and performance of high-tech SMEs

A unique and tailored empirical database on European high-tech enterprises does not exist. To analyse the quantitative importance and performance of high-tech SMEs this report uses (i) a rough but Europe-wide uniform sector approach and (ii) a synopsis of more specific ad-hoc and national analyses at firm level.

The analyses in terms of output and employment reveal a differentiated picture. The variation in performance among high-tech SMEs is considerable, reflecting the risk involved in innovation activities. Only a very small fraction of high-tech firms are rapid growers. However, on average high-tech firms still outperform traditional companies with respect to output and job growth. Their lead is more pronounced for output than for employment as they are achieving significant productivity gains, especially in manufacturing. For this reason, it is rather selected high-tech services which can be regarded as job engines. Nevertheless, in a competitive world economy, labour productivity growth is also essential to secure jobs in the long run.

When assessing the size of high-tech enterprise relative to the entire economy one may conclude that their weight in terms of number of enterprises and employment is not overwhelming. An analysis at sector level shows that some 750 000 European SMEs had been active in typical high-tech industries in 2000, employing approximately 5 million people, i.e. 4 % of total employment in non-primary private enterprise. Due to this, the overall direct impact on the entire economy, e.g. concerning employment, is limited.

However, the importance of new technologies and highly innovative businesses goes far beyond their direct contribution to value added and employment. Significant spill-over effects to the rest of the economy, but also negative external effects (displacement effects) of introducing new technologies and innovation are assumed to exist.

Success factors

Diversifying the product range at an early stage to reduce risk and emphasising customer orientation and service can be regarded as important and specific success factors of high-tech SMEs. Also internationalisa-

tion might be regarded as success factor in a wider sense, since the national market, in particular in small economies, is often too small for a sophisticated niche product. Significant economies of scale in R&D are playing a role in this respect.

Access to finance

The situation of highly innovative SMEs with regard to obtaining finance is characterised by a number of specific features, which make it more difficult for them to access finance (high risk/uncertainty, long development periods, intangible rather than tangible assets, information asymmetry). Overall, however, empirical data suggest that access to finance may not represent the most significant obstacle to high-tech firms and its relevance differs considerably by country, type of enterprise and life-cycle. The problem is more severe in countries having a bank loan culture, when the project couples new technologies and new markets at the same time, and generally depends on the complexity and risk of the innovation project. Moreover, financing problems are far more striking in the start-up and early development stage.

The conditions outlined above make debt/bank financing appear less appropriate, whereas private equity and venture capital seem to constitute a more adequate financing option. However, after steady increases in European venture capital investments, 2001 brought a marked reduction of commitments, especially in the high-tech sector. Moreover, it seems that venture capitalists are reluctant to invest in the early stage and the amount of capital required by very small high-techs is often too small for venture capital companies. Thus, venture capital remains an option only for a small elite of enterprises.

Business angels seem to be comparably more widespread and also more adequate for the smaller firms. But at least three constraining factors can be identified: (i) in very new industries (technologies) there is a shortage of experienced business angels; (ii) many entrepreneurs are reluctant to take in business angles in order to avoid a loss of independence, although those enterprises using this form of funding value highly the non-financial support given; (iii) it is difficult to match businesses with business angels.

Raising capital from stock markets ('new markets') has become less important recently and is by no means an option for the majority of high-tech businesses.

Access to skilled labour

The empirical data available confirms that skill shortages (mostly for highly educated technicians, engineers, and e-business professionals) represent a top barrier to development for European high-tech SMEs, although the scale of the gap rapidly changes over time. If labour is not available externally, companies have increasingly to rely on internal training. This is easier to manage for larger enterprises and therefore posing a relative disadvantage to smaller scaled innovative businesses. Moreover, high-tech firms suffer from high dynamics in staff structure and staff turnover rates.

The problem is definitely rooted in a supply or availability gap rather than in a mere mismatch situation. Therefore, mobilising a possible hidden potential is limited (because it does not really exist), and encouraging European cross-border mobility and improving labour market information (on vacancies and job seekers) will have minor effects only. The main strategy has to be seen in making available a workforce with the required competences and knowledge.

Administrations in European countries have taken measures aimed at attracting experts from outside Europe, increasing the number of science and technology students and the attractiveness of science as a career option as well as promoting further life-long learning to stimulate the up-take of the required qualifications by the European population itself, and adjusting education systems and institutions to the requirements (curricula, PCs in schools, etc.).

Companies react by geographically transferring development and production units and through internal training. Empirical evidence confirms that high-tech firms are comparably more active in terms of training than other businesses.

Interaction with universities and research institutions

Universities and similar research bodies hold an enormous stock of knowledge, but their importance as a source of know-how for smaller high-tech firms is more than limited. Furthermore, the number of university spin-offs is significantly lower in Europe than in the USA. The reason for the poor university-business interaction basically lies

in incompatible structures on the side of firms and universities (different aims, culture, etc.). In addition, smaller enterprises often lack the financial and technical resources required for co-operation projects with universities.

Available evidence shows that successful university-business linkages are regularly based on personal relationships and that science parks may function as facilitator and stimulator for establishing collaboration with research institutions.

The role of networks

For high-tech SMEs networks are almost a necessity to perform innovation projects and tap the required information and know-how to conduct business. Networks make possible the sharing of costs as well as risk sharing and contribute to business success. Empirical evidence reveals that networking is quite common among high-tech companies, although it is somewhat one-sided and oriented mainly towards customers and suppliers. On the other hand, smaller innovative enterprises in particular often express a not too favourable attitude towards co-operation.

The following barriers to networking, specific to smaller high-tech firms, can be identified: (i) Often there is a lack of a 'co-ordinator', which might be an agency or a larger leading firm. (ii) Small firms, in contrast to large ones, have a short-term perspective and expect quick and concrete results. But research networking is comparably time-intensive and results are not immediately visible. To reduce efforts co-operation is kept simple and built with only very few partners. (iii) It is difficult to find a balance between the privacy of information and the necessary knowledge sharing.

Management competences

The dynamic market conditions and the risk involved in high-tech business expect a great deal from managerial skills in high-tech SMEs. In contrast, many high-tech entrepreneurs have an excellent education and experience in their specific scientific area, but lack business management capabilities. This constitutes a threat to their survival and an obstacle to their development. Empirical evidence shows that it is marketing, human resources (including recruiting), and understanding customer needs which are the major deficits. Especially in the early stage careful cash management is an often-ignored aspect.

Policy support

Significant social returns as well as dysfunctions in or absence of market co-ordination justify and call for public intervention in the field of high-tech enterprises and innovation in general. A vast number of policies and measures to foster innovation and high-tech firms have been taken or are currently in force, at both Member State and EU level. The measures cover a broad spectrum of issues. Recent trends relate to intensifying the co-operation between research, universities and companies, the promotion of clustering and networking, and to so-called 'competence networks' and 'technology valleys'.

Chapter 1

Introduction

According to modern growth theory innovation and technological change is the main determinant of economic prosperity, increasing living standards, productivity growth, and competitiveness. It is estimated that in the developed countries more than half of the total growth in output between 1970 and 1995 can be attributed to technological progress¹. Thus, the wealth of today's modern economies depends heavily on their performance in generating new knowledge and on their technological position and development.

In the context of technological change two basic levels may be distinguished: First, the creation of new (scientific) knowledge, often taking place in specific (public) research institutions, and potentially functioning as a basis for the second level, i.e. the actual implementation of technological innovations in the form of new products, services and production processes. The latter in particular is essentially the part of an economy's private (small and medium-sized) enterprise sector. Consequently, economic policy concludes that those SMEs taking over this function, the 'high-tech SMEs', 'have a strong role to play for growth and employment in Europe'².

At the same time, several analyses have pointed to the fact that, in comparison with its main competitors, Europe performs excellently in terms of (public) scientific research, but is lagging behind with respect to business innovation and R&D. Europe seems to find it difficult to translate new scientific knowledge into new commercial products and processes, and economic results. This phenomenon is known as the 'European Paradox'. Moreover, there seem to be indications that only very few innovative and high-technology enterprises in Europe experience rapid growth, with a modest effect on aggregate output³. However, this weakness and ambiguity makes it even more important for economic policy to focus attention on the innovation performance of (small) businesses, the general situation of high-tech firms and the factors limiting their prosperous development.

This report aims primarily at contributing to the further identification and understanding of the barriers for the development of European high-tech SMEs or, put differently, for SMEs to bring new technologies onto the markets. Thus, the focus is on the availability of specific resources regarded as crucial for high-tech firms, namely finance, skilled labour, and knowledge⁴. These resources have been mentioned repeatedly as significant bottlenecks limiting the performance of technology-oriented enterprises⁵. The report discusses questions such as: To what extent do the above-mentioned resources constitute a constraining factor? What are the concrete characteristics of the constraint? What are possible solutions to the problem? The information put forward in this report is based on literature, statistics and case studies from the 15 Member Countries of the EU, Iceland, Liechtenstein, Norway, and Switzerland.

The structure of the report is as follows: Chapter 2 discusses the notion of high-tech SMEs including related concepts, in order to obtain a clearer idea of the subject under consideration. Chapter 3 provides quantitative information on the importance and role of high-tech SMEs and SMEs in high-tech sectors (e.g. number of enterprises, employment and value added) in the economy and illustrates the performance and success of high-tech SMEs. Chapter 4 discusses potential constraints in relation to the crucial resources as outlined above: finance, human

1 European Commission, Building an Innovative Economy in Europe. A review of 12 studies of innovation policy and practice in today's Europe, Luxembourg, 2001, p. 11.

2 European Commission, Creating an entrepreneurial Europe. The activities of the European Union for small and medium-sized enterprises (SMEs). Report from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions, COM(2001) 98 final, Brussels, 01.03.2001, p. 110.

3 Ministry of Trade and Industry, SME Forum: Rapid Growth and Competitiveness through Technology, Final Report, Follow-up of Concerted Actions 2&3, Support Services to SMEs, Helsinki, 2000, p. 10.

4 Other aspects as, for example, the regulatory framework are, although important, not covered in this report.

5 See for example Ministry of Trade and Industry, SME Forum: Rapid Growth and Competitiveness through Technology, Final Report, Follow-up of Concerted Actions 2&3, Support Services to SMEs, Helsinki, 2000; and EOS Gallup Europe, Flash Eurobarometer 100, Innobarometer, Results and Comments, 2001.

resources, and knowledge. In Chapter 5 selected support measures aiming to facilitate the access of high-tech SMEs to finance, skilled labour, knowledge and to networks are presented. Finally, in Chapter 6, some conclusions are drawn to stimulate the policy debate.

Chapter 2

What are high-tech SMEs?

A broadly accepted definition for high-tech SMEs does not exist, neither in the academic area nor in economic policy in general. What is more, the notion we regularly associate with the term high-tech SMEs is surrounded by a diversity of terms with often rather similar or related meanings; examples are: new technology-based firms (NTBFs), innovative SMEs, knowledge-based firms, R&D intensive companies, the new economy, and specific industry sub-groups such as IT-enterprises or biotech firms.

The most significant efforts have been undertaken in the field of defining 'technological product and process (TPP) innovations' and 'technological product and process innovating firms', which resulted in the so-called Oslo Manual⁶. According to this definition a *TPP innovating firm* is one that has implemented technologically new or significantly technologically improved products or processes. Important elements of this definition include the restriction to 'technological' innovation (as opposed to organisational innovation), the 'new to the firm' approach (i.e. the product or process is not necessarily new to the economy as a whole), and the fact that the term 'product' covers both goods and services.

A second strand of frequently used definitions is basically founded upon *R&D intensity*, which is not explicitly taken into account in the Oslo Manual definition. In this sense firms are R&D intensive or 'high-tech' if their expenditure on R&D in relation to their output exceeds a certain threshold. The OECD, for example, uses this measure to define 'high-tech sectors'. Also, in the literature on NTBFs the R&D approach is frequently used to define the subject under review, and sometimes even via identifying relevant sectors as a first step. It should be noted that with regard to new TBFs it is even unclear in some analyses whether the word 'new' refers to the enterprise, or to the technology, or both⁷.

Comparing the two approaches outlined above it may be concluded that the Oslo Manual definition is significantly wider, also comprising firms implementing innovations without conducting R&D. Especially many small businesses may be innovative although not employing sophisticated technologies or carrying out R&D. In contrast, enterprises being R&D intensive but, at the same time, not innovative according to the Oslo Manual will rarely exist, since business R&D generally aims at creating new products or processes. Thus, R&D intensive enterprises might be considered a sub-group of innovative ones. Moreover, for both types of definitions there is a variety of concrete indicators in use for the purpose of measurement in empirical exercises, which adds to the confusion with respect to the conceptual situation. Table 2.1 provides an overview of such measures.

6 OECD/Eurostat: The measurement of scientific and technological activities. Proposed guidelines for collecting and interpreting technological innovation data - Oslo Manual, Organisation for Economic Co-operation and Development (OECD) Paris: OECD, 1997.

7 Storey, D.J. and B. Thether, New Technology Based Firms (NTBFs) in Europe, European Innovation Monitoring System (EIMS) Study, 1996.

Table 2.1: Commonly used indicators for measuring high-tech orientation at the firm level

kind of indicator	indicator	advantages and disadvantages
Innovation input indicator	R&D expenditure (e.g. % of turnover)	- available in many statistics - biased towards large scale enterprises
	R&D personnel (e.g. % of total personnel)	- easy to measure - does not take account of actual working time - does not take account of outsourcing of R&D (particularly important for SMEs)
	R&D intensity (e.g. R&D person year as % of total labour input)	- takes account of the actual working time of R&D personnel - is defined differently across various statistics
Innovation throughput indicator	number of patents	- does not necessarily favour large scale enterprises - limited to rapidly growing patent classes where innovation is science-driven - dependent on the propensity to patent within different industries - not all innovations are patentable
Innovation output indicator	share of turnover attributable to innovation	- includes all kinds of innovation, not only those based on R&D - gives an indication of the economic success of the innovation - difficult to answer for respondents and therefore possibly imprecise
	revenues by selling patents, licences and know-how	- gives an indication of the economic success of the innovation - comparatively easy to measure - not recorded in many statistics
	innovation counts (e.g. self-reported statements on innovation)	- easy to measure - no consensus on what is considered an innovation - gives no indication of the relevance of the innovation

Source: Sheikh, S. and T. Oberholzner, Innovative SMEs and employment creation, report submitted to the European Commission, DG Enterprise, 2001.

Sometimes enterprises belonging to particular industries are altogether viewed as high-tech. This is especially true if a whole new industry emerges around a new major technology, e.g. the information and communication technology sector or biotechnology. However, because of its simplicity this procedure is often used as a makeshift solution in empirical research, too.

For other terms, such as the 'new economy' (see Box 2.1), reasonable definitions do not exist at all or are very vague. In the end, a clear-cut and uniform definition of high-tech SMEs is not put forward in the literature. Also for pragmatic reasons, this report follows a rather broad conceptual approach, taking into account a variety of the above mentioned definitions and refraining from elaborating a very stringent definition or set of indicators to identify high-tech SMEs: Small and medium-sized enterprises being subject to this study are highly innovative and/or R&D intensive companies and/or using sophisticated and complex production technologies. However, this report is mainly based on secondary data and information, applying different concepts and methodologies in analysing 'high-tech' firms. This will undoubtedly pose limitations regarding the comparability of findings and hence one must be careful in interpreting the results of the studies presented here.

Box 2.1: The 'new economy' concept

The term 'New Economy' appeared for the first time in 1993. It is not precisely defined, but used to describe different characteristics and activities of firms, mostly related to technology and the internet in particular. The term 'New Economy' may take on at least the following meanings:

- The period of long-lasting growth in the US economy during the 1990s
- Firms or industries which are information or knowledge intensive rather than capital intensive
- Firms listed at the NASDAQ, the New Market or similar stock exchanges
- Technology-oriented start-ups
- Firms realising their sales mainly via the Internet (dot.coms).

The New Economy is therefore definitely not an 'industry' in the traditional sense (i.e. according to methods applied by economic statistics). New Economy firms may appear in retail trade, in business services and in many other sectors. What is more, the New Economy is a bundle of firm characteristics related to a new way of corporate organisation and a new way of pursuing business. Thereby, the involvement of the internet and of new information technologies is most relevant. New Economy companies are not necessarily innovative (at least after a certain period of existence) nor R&D intensive in the strict sense.

Source: Based on Radauer, A., New Economy, Industry Monitor Report, Austrian Institute for Small Business Research, Vienna, 2002.

Chapter 3

The importance and performance of high-tech SMEs in Europe

Comparable and uniform data on high-tech SMEs across Europe are scarce, due to the vagueness with respect to the definition of high-tech SMEs as described in Chapter 2 and because of the variety of methods used by different ad-hoc studies. Generally this situation makes it difficult to grasp high-tech SMEs in a statistical way. Still, in Section 3.1 an effort has been undertaken to get a first approximate estimate of the quantitative importance of high-tech SMEs in Europe by applying a uniform, although rough, sector approach. This investigation is supplemented by further related literature and data at sector level. Subsequently, Section 3.2 presents some more specific analyses pertaining to the performance and success of European high-tech SMEs, mainly based on firm level data.

3.1. The size and development of high-tech sectors

This section aims at filling a gap in research on high-tech SMEs insofar as it attempts to provide a consistent quantitative overview of the importance (number of enterprises, employment, value added) of these companies in Europe-19. For this purpose we have chosen a methodological approach that is based on aggregated sector data⁸. Consequently, the definition of the term 'high-tech' is sector-based as well, i.e. (all) those enterprises are said to be high-tech that belong to the industries selected. The advantages of this method are the possibility to utilise existing statistical data (thus avoiding additional surveying) and, above all, the application of comparable concepts across all countries. The main disadvantage associated with the sector approach is the extent to which the industry a firm belongs to is an appropriate indicator for high technology. Put differently, there might be enterprises outside the selected sectors which are nevertheless high-tech as well as enterprises actually being low-tech although belonging to the relevant industries⁹.

In the frame of this analysis eight business sectors¹⁰ are considered to be typical high-tech. The selection is based on the following considerations: (i) The industries shall represent those sectors which are generally viewed as being dominated by high-tech firms, i.e. information and communication technology¹¹, biotechnology¹², and research and development; (ii) furthermore, an OECD classification grouping industries by R&D intensity is taken into account. The relevant classifications are presented in detail in Annex I. Out of the eight sectors two, computer and related activities as well as research and development, are service sectors, the remaining ones are manufacturing industries.

8 The analysis performed in this section relies on a specific data pool, which originally forms the basis of another report of the Observatory of European SMEs (i.e. European Commission, Observatory of European SMEs: SMEs in Europe, including a first glance at EU Candidate Countries; Report submitted to the Enterprise Directorate General by KPMG Special Services, EIM Business & Policy Research, and ENSR; Brussels, 2002). The data are adapted carefully from various sources, of which Eurostat's SME database forms the starting point. A detailed methodological description may be obtained from the above-mentioned report and its annexes.

9 The extent of this error of course depends on the underlying hypothetical high-tech concept.

10 Sectors represent 2-digit levels of NACE Rev.1 (i.e. the Statistical Classification of Economic Activities in the European Community): Manufacture of chemicals, chemical products and man-made fibres (NACE 24), manufacture of machinery and equipment, n.e.c. (NACE 29), manufacture of office machinery & computers (NACE 30), manufacture of electrical machinery (NACE 31), manufacture of radio, television & communication equipment (NACE 32), manufacture of medical, precision & optical instruments (NACE 33), computer & related activities (NACE 72) and research & development (NACE 73).

11 *Measuring the ICT Sector* (2000) Information Society, OECD internet publication, http://www.oecd.org/dsti/sti/it/prod/measuring_ict.htm, situation on 11.7.2001 and OECD (1997) *Revision of the high-technology sector and product classification*, STI Working Papers 1997/2, OECD/GD(97)216, Organisation for Economic Co-operation and Development. Paris.

12 In addition to the manufacture of chemicals, chemical products and man-made fibres (NACE 24) and manufacture of medical, precision & optical instruments (NACE 33) biotechnology plays a growing role also in the foods industry, but as this industry is rather dominated by lowtech it is not considered here.

In this context it should be noted that one can regularly identify a high concentration of R&D activities at sector level. For example, telecommunications, pharmaceuticals and chemicals, R&D and transport machinery represent 70 % of enterprise R&D expenditure in Italy¹³. Pharmaceuticals and chemicals, electronic materials, mechanical machinery and equipment, and electric machinery and equipment represent 80 % of total R&D investments incurred by Spanish SMEs¹⁴. The Flemish ICT sector is responsible for almost 25 % of all R&D investments, which contributes to an R&D intensity of 6 % (of total sales)¹⁵.

3.1.1. The size of high-tech sectors

Initially, it must be noted that any estimate on the quantitative importance or size of high-tech business is highly sensitive to the underlying definition. This should be taken into account when interpreting the following data. In 2000, more than 750 000 or almost 4 % of enterprises in Europe-19 were active in the defined high-tech industries, employing 10.5 million people or 8.7 % of the total workforce in non-primary private enterprise (see Table 3.1). A comparison of the proportions in number of enterprises and employment respectively shows that, on average, firms in high-tech sectors are larger-scaled than in other sectors. Average enterprise size in high-tech is more than twice the average enterprise size in non-high-tech (14 versus 6 employees). Accordingly, within the high-tech sectors the weight of SMEs (i.e. enterprises employing less than 250 persons) is significantly smaller than within the total economy, especially in terms of employment. The 746 000 SMEs in high-tech employ approximately 5 million people, which is less than 50 % of total high-tech employment and about 4 % of total employment in non-primary private enterprise. Also, average firm size of high-tech SMEs is well above the respective ratio for non-high-tech SMEs (7 versus 4 employees).

Table 3.1: Structure of non-primary private enterprise, Europe-19, 2000 (absolute numbers in 1 000s and percentage of grand total)

		SMEs		LSEs		All size classes	
High-tech sectors	Enterprises	746	3.8 %	7	0.0 %	753	3.8 %
	Employment	4 985	4.2 %	5 480	4.6 %	10 465	8.7 %
Non high-tech sectors	Enterprises	18 890	96.0 %	33	0.2 %	18 923	96.2 %
	Employment	74 363	61.9 %	35 287	29.4 %	109 650	91.3 %
All sectors	Enterprises	19 637	99.8 %	40	0.2 %	19 676	100.0 %
	Employment	79 348	66.1 %	40 768	33.9 %	120 116	100.0 %

Source: Estimated by EIM Business & Policy Research; estimates based on Eurostat's SME Database. Also based on European Economy, Supplement A, June 2001 and OECD: Economic Outlook, No. 69, June 2001.

However, Table 3.2 reveals important differences between industries within high-tech business. When measured in terms of number of enterprises, high-tech business is dominated by a single service industry, namely computer & related activities (45 % of firms). Since enterprises in this industry appear to be rather small scaled and companies in the other sectors are comparably large scaled, employment is more evenly distributed over the eight sectors. Overall, however, manufacturing industries dominate with respect to employment and 'machinery and equipment' accounts for almost 30 % of jobs. Summing up, high-tech business as defined here is composed of a fairly small-scaled service sector with a relatively high number of firms and several rather large scaled manufacturing sectors¹⁶.

13 ISTAT, 2000.

14 Yagüe, M.J., La Actividad Innovadora de la Pyme Industrial Española (Innovation activities in Spanish SMEs), in: *Economía Industrial*, No. 284, 1992, pp. 137-149.

15 ICT Clusters in Flanders: Co-operation in Innovation in the New Network Economy. Flemish Contribution to the Focus Group on Cluster Analysis and Cluster-based Policy [TIP/OECD], written by J. Larosse, P. Slets, J. Wauters, and S. Bruninx, M. Hinoul, L. Peeters, D. Salens, P. Simkens, R. Wintjes, P. Zeeuwts, IWT-Observatory, IWT Studies, D/2001/7037/1, No. 35, April 2001.

16 High-tech manufacturing is relatively large scaled in comparison to total manufacturing.

Table 3.2: Industry structure of high-tech business, Europe-19, 2000

	Enterprises (1 000s)			Employment (1 000s)			Average enterprise size
	SMEs	LSEs	Total	SMEs	LSEs	Total	
Chemicals, chemical products and man-made fibres	32	1	33	507	1 319	1 826	55.3
Machinery and equipment	144	2	146	1 597	1 421	3 018	20.7
Office machinery and computers	13	0	13	75	138	213	16.4
Electrical machinery	53	1	54	555	920	1 474	27.3
Radio, television & communication equipment	26	0	27	233	596	829	30.7
Medical, precision & optical instruments	86	1	87	576	378	955	11.0
Computer & related activities	342	1	342	1 234	364	1 599	4.7
Research & development	50	1	51	208	343	551	10.8
Total high-tech sectors	746	7	753	4 985	5 480	10 465	13.9

Source: Estimated by EIM Business & Policy Research; estimates based on Eurostat's SME Database. Also based on European Economy, Supplement A, June 2001 and OECD: Economic Outlook, No. 69, June 2001.

3.1.2. The development of high-tech sectors

This section focuses on the development of high-tech sectors (and its SMEs) in the period from 1988 to 2000. Since there are remarkable differences between high-tech manufacturing and high-tech services in this respect, it is distinguished between these two categories in Table 3.3. The single industries within these categories developed more homogeneously. In Europe-19, both high-tech manufacturing and high-tech services experienced a slightly higher growth of real value added than total non-primary private enterprise during the period 1988 to 2000. Generally, large scaled enterprises performed better than SMEs. Especially in the period after 1993, high-tech manufacturing was able to grow faster than other sectors.

However, in contrast to high-tech manufacturing, real value added growth was extraordinary labour intensive in high-tech services. During the period 1988 to 2000, employment in high-tech services increased by 1.5 % annually while the figure was only 0.1 % for total non-primary private enterprise and high-tech manufacturing employment declined by 1.6 % per year. Especially computer & related activities became a job creator after 1993, increasing employment by 2.2 % annually. On the other hand, due to the still relatively small weight of this industry within the entire economy, the absolute economic impact remains modest.

In high-tech services growth was not only employment intensive but also 'enterprise intensive'. During the period under review the number of firms increased at the same pace as employment did, suggesting that average enterprise size remained stable, and clearly outperforming the rest of the economy. In other words, new enterprises contributed considerably to employment and real value added growth in high-tech services. In high-tech manufacturing the number of firms went down by 1 % annually and average enterprise size decreased as well.

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The high labour intensity of growth in high-tech services resulted in a below average labour productivity growth. In contrast, high-tech manufacturing experienced impressive gains in labour productivity of 4.2 % per year. Here larger firms distinctly outperformed smaller units.

Table 3.3: Number of enterprises, employment, real value added and labour productivity, Europe-19, average annual change in % 1988-2000

		Enterprises	Employment	Real value added	Labour productivity
High-tech manufacturing	SMEs	-0.9	-1.5	2.2	3.7
	LSEs	-1.7	-1.7	2.8	4.5
	Total	-1.0	-1.6	2.5	4.2
High-tech services	SMEs	1.3	1.5	2.2	0.8
	LSEs	1.5	1.5	2.7	1.1
	Total	1.3	1.5	2.4	0.9
Total non-primary private enterprise	SMEs	0.4	0.2	2.0	1.8
	LSEs	-0.2	-0.2	2.6	2.7
	Total	0.4	0.1	2.3	2.2

Source: Estimated by EIM Business & Policy Research; estimates based on Eurostat's SME Database. Also based on European Economy, Supplement A, June 2001 and OECD: Economic Outlook, No. 69, June 2001.

A country-by-country analysis of the growth of real value added and employment in high-tech sectors reveals significant geographical differences. With respect to high-tech manufacturing average annual growth rates of real value added in the period 1988-2000 range from 0.6 % in Spain to almost 15 % in Ireland (see Table 3.4). The clear lead of Ireland is explained by the tremendous inward investments in these sectors. Also a number of other countries performed well above entire Europe-19 average: Finland, Portugal, Norway, the Netherlands, Luxembourg, Belgium, Germany and Denmark. On the other hand, the high-tech manufacturing sectors of Spain, Italy, Sweden, Switzerland and the United Kingdom developed distinctly worse than Europe-19 average. Interestingly, country differences in employment growth in high-tech manufacturing are much smaller and the country ranking appears to be different, too. Many of those countries experiencing high growth rates of real value added showed, at the same time, an above average increase in labour productivity. In contrast, some countries had a rather weak but labour intensive growth of production and improved their labour productivity less. In high-tech manufacturing, productivity increases seem to be strongly associated with production growth.

Table 3.4: Development of employment and real value added in high-tech manufacturing sectors by country, average annual change in %, 1988-2000

	Employment			Real value added		
	SMEs	LSEs	Total	SMEs	LSEs	Total
Austria	-1.9	-1.8	-1.9	2.0	2.1	2.1
Belgium	-0.7	-0.3	-0.4	3.9	3.7	3.8
Denmark	-0.7	-0.5	-0.6	3.5	3.5	3.5
Finland	-2.6	-1.9	-2.2	4.8	5.5	5.3
France	-1.3	-0.4	-0.8	1.3	2.8	2.3
Germany	-2.3	-2.1	-2.2	3.4	3.8	3.7
Greece	-1.5	-1.5	-1.5	2.8	3.3	3.1
Ireland	3.2	3.5	3.4	14.8	14.6	14.7
Italy	-1.7	-1.7	-1.7	0.8	1.4	1.1
Luxembourg	-1.3	-1.3	-1.3	4.8	3.7	4.0
Netherlands	0.1	-0.6	-0.3	4.3	4.1	4.2
Portugal	-2.0	-0.9	-1.6	4.1	5.1	4.6
Spain	0.3	0.1	0.3	0.3	0.9	0.6
Sweden	-2.9	-2.3	-2.5	1.4	1.2	1.3
United Kingdom	-1.4	-2.7	-2.2	2.6	1.0	1.5
Iceland	-0.6	n/a	-0.6	2.0	n/a	2.0
Norway	0.7	-0.2	0.3	3.9	4.6	4.3
Switzerland	-0.8	-1.1	-0.9	1.4	1.2	1.3
Europe-19	-1.5	-1.7	-1.6	2.2	2.8	2.5

Source: Estimated by EIM Business & Policy Research; estimates based on Eurostat's SME Database. Also based on European Economy, Supplement A, June 2001 and OECD: Economic Outlook, No. 69, June 2001.

Differences in real value added growth between countries are also considerable for high-tech services (see Table 3.5), however, the relative position of individual countries does not always correspond to their position with reference to high-tech manufacturing. Again, Ireland leads by far with an average annual growth rate of some 10 % in the period 1988-2000. Also Luxembourg, the Netherlands, Norway and Spain (which is lagging behind in the domain of high-tech manufacturing) performed clearly better than Europe-19 average. On the other hand, in Finland, showing strong growth in high-tech manufacturing, real value added of high-tech services decreased by some 3 % annually. Belgium, Sweden and Switzerland as well show a relatively weak development. The association between labour productivity growth and development of output is prevalent in high-tech services, too, but it is not that striking. So, the country ranking with respect to employment change follows more or less the one with respect to value added growth.

Table 3.5: Development of employment and real value added in high-tech service sectors by country, average annual change in %, 1988-2000

	Employment			Real value added		
	SMEs	LSEs	Total	SMEs	LSEs	Total
Austria	1.4	1.3	1.4	1.8	1.6	1.8
Belgium	0.9	1.3	1.0	1.2	1.8	1.4
Denmark	1.0	1.3	1.1	2.4	2.4	2.4
Finland	-1.7	-0.8	-1.4	-3.6	-2.4	-3.2
France	2.1	2.6	2.3	2.0	2.6	2.2
Germany	1.8	1.1	1.4	1.9	1.4	1.8
Greece	3.5	3.6	3.5	2.4	2.4	2.4
Ireland	6.7	7.5	6.8	10.1	10.3	10.1
Italy	0.6	1.5	0.7	2.8	3.8	3.0
Luxembourg	4.4	4.3	4.4	5.7	5.4	5.6
Netherlands	2.7	4.4	3.3	3.9	6.8	5.3
Portugal	2.0	1.5	2.0	2.0	1.9	2.0
Spain	2.0	2.3	2.1	3.5	3.9	3.6
Sweden	-0.5	0.0	-0.3	0.7	0.7	0.7
United Kingdom	1.4	1.3	1.4	2.4	2.3	2.4
Iceland	2.9	n/a	2.9	2.1	n/a	2.1
Norway	2.7	2.6	2.7	3.7	4.1	3.9
Switzerland	0.8	0.8	0.8	0.7	0.7	0.7
Europe-19	1.5	1.5	1.5	2.2	2.7	2.4

Source: Estimated by EIM Business & Policy Research; estimates based on Eurostat's SME Database. Also based on European Economy, Supplement A, June 2001 and OECD: Economic Outlook, No. 69, June 2001.

3.1.3. Comparing the results with other studies

A number of other studies on the performance of high-tech industries in the 1990s, although applying somewhat different high-tech industry definitions, by and large confirm the results obtained above. Thereby, the following remarkable patterns show up:

(i) *In general, high-tech industries perform better than low-tech industries with respect to various variables (output, employment, productivity, etc.).* This seems to be a long-term stable phenomenon, even though the actual composition of high-tech industries changes over time. A statistical exercise¹⁷ utilising an OECD database and covering the manufacturing sectors of the OECD member countries found that high- and medium-tech industries performed distinctly better than low-tech industries in terms of employment and productivity growth over the period 1970 to 1991. A repetition of this approach covering 14 European countries, the USA, and Japan and referring to the period from 1990 to 1997 revealed similar results, although the composition of high-tech industries had slightly changed¹⁸.

17 Blechinger, D., A. Kleinknecht, G. Licht, and F. Pfeiffer: The impact of innovation on employment in Europe. Zentrum für europäische Wirtschaftsforschung (ZEW), publication No. 46 of the European Innovation Monitoring System (EIMS), Luxembourg, 1997.

18 Sheikh, S. and T. Oberholzner, Innovative SMEs and employment creation, report submitted to the European Commission, DG Enterprise, 2001.

(ii) *However, the development of employment in high-tech manufacturing is, although more favourable than for low-tech manufacturing, relatively modest.* This is shown by a pan-European study¹⁹, pointing to the fact that for the aggregate high technology manufacturing sector no clear-cut trend of an increase in employment could be observed. Also, a national Austrian study²⁰ found that high and medium high technology industries by far outperform low and medium low technology sectors in terms of employment change, however, the average increase of approximately 5 % over a 10 years period is seen to be rather modest.

(iii) *The main (job) growth engines (in the 1990s) are high-tech service sectors, in particular computer-related services, technical services and telecommunications.* This is confirmed by both the pan-European and the Austrian study quoted above, as well as by a number of additional national analyses. In Denmark²¹ the medical and the ICT sectors are high performance industries with growth rates that are significantly higher than the rest of the economy. In Finland, the software industry, which is comprised mainly of very small enterprises, has grown significantly in the 1990s in terms of turnover and employment²². Average growth rate per year in 1991-1997 for the Irish indigenous software industry was 16 % in employment, 23.3 % in turnover, and 11.6 % in number of enterprises²³.

(iv) *High-tech industries, especially those in manufacturing, experience significant increases in labour productivity, suggesting that their contribution to output growth is higher than their direct contribution to job growth.* This phenomenon is clearly demonstrated in Section 3.1.2. In this context it is important to note that, in the long term, productivity growth is essential to secure future jobs in a competitive world economy. However, comparative investigations reveal that productivity growth in high-tech sectors was clearly faster in the USA than in Europe²⁴.

3.2. The performance of high-tech SMEs

Overall, the analysis at industry level showed a relatively favourable development of high-tech sectors with respect to different performance indicators. However, what is true for an industry in general must not necessarily hold for each individual firm in that industry. On the one hand, if output or employment growth in a high-tech sector occurs mainly via start-ups, the performance of each individual enterprise might be below the industry rate. On the other hand, if there is a large share of non-high-tech companies with only very modest or negative growth rates in the respective sector, the performance of 'true' high-tech firms might be well above sector average. This section discusses how high-tech SMEs perform in terms of employment and/or turnover growth, R&D investments and internationalisation at the firm level. A particular emphasis is given to the analysis of success factors of high-tech SMEs.²⁵

3.2.1. Growth of employment and turnover

High-tech SMEs are assumed to grow more rapidly than SMEs in general. Research results from both European and national studies provide some support for the idea that high-tech SMEs indeed perform better than other enterprises. A study of 351 high-tech SMEs from 10 European countries revealed an average turnover growth of almost 26 % between 1998 and 1999 (see Table 3.6)²⁶. To enable a comparison, one might presume that average turnover growth of SMEs amounts to approximately 4 % to 5 % annually²⁷. Thus, the growth rate for these high-tech SMEs seems to be five times faster. A survey of 364 European venture capital backed companies re-

19 Tether, B.S., Small firms, innovation and employment creation in Britain and Europe: A question of expectations, *Tecnovation* 20, 2000, p.p. 109-113.

20 Lettmayr, C., T. Oberholzner, T. Parger and S. Sheikh, Auswirkungen von innovativen Unternehmen auf die Beschäftigungssituation (The impact of innovative enterprises on employment), Research report, Austrian Institute for Small Business Research, Vienna, 1997.

21 Erhvervsfremme Styrelsen (Business Promotion Agency): Medico/sundhed-en erhvervsanalyse (The Health Care Cluster - a business analysis), Erhvervsfremme Styrelsen; 10, 2001; Erhvervsministeriet, Erhvervsredegørelse Jylland Fyn (The Ministry of Trade and Industry, Business Statement Jylland Fyn), 2001; Erhvervsfremmestyrelsen, IT/Kommunikation- en erhvervsanalyse (Business Promotion Agency, ICT-business analysis), Erhvervsfremme styrelsen, 2001.

22 Teknologiakatsaus (Technology review), Suomen ohjelmistoteollisuuden kasvun strategia ja haasteet (Growth strategy and challenges of Finnish software industry), 67/99. Nukari, J., M. Forsell, TEKES, Helsinki, 1999.

23 O'Malley, E., C. O'Gorman, Competitive Advantage in the Irish Indigenous Software Industry and the Role of Inward Foreign Direct Investment, *European Planning Studies*, Vol. 9, No. 3, 2001.

24 Sheikh, S. and T. Oberholzner, Innovative SMEs and employment creation, report submitted to the European Commission, DG Enterprise, 2001; European Commission, *European Competitiveness Report 2001*, Luxembourg, 2001, p. 66ff.

25 The analysis in this section is mainly based on ad-hoc studies provided by the ENSR partners representing 19 European countries. In this section the definition of high-tech SMEs does not necessarily derive directly from its main economic activity (or industry), however, the definitions in the studies as well as other research parameters were rarely identical, so it is difficult to compare national results across countries. However, the studies may provide an overall picture of the performance of high-tech SMEs in Europe.

26 Achieving the Dream, The 1999 European Benchmarking Study for Technology Enterprises (up to 250 employees). PricewaterhouseCoopers. <http://www.pwcglobal.com/uk/eng/ins-sol/survey-rep/dream.html>, situation on 11.7.2001.

27 In the period 1988-2001, average annual change of real turnover growth in the non-primary SME sector in Europe-19 was 2.3 % (see European Commission, *Observatory of European SMEs; SMEs in Europe, including a first glance at EU Candidate Countries*; Report submitted to the Enterprise Directorate General by KPMG Special Services, EIM Business & Policy Research, and ENSR; Brussels, 2002). When taking into account inflation (of some 2 %) one arrives at a nominal growth rate of approximately 4 % or 5 %.

vealed an average turnover increase by 120 % within the first four years following the investment for early stage firms and by 33 % in the same period for businesses in the expansion phase²⁸.

Table 3.6: Performance characteristics of high-tech SMEs from 10 European countries in 1998-1999

Performance characteristic	Value
Realised growth in turnover (%)	25.9 %
Share of respondents expecting turnover growth > 10 %	76 %
Share of respondents expecting turnover growth > 50 %	19 %
Time to bring a product to market	1.9 years

Note: The study covers Denmark, Finland, France, Germany, Ireland, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom.

Source: PricewaterhouseCoopers 1999.

Similar findings can be obtained from national studies in a number of European countries:

- An Italian study²⁹ surveying 3 000 enterprises of the manufacturing sector employing 6 to 249 people shows that two thirds of firms, regarded as innovative, have increased the number of jobs between 1998 and 1999, whereas this holds true for only 51 % in the total sample.
- In Germany, turnover of technology enterprises grew by 36 % and employment by 17 % from 1996 to 1997³⁰.
- In the Netherlands, the growth of employment in technology-based start-ups is higher than for start-ups in general. Employment growth for all enterprises set up in 1994 was 53 % during the period of 1994-1998, whereas employment growth in R&D intensive enterprises was 151 %. In addition to growth in employment, new technology-based enterprises were able to realise a higher than average growth of turnover during the period 1994-1998³¹.
- Another analysis³² from the Netherlands, based on data from the Community Innovation Survey, reveals that R&D and innovation have a stronger positive impact on turnover compared to employment. Moreover, the effects are more favourable in services than in manufacturing.
- Also, an Austrian research report³³ finds that the innovation performance of an enterprise correlates closer (in a positive way) with turnover growth than with job growth. In addition, this study shows that the spectre between success and failure increases with high innovation activity, which is concluded from consistently higher standard deviations of output and employment change if compared to traditional non-innovative firms.
- This result is in line with an analysis in the United Kingdom³⁴ suggesting that growth amongst innovative and technology based new and small firms tends to be concentrated in only a few firms.
- A Finnish study on very rapid growth firms, the so-called 'gazelles', found that only 5 gazelles out of a total of 412 contributed 35 % of the employment growth and 44 % of the sales growth generated by the total gazelles population³⁵ in the period from 1994 to 1997. A number of other studies from Austria³⁶, Finland and Germany³⁷ point into the same direction.

The studies at firm level can be summarised as follows:

- (i) On average, high-tech SMEs perform better than 'ordinary' enterprises as far as output and job growth is concerned.
- (ii) Their lead is, however, more pronounced with respect to output compared to employment.

28 EVCA, The Survey of the Economic and Social Impact of Venture Capital in Europe, 2002.

29 Unioncamere and Istituto G. Tagliacarne, Le piccole e medie imprese nell'economia italiana. Rapporto 2000 (Small and medium enterprises in the Italian economy. Report 2000), Rome, 2000.

30 Lessat, V. et al.; Beteiligungskapital und technologieorientierte Unternehmensgründungen: Markt - Finanzierung - Rahmenbedingungen; Wiesbaden; (Venture - Private Equity- Capital and Technology-based Start-ups: Market - Finance - Business Environment), 1999.

31 Uxem, F.W. van, and H.E. Hulshoff, Technostarters (Technology start-ups), EIM, 2000.

32 Klomp, L. and G. Leeuwen, Linking innovation and firm performance: A new approach. Paper for the conference on 'Innovation and enterprise creation: Statistics and Indicators', Sophia Antipolis, 23-24 November 2000.

33 Lettmayr, C., T. Oberholzner, T. Parger and S. Sheikh, Auswirkungen von innovativen Unternehmen auf die Beschäftigungssituation (The impact of innovative enterprises on employment), Research report, Austrian Institute for Small Business Research, Vienna, 1997.

34 Tether, B.S. and S. Massini, Employment creation in small technological and design innovators in the United Kingdom during the 1980s, Small Business Economics, Vol. 11, 1998, pp. 353-370.

35 Ministry of Trade and Industry, SME Forum: Rapid Growth and Competitiveness through Technology, Final Report, Follow-up of Concerted Actions 2&3, Support Services to SMEs, Helsinki, 2000, p. 36.

36 Almus, M. et al., Berichterstattung zum Unternehmensgründungsgeschehen in Österreich bis 1998 (Start-up Activity in Austria until 1998), study by Zentrum für Europäische Wirtschaftsforschung GmbH and Austrian Research Center Seibersdorf, Vienna, 1999.

37 Lessat, V. et al.; Beteiligungskapital und technologieorientierte Unternehmensgründungen: Markt - Finanzierung - Rahmenbedingungen; Wiesbaden; (Venture - Private Equity- Capital and Technology-based Start-ups: Market - Finance - Business Environment), 1999.

- (iii) The variation in performance amongst high-tech SMEs is considerable and higher than for non-high-tech firms. This reflects the risks involved in innovation activities. Only a very small fraction of high-tech SMEs experience rapid growth.
- (iv) High-tech service companies outperform high-tech manufacturing ones.

It should be noted that the data used here to assess the economic impact of high-tech enterprises (at both firm and sector level) do not take into account any **external effects**, i.e. effects on other businesses or industries. Such outside effects may be positive, e.g. multiplier effects, or negative, for example when innovative firms displace traditional ones. There is wide consensus that innovation induces significant positive external effects (see also Chapter 5). However, comparing performance indicators at high-tech firm level with those at high-tech industry level, with the latter being more modest, might also point to the prevalence of displacement effects of introducing new technologies and innovation. Yet, it is extremely difficult to capture and quantify these phenomena in empirical analysis.

3.2.2. Expenditures on R&D and innovation

The larger an enterprise the more likely it is to be engaged in R&D or innovation activities. This is a well-known fact, although it needs to be interpreted carefully since, especially in the smallest enterprises, the measurement of R&D is hampered by the difficulty to distinguish between R&D and regular production activities. Still, amongst others, a Luxembourg study shows that the larger the size of the enterprise the more often innovation activities are carried out³⁸. Similarly, the results of an Italian study show that 46 % of small industrial enterprises (<49 employees) engage in technological innovation whereas the corresponding figure for larger enterprises is 69 % (250-499 employees) and 82 % (>500 employees)³⁹. A Spanish study⁴⁰ found that 72 % of small innovative enterprises are engaged in regular R&D activities while 88 % of larger enterprises (>500 employees) are active in regular R&D.

However, there is evidence that small innovating enterprises invest relatively more in R&D (or innovation) than their larger counterparts if measured by expenditure in relation to turnover. In Spain, small IT enterprises have significantly higher levels of R&D than large enterprises⁴¹. Also an Austrian study⁴² suggests that small innovative firms spend relatively more on innovation (as a percentage of turnover) than larger innovative companies do. Thus, it may be rarer for small high-tech enterprises to engage in R&D, but when they do, their activity levels are particularly high. Both observations indicate that for innovation and R&D activities economies of scale (and scope) are prevalent. Often the costs of developing the first prototype or blueprints are enormous compared to the marginal costs of producing further copies of the new product. Under these conditions small enterprises are pushed towards co-operation in R&D and innovation in order to balance out size disadvantages (see also Section 4.3).

3.2.3. Internationalisation

For small high-tech enterprises international orientation is crucial for growth and long-term survival⁴³. It is often argued that technology-intensive small enterprises need to internationalise at a very early stage because of the limited size of the technological market niche which they have been set up to exploit. Domestic market sales are often insufficient to achieve the necessary returns on R&D investment.

Indeed, high-tech enterprises seem to show a higher degree of internationalisation than non-high-tech firms of the same size. A survey⁴⁴ of high-tech SMEs from 10 European countries reported an important degree of internationalisation, with 65 % of firms operating internationally and a share of exports in turnover of 19 % (Table 3.7).

38 STATEC, L'innovation dans le secteur des industries au Grand-Duché de Luxembourg - Bulletin du Statec No. 6, 1994 (Innovation in the industrial sector in the Grand-Duchy of Luxembourg). This is a sample of 372 industrial enterprises with more than 1 employee.

39 ISTAT, Note Rapide, The technological innovation in the industrial firms, 23 July 1999. A sample of 5,256 Italian industrial firms with more than 20 employees.

40 Buesa, M. and J. Molero, Tamaño Empresarial e Innovación Tecnológica en la Economía Española (Enterprise Size and Technological Innovation in the Spanish Economy), in: Información Comercial Española, No. 773, 1998, pp. 155-173.

41 Rodwell, J. and M. Shadur, What's Size Got to Do with It? Implications for Contemporary Management Practices in IT Enterprises, *International Small Business Journal*, 15:2, 1997, pp. 51-62.

42 Lettmayr, C., T. Oberholzner, T. Parger and S. Shekh, Auswirkungen von innovativen Unternehmen auf die Beschäftigungssituation (The impact of innovative enterprises on employment), Research report, Austrian Institute for Small Business Research, Vienna, 1997.

43 Karagozlu, N. and M. Lindell, Internationalization of Small and Medium-sized Technology-Based Firm: An Exploratory Study, *Journal of Small Business Management*, January 1998.

44 Achieving the Dream, The 1999 European Benchmarking Study for Technology Enterprises (up to 250 employees). PricewaterhouseCoopers. <http://www.pwcglobal.com/uk/eng/ins-sol/survey-rep/dream.html>, situation on 11.7.2001.

By comparison, for European SMEs in general the share of exporters is only 20 %⁴⁵ and the share of exports in total sales is 13 %⁴⁶.

Table 3.7: Internationalisation of high-tech SMEs from 10 European countries in 1998/1999

Performance characteristic	Value
Percentage of turnover from abroad	19 %
Enterprises operating internationally	65 %

Note: The study covers Denmark, Finland, France, Germany, Ireland, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom.

Source: PricewaterhouseCoopers 1999.

Also, a survey of 100 technology-based smaller enterprises in the United Kingdom⁴⁷ demonstrates that many of them engage in a range of international networks and internationalisation processes, including internationalisation of markets, research collaboration, labour recruitment, ownership and facilities location. However, and as is the case for SMEs in general, the size of high-tech enterprises and the level of internationalisation correlate positively. This is shown, for instance, by studies from Spain⁴⁸ and Switzerland⁴⁹.

Based on a Finnish follow-up study of 60 entrepreneur-led technology enterprises three explanatory factors for the success of internationalisation could be identified⁵⁰:

- 1 The younger the enterprise is when going international, the bigger growth through exports it can achieve.
- 2 The fastest growth in export turnover was found for enterprises whose core technology was easy to imitate. This rather surprising outcome is explained by the effect on the development of the overall market and the acceptance of the technology the enterprise provides.
- 3 The higher the technological intensity of the enterprise, the faster its export turnover grows.

Moreover, in a study on internationalisation of high-tech enterprises in Finland, France and Canada early professional experience in foreign trade of the owner-manager proved to have a significant influence on the success of international activities. Further, motivation, commitment and personal ambition to expand the business are key success factors for internationalisation⁵¹.

3.2.4. Success factors

In principle, success factors relevant to SMEs in general are to a large extent also relevant to high-tech firms. This refers, for instance, to entrepreneurial attitude, strategic approach or marketing activities. However, because of the specific characteristics of high-tech SMEs some factors may show higher significance and some particular factors may exist. In the following a number of studies dealing with these special features are summarised.

Often new technology-oriented enterprises start with one initial project or product, based on a particular invention. However, both an Austrian⁵² as well as a German⁵³ study suggest that it is advisable to diversify the product range at an early stage in order to minimise risk and ensure long-term success of the company. Too frequently, high-tech SMEs exclusively depend on the success or failure of a single project, as is reported for example in Italy⁵⁴.

45 European Commission, Observatory of European SMEs: Highlights from the 2001 Survey; Report submitted to the Enterprise Directorate General by KPMG Special Services, EIM Business & Policy Research, and ENSR; Brussels, 2002.

46 European Commission, Observatory of European SMEs: SMEs in Europe, including a first glance at EU Candidate Countries; Report submitted to the Enterprise Directorate General by KPMG Special Services, EIM Business & Policy Research, and ENSR; Brussels, 2002.

47 Moore, B., C. Lawson, D. Keeble, F. Wilkinson, H. Lawton-Smith, Internationalisation Processes, Networking and Local Embeddedness in Technology-Intensive Small Firms, Centre For Business Research, WP 53, 1997.

48 Buesa, M. and J. Molero, Tamaño Empresarial e Innovación Tecnológica en la Economía Española, (Enterprise Size and Technological Innovation in the Spanish Economy), in Información Comercial Española, No. 773, 1998, pp. 155-173.

49 SAP Schweizer Automatik Pool: Unternehmensbefragung (SAP Swiss Automatic Pool: Survey among Managers), Presseunterlagen 23.11.98, Zürich 1998. This is a survey among 300 executives in technology enterprises with up to 500 employees.

50 Autio, E., Nopeasti kasvavien teknologiayritysten menestysstrategiat (Success strategies of fast-growth technology enterprises), in: Strateginen yrittäjyys (Strategic Entrepreneurship), ed. by P. Lehtonen, Kauppakaari Oyj, Helsinki, 1999.

51 Avikainen, T. and W.H. Frost, Internationalisation of High-Tech Enterprises. Health Care, Biotechnology, Information Technology. - Finland, France, Canada, Ministry of Trade and Industry, Studies and reports, 1993.

52 Almus, M. et al., Berichterstattung zum Unternehmensgründungsgeschehen in Österreich bis 1998 (Start-up Activity in Austria up to 1998), study by Zentrum für Europäische Wirtschaftsforschung GmbH and Austrian Research Center Seibersdorf, Vienna, 1999.

53 Pleschak, F. and H. Werner, Technologieorientierte Unternehmensgründungen in den neuen Bundesländern (Technology-based Start-ups in the new German Länder), Heidelberg, 1998.

54 Chiesa, V. and A. Piccalunga, The Birth of High-Tech Firms, Impresa & Stato, N. 43.

From the viewpoint of customers the products of highly innovative SME are often rather complex and, because of their novelty, difficult to understand and handle. Two studies from Germany⁵⁵ and Australia⁵⁶ show that under these conditions customer-orientation and, in particular, customer service seems to be of great importance in order to increase the acceptance (and therefore the success) of the new product. Also, in a survey of early stage and expanding companies supported by venture capital 'gaining market acceptance' was mentioned as one of the key factors in value creation⁵⁷. At a more general level this is also confirmed by an analysis of young Swiss technology enterprises which were classified into customer-oriented niche providers, marketing professionals, systematic niche providers, pure technology specialists and ambitious & overloaded technology enterprises. The first group operating in relatively stable markets, knowing their customer needs, and thus developing products with unique advantages and high customer benefit were considered most successful. In contrast, pure technology specialists suffer from exaggerated technology focusing, lack of customer contact, inadequate marketing competence and careless market selection. In the case of ambitious and overloaded enterprises massive market forces and grossly inadequate marketing had been identified⁵⁸.

Furthermore, successful and profitable high-tech enterprises seem to be characterised by holding patents and copyrights⁵⁹. These instruments might reduce the vulnerability of firms with respect to competition and equip them with a more favourable market position.

55 Pleschak, F. and Werner, H., *Technologieorientierte Unternehmensgründungen in den neuen Bundesländern* (Technology-based start-ups in the new German Länder), Heidelberg, 1999.

56 Warren, L. and W.E. Hutchinson, Success factors for High-technology SMEs: A Case study from Australia, *Journal of Small Business Management*, July 2000.

57 EVCA, *The Survey of the Economic and Social Impact of Venture Capital in Europe*, 2002.

58 Frauenfelder, P. and A. Meier, Marketing junger Technologieunternehmen (Marketing of Young Technology Enterprises), in: *ioManagement*, Nr. 9, Zürich, 1998, pp. 18-23.

59 Lehtoranta, O., R&D, Patenting and Firms' Economic Performance: Study on the Panel Data of Finnish Manufacturing Firms, Statistics Finland, Helsinki, 1999; Lehtoranta, O., Impact of Public R&D Funding on the Profitability and Growth Performance of Firms: A Panel Data Study on Finnish Firms, Statistics Finland, Science, Technology and Research, 1999:4; Warren, L., and W.E. Hutchinson, Success factors for High-technology SMEs: A Case study from Australia, *Journal of Small Business Management*, July 2000.

Chapter 4

Crucial resources for high-tech SMEs

In order to fulfil their economic function of implementing innovations and new technologies in the economy and to be able to exploit the potential demand for their products and services in an effective and efficient manner, high-tech SMEs have to rely on the availability of various resources or input factors. In principle, of course, this holds true for any (private) business. However, high-tech SMEs deal with new production processes, with producing new goods and services and with novelty and change in general, which in turn translates into new and changed requirements and demands on the resources used. The supply side of inputs may not (immediately) be geared to these changing demands. Thus, respective mismatches may arise that are, therefore, specific to high-tech firms. Such a situation represents a challenge for the supply side of resources to adapt to the needs of high-tech businesses as well as for the concerned enterprises to acquire the most appropriate inputs.

This chapter focuses on three types of resources which have repeatedly been considered to represent bottlenecks for the development of high-tech SMEs: finance, skilled labour, and knowledge⁶⁰. The chapter discusses to what extent these resources constitute a constraining factor, what the relevant features of the constraint are and considers possible solutions to the problems.

4.1. Access to finance

4.1.1. Barriers specific to high-tech SMEs

Non-availability of sufficient finance restricts the possibilities of businesses to invest and expand and, therefore, exploit market opportunities. From a rather theoretical perspective, the following features characterise the specific and more difficult situation of high-tech or highly innovative SMEs with respect to obtaining finance via traditional channels⁶¹:

- There is uncertainty of expected returns: the financial system knows how to cope with risk but not with uncertainty attached to the innovation projects in high-tech SMEs.
- Not all benefits can be fully protected against copy and imitation: the possibilities of a high-tech SME to protect itself are limited and sharing benefits means reduced profitability.
- For financing institutions the firm's investment portfolio is difficult to divide into several projects that would each have their own source of finance. In particular, these institutions do not provide sufficiently differentiated financing options.
- The development periods and lead times for the projects are rather long.

60 See for example Ministry of Trade and Industry, SME Forum: Rapid Growth and Competitiveness through Technology, Final Report, Follow-up of Concerted Actions 2&3, Support Services to SMEs, Helsinki, 2000; and EOS Gallup Europe, Flash Eurobarometre 100, Innobarometer, Results and Comments, 2001.

61 Based on European Commission, The European Observatory for SMEs - Sixth Report, Submitted to the Enterprise Directorate General by KPMG Consulting, EIM Business & Policy Research, and ENSR, Luxembourg, 2000; Auer, J. The Venture Capital Industry in the USA, Europe, and Finland: Development, Environment and Incentives. SITRA, Helsinki, 1990; Virtanen, M., Entrepreneurial finance and venture capital advantage, Helsinki School of Economics and Business Administration, Helsinki, 15, 1996; Zacharakis, A.L. & Meyer, D. G., A Lack of Insight: Do Venture Capitalists Really Understand Their Own Decision Process? Journal of Business Venturing, Vol. 13:1, pp. 57-76, 1998; HM Treasury Financing of High Technology Businesses, A Report to the Paymaster General November 1998. <http://www.hm-treasury.gov.uk/pub/html/docs/fhtb.html>, situation on 11.7.2001; IMPI, 'Iniciativa PYME de Desarrollo Industrial 1994-1999' (Industrial Development SME Initiative, 1994-1999), pp. 3-25, Madrid, 1994; Bank of England, Domestic Finance Division, Financing Technology-based Small Firms, February 2001; Lessat, V. et al., Beteiligungskapital und technologieorientierte Unternehmensgründungen: Markt - Finanzierung - Rahmenbedingungen; Wiesbaden: (Venture -Private Equity- Capital and Technology-based Start-ups: Market - Finance - Business Environment), 1999.

- A high importance of intangible assets as compared to tangible assets: Intangible assets, such as ideas, research results, technologies possessed by the enterprise, technical skills or market access, are much more difficult to understand than valid collateral. Generally, the (legal) framework conditions for reporting, documenting and assessing intangible assets are far less developed.
- Investors have problems in assessing the investment and hence the perceived risk is high.

However, from an empirical perspective the picture concerning finance as a business constraint is somewhat ambiguous and more differentiated. First, the severity of the problem differs by country. For example, in Denmark financing innovations is reported as a major problem⁶². On the other hand, the availability of capital seems to be a problem only for a minority of indigenous Irish software enterprises⁶³. Also, in a study conducted in 1999⁶⁴ a minority (23 %) of Finnish technology enterprises saw access to finance as a severe problem as opposed to half of the enterprises in 1995. This was seen to reflect the positive development of the economic situation and its influence on the availability of finance. Generally, financial markets in Europe are fragmented and the importance of access to finance is ranked differently in the individual countries⁶⁵. Some European countries such as Denmark⁶⁶ and Austria⁶⁷ are characterised by a system emphasising bank loans that has its limitations when financing innovation.

Second, the significance of the barrier differs by type of high-tech SME (or innovation project). Obviously, the need for finance is one aspect. For example, biotechnology enterprises are running costly and long-term R&D projects, whereas the start-up investment may be relatively small for certain types of knowledge-based enterprises. In a Portuguese⁶⁸ study it is shown that the amount of funding needed in an independent knowledge-based business is actually low. Interestingly, a Finnish study indicated that enterprises holding patents or patent applications found it significantly more difficult to access finance than other enterprises in the sample⁶⁹. A Swedish study suggests that enterprises aiming at new markets with a new technology have more difficulties in attracting financiers than other types of high-tech enterprises, not only in their early stage of development, but also later on⁷⁰. In a UK study the shortage of finance was found to be a constraint, notably on the growth of the most technologically sophisticated businesses⁷¹. From these results one may conclude that: (i) the more complex and/or risky the project is the more difficult it is to acquire finance, and (ii) tapping new markets (i.e. new customers) is considered to be especially risky and investors are even more reluctant to provide money for such kinds of undertakings.

Third, the relevance of financing as a constraint also differs by business life-cycle, which again partly reflects the need of funds. Not only for innovative companies the start-up phase, and especially commercialisation, is the most difficult phase for raising adequate financing. In a German study, two thirds of the high-tech SMEs considered the start-up phase to be the most difficult in terms of financing whereas only 42 % considered financing growth to be major problem⁷². The Dutch Ministry of Economic Affairs highlights access to finance as one of the most important bottlenecks for technology start-up enterprises. This is because the product development phase takes a long time and a lot of money and financiers withdraw from the investments due to the high risks and uncertainties involved in the start-up enterprises⁷³. In Switzerland, the phase from start-up to breakeven is seen to be especially difficult with respect to financing possibilities⁷⁴.

62 Several sources; e.g. Erhvervsfremme Styrelsen, Formidling mellem private Investorer (Business Angels) og kapital søgende innovative virksomheder (Intermediation between private investors (Business Angels) and innovative businesses seeking capital), 2000.

63 O'Gorman, C., E. O'Malley, E. and J. Mooney, Clusters in Ireland - The Irish Indigenous Software Industry: An Application of Porter's Cluster Analysis, National Economic and Social Council, Research Series Paper No. 3, Dublin, 1997; and O'Malley, E. and C. O'Gorman, Competitive Advantage in the Irish Indigenous Software Industry and the Role of Inward Foreign Direct Investment, European Planning Studies, Vol.9, No. 3, 2001.

64 Haarala, S. Teknologikeskuksissa toimivien pk-yritysten alku rahoitus - yritysten asenteet (Initial Funding of Small and Medium-Sized Enterprises Operating at Technology Centres - Attitudes of Businesses), Ministry of Trade and Industry, Studies and reports 26/1999, December 1999.

65 European Commission, The European Observatory for SMEs - Sixth Report, submitted to the Enterprise Directorate General by KPMG Consulting, EIM Business & Policy Research, and ENSR, Luxembourg, 2000, p. 151.

66 Erhvervsfremme Styrelsen, Formidling mellem private Investorer (Business Angels) og kapital søgende innovative virksomheder (Intermediation Between Private Investors (Business Angels) and Innovative Businesses Seeking Capital), 2000.

67 Sturn, D., et al., Start auf dem Campus: Infrastruktur für Gründungen aus Hochschulen und Forschungseinrichtungen (Start on the Campus: Infrastructure for Start-ups from Universities and Research Organisations), study by Joanneum Research, Vienna, 1999.

68 Laranja Duarte Mendes Monteiro, M., Small firm Entrepreneurial Innovation in Portugal: The Case of Electronic and Information Technologies, Doctoral thesis, University of Sussex, 1995.

69 Haarala, S. Teknologikeskuksissa toimivien pk-yritysten alku rahoitus - yritysten asenteet. (Initial Funding of Small and Medium-Sized Enterprises Operating at Technology Centres - Attitudes of Businesses). Ministry of Trade and Industry, Studies and reports 26/1999, December 1999. This is a survey of 123 high-tech enterprises residing in a technology park.

70 Lindström, G., C. Olofsson, Teknikbaserade företag I tidig utvecklingsfas. (Technology-Based Enterprises in an Early Development Phase), 1998.

71 Storey, D., P. Westhead, Financing Technology Based Firms in the United Kingdom, June 1995.

72 Lessat, V. et al.: Beteiligungskapital und technologieorientierte Unternehmensgründungen: Markt - Finanzierung - Rahmenbedingungen: Wiesbaden: (Venture - Private Equity- Capital and Technology-based Start-ups: Market - Finance - Business Environment), 1999. (n = 118 young technology-based enterprises).

73 Ministerie van Economische Zaken, Technology Radar: Main Report and Executive Summary, 1998.

74 Volkart, R., P. Lautenschlager, Finanzierung von High-Tech-Unternehmen (Financing High-Tech Enterprises), in: Scheidegger, A./Hofer, H./Scheuenstuhl, G. (Hrsg.): Innovation - Venture Capital - Arbeitsplätze: Antworten zu den Kernfragen, p. 145-158, Bern/Stuttgart/Wien, 1998.

4.1.2. Sources of finance for high-tech SMEs

Debt financing

Banks continue to play an important role even in the financing of high-tech SMEs. However, credit-based financing generally does not appear adequate in the case of high-tech and innovative SMEs, which is rooted in the special features of innovative projects as outlined above. First, the bank system is not geared to coping with high risk. High risk would in principle require higher interest rates, but such a flexible system is hardly foreseen in bank business policies and an acceptance by the market would be difficult. Second, the bank staff are not in a position to assess seriously the innovative investment project and its risk. Third, the investment often results in knowledge, blueprints, skills, or other intangibles, which are less appropriate to function as collateral (compared to material investments or assets). Empirical research points in the same direction: In a study⁷⁵ of Italian high-tech enterprises banks are criticised for their limited understanding of these businesses, for too costly loans and the inability to evaluate growth opportunities of high-tech SMEs correctly. Hence, for improving the access to finance for high-tech SMEs focus should be put on other sources than the credit-based system.

Venture capital and business angels

Due to the specific characteristics related to financing high-tech SMEs, equity finance - and venture capital and business angels in particular - appears to be more appropriate than credit finance for these kinds of enterprises. In this case the provider of capital fully participates in opportunities and risks, the question of collaterals is not relevant and investors consider the concrete projects in more depth, allowing them a better assessment.

The following Table 4.1 provides an overview of the European private equity and venture capital⁷⁶ market in 2000 and 2001. In 2001, overall investments went down by more than 30 %. This decrease is the result of both a declining number of companies receiving finance and shrinking average investment size, the latter also reflecting a normalisation in company valuations. However, in this context it has to be taken into account that investments had been exceptionally high in 2000. Commitments to high-tech firms decreased even more (-38 %) which is seen to be in line with the general problems in the ICT industry. Within high-tech, biotechnology investments developed comparably favourable between 2000 and 2001. Overall this could be signalling a break in the observed trend of an increasing orientation of investments towards high technology⁷⁷. In their strategies, some investment houses now have explicitly excluded new economy firms from funding. Still, the high-tech sectors hold a share of almost 30 % of the European private equity market. With a share of 54 % Ireland seems to have a particular emphasis on high-tech industries⁷⁸.

Table 4.1: The European private equity and venture capital market, 2000-2001

	2000	2001	Change 2000/01 (%)
Total investment (billion Euro)	35.0	24.3	-30.5
Number of companies	10 440	8 104	-22.4
Average deal size (million Euro)	2.7	2.3	-14.8
Investment in high-tech* (billion Euro)	11.0	6.9	-37.5
Proportion computer related (billion Euro)	4.7	3.0	-35.8
Proportion biotechnology (billion Euro)	1.0	0.8	-17.1

* i.e. telecommunications hardware, internet technology, computer hardware, software and computer services, electronics, semiconductors, biotechnology, medical instruments and devices.

Source: EVCA.

Although the US venture capital market experienced an even stronger decline between 2000 and 2001, it is still larger than the European market when measured in terms of money invested (37.7 billion USD in 2001). However, Europe clearly leads with respect to the number of companies receiving financing as this number amounted to only 3 224 in the USA in 2001⁷⁹. Thus, the average investment in the USA is much larger than in Europe.

75 Giudici, G., S. Paleari, The Provision of Finance to Innovation: A Survey Conducted Among Italian Technology-Based Small Firms', *Small Business Economics*, Vol. 14, No. 1, 2000.

76 Venture capital is defined as those private equity investments targeted at the early stage and expansion phase.

77 See for example Hertz-Eichenrode, A., *Die Entwicklung des Beteiligungsmarktes in Deutschland* (The Development of the Venture Capital Market in Germany), in: Bundesverband Deutscher Kapitalbeteiligungsgesellschaften: Jahrbuch 2000, Berlin.

78 O'Gorman, C. and D. Jones-Evans, *Review of Entrepreneurship in Ireland*, Report to Forfas, July 2000, quoting figures of EVCA Annual Report 1999, 2000.

79 National Venture Capital Association, *Venture Capital Investments Made From 1990-2001*, www.nvca.com, situation on 28.06.2002.

Moreover, the proportion of high-tech investments in overall investments is much higher in the USA. Also within Europe, considerable differences exist with respect to the importance of private equity investment. If measured in terms of investment as a percentage of GDP in 2001, Sweden (0.87 %), the United Kingdom (0.65 %), and the Netherlands (0.44 %) are clearly above the European average (0.25 %), whereas Austria (0.07 %), Greece (0.08 %) and Portugal (0.09 %) represent the tail enders.

Some studies point to the fact that investors are rather reluctant to provide finance in the early stage of a high-tech company's life cycle. For example, in Spain⁸⁰ innovative and high-tech enterprises in the start-up phase are not attractive to the local venture capital market because of low profitability. The Dutch⁸¹ venture capitalists prefer investing in the growth phase rather than in the start-up phase of an enterprise. The Austrian venture capital market is dominated by the public sector especially during the start-up phase⁸². Indeed, 2001 data from the EVCA shows that the amount of venture capital made available for the expansion phase is approximately twice the amount provided for the seed and start-up stage.

Those enterprises being backed by venture capital seem to appreciate this form of financing highly, as shown by a survey on behalf of the EVCA among 364 European early stage and developing companies in receipt of venture capital⁸³. According to this study almost 95 % of respondents perceived venture capital as an essential element in their creation, survival or growth, and 60 % stated that without that funding they would not be in business today. Firms also value the non-financial support given, e.g. strategic advice, access to networks, innovative ideas, financial monitoring or budget reporting. These non-financial contributions are in many cases a pre-condition for growth and success. Currently, however, venture capital seems to be available only for a very small elite of companies. Furthermore, the amount of capital required by very small high-tech firms, especially start-ups, might often be too small for an investment by a professional venture capital company.

Business angels (i.e. wealthy individuals with substantial business and entrepreneurial experience who invest their own funds in an enterprise) are a rather informal source of finance. In comparison to venture capital funds they are even more involved in entrepreneurial affairs and business management, which is reflected by the frequently used catch word 'smart money'. Accordingly, business angels, besides customers and suppliers, are ranked as the key figures by small high-tech enterprises in a Swedish study⁸⁴. Sound information and research results regarding the quantitative importance of business angels in financing high-tech SMEs seems to be scarce. It is also difficult to measure business angel activity, partly because the individuals concerned are often reluctant to reveal it, but also because these individuals are hard to identify⁸⁵. However, a Finnish survey indicates that informal investors provide up to five times as much capital to start-up enterprises as the venture capital industry⁸⁶.

Although the theoretical potential of business angels and business angel financing is estimated to be rather high in general, there are several factors limiting the realisation of this potential. First, especially in the case of high-tech firms a certain shortage of investors might exist, because exactly in those young and emerging industries, such as biotechnology, individuals with good industry experience and sufficient money available will be rare.

Second, concerning the demand side, many entrepreneurs might be reluctant to take in business angels as they fear to lose independence. For example, a study shows that amongst Italian SMEs external equity is widely associated with a loss of power and control over the business. This attitude results in the following preferences with respect to financing amongst high-tech SMEs: First comes self-financing, followed by short-term or long-term debt and only in the end, if necessary, external equity financing⁸⁷. A Finnish study points in the same direction when stating that high-tech enterprises prefer public to private venture capital, because enterprises would expect less interference from public equity financiers than from private financiers⁸⁸. Also, a study on 50 European new technology-based firms states that venture capital is widely perceived as a necessary evil and companies sought to avoid the consequent dilution of equity and loss of managerial control for as long as possible. Interestingly, those firms which maintained their financial independence actually were the most successful⁸⁹.

80 Martí Pellón, J., Financiación de la Innovación con Capital Riesgo (Venture Capital Financing of Innovation), in: Papeles de Economía Española, No. 81, 1999, p. 196-210.

81 Hulsink, W., B. van der Meer and E. Meeusen-Henniger, High Tech Entrepreneurship in the Low Countries?, Erasmus Universiteit Rotterdam, 1999.

82 Jud, T. and A. Kremshofer, Der Österreichische Beteiligungsmarkt (The Austrian Venture Capital Market), study by Joanneum Research, Vienna, 2000.

83 EVCA, The Survey of the Economic and Social Impact of Venture Capital in Europe, 2002.

84 Lindström, G., C. Olofsson, Teknikbaserade företag i tidig utvecklingsfas (Technology-Based Enterprises in an Early Development Phase), 1998.

85 European Commission, Directorate General III, Benchmarking Financing of Innovation Pilot Study, Final report, 1998.

86 Arenius, P. and E. Autio, Global Entrepreneurship Monitor. Finnish Executive Report, Helsinki University of Technology, Research Reports, Center for Technology Management 1-2000.

87 Chiesa, V. and A. Piccalunga, The Birth of High-Tech Firms, Impresa & Stato, N. 43, 1999.

88 Haaraala, S., Teknologiakeskuksissa toimivien pk-yritysten alku-rahoitus - yritysten asenteet (Initial funding of small and medium-sized enterprises operating at technology centres - attitudes of businesses), Ministry of Trade and Industry, Studies and reports 26/1999, December 1999.

89 European Commission, Building an Innovative Economy in Europe. A review of 12 studies of innovation policy and practice in today's Europe, Luxembourg, 2001, p. 39.

Finally, because business angel support is by no means a standardised service (in comparison to a bank credit, for example), it is more difficult for a formalised and well-functioning business angels market to evolve. Consequently a matching problem exists where it seems to be relatively more difficult to match businesses with business angels in smaller economies than it is in larger ones. In Austria, for instance, the business angel potential is still largely untapped⁹⁰. In this context, facilitating the matching of supply and demand should be seen as an important area for public policy action.

The following case study from Sweden illustrates some of the main points discussed above, such as the importance and contents of the non-financial support provided by venture capitalists - and that this can be a decisive aspect from the perspective of the receiving company; the problem of (in)sufficient business experience and knowledge on the side of the investor where highly innovative industries are concerned; and the difficulties and efforts related to the matching and selection procedure.

Box 4.1: Idonex Ltd, <http://www.idonex.se/>, situation on 11.7.2001.

Idonex started as a spin-off from the University of Linköping in 1993. It develops and sells Internet technology, the main product being a web server programme (Roxen).

In 1998, Idonex decided to introduce the programme Roxen to the global market, for which it required external capital, so it started searching for the most suitable venture capitalist. Besides capital Idonex set the following requirements for its venture capitalist: an operational network and strategic counselling in the internationalisation process, relevant and specific knowledge of IT and Internet technology/software, provision of help in recruiting key employees, an intermediary in customer contacts and strategic networks. It also needed to handle the introduction of Idonex to the Stock Exchange. The highest priority in their decision process was promptness and flexibility of the venture capital investors.

The process of tracking venture capital took a lot of time and resources, because the enterprise did not have sufficient knowledge of existing venture capital investors and the investors were not able to make an immediate due diligence test as they did not understand the business idea.

Then the enterprise won the competition 'Guldmusen' in the category of best software and a similar prize at the Comdex trade fair in the autumn of 1998. At this time the enterprise was almost in bankruptcy. Partly due to attention the enterprise received in the media it finally succeeded in raising capital. The selected venture capital investor did not offer the best business in terms of capital per share, but it had the required competencies.

Idonex suggests that intermediaries, such as business consultants with experience in venture capital projects, should function as filter or information agents between enterprises and venture capital investors. Idonex operates in the turbulent global IT market, and, therefore, the venture capital investor needed a well-structured process of evaluation and solid knowledge of the industry to make rapid and professional investment decisions.

Source: Swedish venture capital investments in early-stage IT ventures. A seminar essay, The Swedish School of Economics and Business Administration in Stockholm, Hellers O, Molvin A, Molvin R.

The role of stock markets in financing high-tech SMEs

In recent years so-called NM-lists (New Market, Neuer Markt, Nouveau Marché, Nuovo Mercato, Nuevo Mercado) have been established in many of the national stock exchanges especially to attract high-tech enterprises and interested investors. The European markets opened in the second half of the 1990s whereas the oldest of these markets, the US NASDAQ Stock Market, started trading in 1971, and in 1994 it surpassed the New York Stock Exchange in annual share volume. The NM-lists have indeed attracted some enterprises, but so far the take-up rate has been relatively low⁹¹. So, raising capital from stock markets is by no means a widespread option for the majority of high-tech SMEs. This is also confirmed by various national surveys. For example, according to a survey of 300 technology enterprise executives in Switzerland⁹² only 4 % of high-tech SMEs are listed, and only 8 % have any plans for going public through an initial public offering (IPO). The figure for electronics is some-

⁹⁰ Springer, W., Factbook Beteiligungskapital in Österreich (Equity Capital Fact Book, Austria), Vienna, 2000.

⁹¹ Examples of the number of enterprises listed in the NM lists: By October 2001, fifteen Swiss enterprises were listed at the SWX Swiss Exchange New Market (www.swx.ch, situation on 30.10.2001), by July 2001, 342 enterprises were listed in the German Neuer Markt, 165 enterprises in the Nouveau Marché, 61 enterprises in the Nasdaq Europe and 44 enterprises at the Nuevo Mercato (<http://news.neuermarkt.com>, situation on 30.10.2001).

⁹² Zürcher Hochschule, Winterthur & Zürcher Kantonalbank & SAP Schweizer Automatik Pool, Skeptische Zuversicht, gemächlicher Aufbruch, KMU-Befragung 2000 (Reserved confidence, gradual start, Survey 2000 among SMEs), Zürich, 2000.

what higher (12 %). This is in line with the comparably low number of only 47 IPOs used as an exit route (divestment) by European venture capitalists in 2001⁹³. Moreover, there was a pronounced decrease in the number of IPOs between 2000 and 2001.

After the boom of 2000 in the stock markets, major losses have taken place in 2001 and the first half of 2002, and the performance of the technology stocks turned out to be particularly bad. The profits and sales forecasts calculated into the prices cannot be achieved under the present market conditions by a long way. After a period of exaggerated valuations of high-tech or new economy companies, when it was perhaps too easy for them to attract funds and investors, the trend might now change right round making it more difficult for high-tech enterprises to succeed in raising finance in the future (and especially for those associated with the new economy or ICT).

Furthermore, especially trading in the securities of young, innovative growth companies requires a high standard of transparency to attract potential investors. Rules and regulations stating conditions for admission, trading and creating terms of disclosure are a necessary pre-condition for the functioning and credibility of the equity market⁹⁴. The current trend is to tighten up these rules.

Interestingly, a US study shows that venture capitalists add value to the going public process by improving the survival profile of initial public offering (IPO) issuers. Venture capitalists influence the actions of managers, investment bankers, and analysts, and attract institutional interest⁹⁵. This suggests that it is advisable to take in venture capital even if the enterprise intends to be listed.

Self-financing

Although external financing is without doubt indispensable for high-tech SMEs, the funds of the founder or cash-flow financing of the enterprise are, of course, an important source of finance as well. This especially applies in southern European countries, where this often constitutes the sole or major method of financing. For instance, out of 46 respondents, 73 % of Italian high-tech start-ups had been financed exclusively by the entrepreneurs' personal wealth and only one enterprise had made use of external sources. The majority (76 %) of respondents considered it dangerous to issue debt in the start-up phase, because this may interfere with the future growth of the enterprise⁹⁶. The majority of Spanish innovating activities are self-financed, although 63 % of SMEs believe that enterprises in their sector of activity do not have sufficient funds to generate technological innovation by themselves⁹⁷. In the early stages, small independent founder-owned enterprises in Portugal in the field of electronics and information technology are financed essentially by the entrepreneurs or the enterprise's own funds⁹⁸. Similarly, founders represent the most important source of finance for 56 % of the French start-ups⁹⁹.

Clearly, the funding generated by the founder or the enterprise is of considerable quantitative importance. It is also functioning as a good signal to external financiers, especially in the start-up phase. However, it should not and cannot be the sole source of finance. The funds of business founders are most often rather limited and so is the cash flow during the early stage.

4.2. Access to skilled labour

4.2.1. Barriers specific to high-tech SMEs

By definition, high-tech or highly innovative enterprises are dealing with new or changed products and production processes. This means new work tasks and operative actions to be performed in the firm and, consequently, new and non-established knowledge and skills are required. This may not only refer to the technical level but also to soft skills, e.g. teamwork etc. The education and training system as well as the people (prospective employees)

93 www.evca.com, situation on 28.06.2002.

94 Neuer Markt Report, Gateway to European capital markets - key to growth, published by Deutsche Börse AG with contributions by Dresdner Kleinwort Wasserstein, Shearman & Sterling and Roland Berger Strategy Consultants (<http://tools.neuermarkt.com>, situation on 28.11.2001).

95 Jain, B.A. and K. Omesh, Does the presence of venture capitalists improve the survival profile of IPO firms?, *Journal of Business Finance & Accounting*, Oxford, Nov/Dec 2000, p. 465-492.

96 Giudici, G. and S. Paleari, The Provision of Finance to Innovation: A Survey Conducted Among Italian Technology-Based Small Firms, *Small Business Economics*, Vol. 14, No. 1, 2000.

97 Camarero, M. and P. Lázaro, La opinión de cien PYMES españolas preocupadas por la Innovación (The Opinion of One Hundred Spanish SMEs Concerned with Innovation), Estudio nº 5, Fundación COTEC, Madrid, 1995.

98 Laranja Duarte Mendes Monteiro, M., Small Firm Entrepreneurial Innovation in Portugal: The Case of Electronic and Information Technologies, Doctoral thesis, University of Sussex, 1995.

99 Start-up en France, du mythe aux réalités (Start-up in France, From Myth to Reality), Agence pour la Création d'Entreprise -APCE (Agency for Enterprise Creation), 2000. This is a survey of 84 enterprises, half of which represented high-tech SMEs.

to be trained cannot meet these requirements immediately, because they are not able to foresee in time the new demand with respect to substance and quantitative extent. Moreover, the often rather sophisticated skill requirements call for relatively long training periods. This results in a lack of appropriate skills and knowledge in the labour market. Thus, exactly high-tech and highly innovative firms will systematically face a certain shortage of highly skilled and knowledgeable labour. Of course, the severity of the problem then depends on the specific technology in question and the quantity of demand.

In cases where external availability of required expertise is lacking the importance of internal skill and knowledge creation increases. As is generally known, however, small enterprises have comparably more difficulties than larger firms in conducting internal training. What results is a particular disadvantage in very small high-tech enterprises rather than larger ones as far as the availability of skilled labour is concerned.

Due to methodological problems it is difficult to quantify exactly the skill shortages empirically. Moreover, the scale of the gap changes rapidly over time. However, there is a vast amount of empirical evidence that confirms the relevance of skill shortages in high-tech SMEs:

- In a survey of 351 European technology SMEs 80 % of respondents state that the problem of finding and retaining quality staff is a key concern¹⁰⁰.
- According to survey of 50 European new technology-based firms 70 % of those enterprises had experienced difficulty in recruiting specialists of sufficiently high quality¹⁰¹.
- In a survey of some 3000 enterprises across the EU, although not focussed solely on high-tech companies, almost two thirds of SMEs (20-249 employees) rated finding highly qualified staff for innovation activities an important or very important problem. Moreover, mobilising human resources was regarded as the most striking, unsatisfied need of all when conducting innovations, in the EU as a whole and in 12 out of 15 countries individually¹⁰².
- Concerning ICT skills, the European Competitiveness Report 2001 provides a comprehensive overview of various analyses on skill shortages, concluding that the gap may be even as high as 1.5 % of total employment in Western Europe.
- In Switzerland, 83 % of technology enterprises have problems finding suitable employees. Surprisingly, the situation in the manufacturing and service sectors seems to be even worse than in the IT sector¹⁰³.
- In the Netherlands, the most important problem for young, small, innovative IT enterprises is getting qualified staff¹⁰⁴.
- Several Danish studies show that access to skilled labour is increasingly becoming a bottleneck in the high-tech area and that the lack of skilled professionals is hampering enterprise growth¹⁰⁵.
- Every seventh German enterprise in the business-related service sector is seeing its innovation activities hindered by a shortage of skilled labour¹⁰⁶.

Overall, it is highly skilled technicians (university graduates of technical studies) who are mostly searched for by high-tech companies. They seem to be more in demand than other broad skill categories (e.g. graduates of natural sciences, social sciences, secondary education, vocational education, etc.)¹⁰⁷. Research from Sweden¹⁰⁸ shows that it is engineers in information technology and electronics for whom there is particular demand. Within ICT there seems to be a relatively high skills gap for e-business professionals¹⁰⁹. However, this of course depends on the activity of the business. In biotechnology, for example, natural scientists will obviously be of higher importance. With respect to ICT experts it should be noted that traditional sectors also show high demand, which aggravates the situation for the ICT sector itself.

100 Achieving the Dream, The 1999 European Benchmarking Study for Technology Enterprises (up to 250 employees). PricewaterhouseCoopers. <http://www.pwcglobal.com/uk/eng/ins-sol/survey-rep/dream.html>, situation on 11.7.2001.

101 European Commission, Building an Innovative Economy in Europe. A review of 12 studies of innovation policy and practice in today's Europe, Luxembourg, 2001, p. 39.

102 EOS Gallup Europe, Flash Eurobarometre 100, Innobarometer, Results and Comments, 2001.

103 Zürcher Hochschule, Winterthur & Zürcher Kantonalbank & SAP Schweizer Automatik Pool, Skeptische Zuversicht, gemächlicher Aufbruch, KMU-Befragung 2000 (Reserved Confidence, Gradual Start, Survey 2000 Among SMEs), Zürich, 2000.

104 Eck van der Sluijs, P.A. van, H.E. Hulshoff, Y.M. Prince, Jonge, kleine, innovatieve ICT-bedrijven in Nederland (Young, Small, Innovative IT Firms in the Netherlands), EIM, 1998.

105 Erhvervsministeriet, Erhvervsredogørelse Jylland Fyn (The Ministry of Trade and Industry, Business Statement Jylland Fyn), 2001; Erhvervsfremmestyrelsen, IT/Kommunikation - erhvervsanalyse (Business Promotion Agency, ICT-business analysis), Erhvervsfremme styrelsen, 2001; Erhvervsministeriet, Danmarks kreative potentiale (Ministry of Trade and Industry, The Creative Potential of Denmark), 2000.

106 Ebling, G., Dienstleistungen in der Zukunft. Innovationsaktivitäten im Dienstleistungssektor. Ergebnisse der Erhebung 1999 (The Service Sector in the Future. Innovation Activities in the Service Sector. Results of the 1999 survey), Mannheim, 2000.

107 Leo, H. and V. Steiner, Innovation and employment at firm level, in: Publication No. 50 of the European Innovation Monitoring System (EIMS), Luxembourg, 1995; Lettmayr, C., T. Oberholzner, T. Parger and S. Sheikh, Auswirkungen von innovativen Unternehmen auf die Beschäftigungssituation (The impact of innovative enterprises on employment), Research report, Austrian Institute for Small Business Research, Vienna, 1997.

108 The Swedish Labour Market Board, AMS, 2000.

109 European Commission, European Competitiveness Report 2001, Luxembourg, 2001.

The continually changing activities of innovative organisations also lead to high dynamics in staff structure and high staff turnover rates, which appears to be another characteristic (and burden) of high-tech SMEs. According to an Austrian study the qualification structure of employees hardly changed in less innovative enterprises during the period 1991 to 1996, while in innovative enterprises it underwent a comparatively large change¹¹⁰. The above-mentioned survey of 351 European technology SMEs revealed that staff turnover rates are about 17 % on average. Also, a French investigation identified this problem of a significant turnover of employees in high-tech enterprises¹¹¹. These dynamics imply major burdens and expenses, because firms bear the added cost of training new staff and pay considerable fees to recruitment agencies (which are commonly used).

In the end, the employees themselves are also affected by the nature of change and novelty typical for many high-tech SMEs. Innovations and their impacts on work tasks and corporate organisation require a comparably higher flexibility from employees. Using the example of the IT sector, a German paper¹¹² indicates that permanent restructuring of enterprises, outsourcing, project work as well as the use of freelancers and temporary employment contracts might also contribute to the fluctuation and recruitment problems in this sector.

4.2.2. Improving the access to skilled labour

Skill shortages are a major business constraint in high-tech industries. It is evident that the problem is rooted in a clear, and by and large European-wide, supply or availability gap of persons bearing the appropriate (high) qualifications rather than constituting a mere mismatch situation. This is confirmed, for example, by statistics on the number of researchers per 1 000 labour force, which is 5 researchers in the EU (1997), 7.4 in the US (1993) and 9.6 in Japan (1998)¹¹³. Filling the gap through mobilising a possible hidden potential is limited, because, in the high skill category concerned, participation rates are already high and unemployment is low¹¹⁴. Similarly, even though fostering cross-border mobility within Europe is important, no significant improvement of the situation can be expected at the EU level, since high-tech skill shortages are prevalent almost everywhere in Europe. Also, improving labour market information (information on vacancies and job seekers) will have a limited impact, as this strategy would primarily be geared at solving mismatch problems. Thus, making available a workforce with the required competences and knowledge has to constitute the main strategy.

Taking in experts from abroad

One strategy to increase the available workforce with the needed skills is to acquire respective experts from outside the EU or from outside Europe, which to a certain extent actually takes place¹¹⁵. In Sweden and Denmark, measures have been introduced to lower the tax rates for highly skilled professionals coming from abroad¹¹⁶. A similar strategy has also been adopted across the Atlantic - the US high-tech enterprises have been active in promoting the increase in the number of visas for high-technology foreign workers¹¹⁷. The mirror-image strategy for companies is to establish, or transfer, development and production units to other countries. In the long term, however, the externalisation of education and training cannot be regarded as the main method for tackling the problem and it should not prevent Europe from performing the required education and training itself.

Educating and training the European workforce

The availability of an appropriately skilled workforce to a sufficient extent is dependant upon two conditions. First, it depends on decisions by individuals about the type of human capital they are intending to supply during their work life, which then shows up in the demand for training offered. Second, it depends on the provision of training services (the capacity of the training system), in qualitative and quantitative terms. One approach to close a specific skill gap is, therefore, to stimulate by incentives the up-take of a particular education. The incentive might be related directly to the acquisition of the qualification or indirectly via (high) wage differentials. However, the decision of individuals about their education and future profession might only partly be directed by economic

110 Lettmayr, C., T. Oberholzner, T. Parger and S. Sheikh, Auswirkungen von innovativen Unternehmen auf die Beschäftigungssituation (The impact of innovative enterprises on employment), Research report, Austrian Institute for Small Business Research, Vienna, 1997.

111 Fidéliser ses salariés (Developing loyalty in your employees), 1999, in L'Usine Nouvelle, no. 2762, 01/1999.

112 Trautwein-Kalms, G., IT-Fachkräftemangel: Der Mensch lebt nicht von Qualifikation allein (Shortage of Skilled Labour in the IT-sector: Man Does Not Live on Qualifications Only), in: Gewerkschaftliche Monatshefte, No. 2, 2001, pp. 94-99.

113 OECD data cited in: European Commission, Trends in European innovation policy and the climate for innovation in the Union, Commission Staff Working Paper, SEC(2000) 1564, Brussels, 2000.

114 European Commission, European competitiveness report 2002, Luxembourg, 2002.

115 European Commission, Towards a European Research Area, COM(2000) 6, Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions, Brussels, 18 January 2000.

116 From 1st January there has been a reduction of the level of taxes for foreign experts for a maximum duration of three years. The individual must be highly qualified as well as possess a unique competence. The Government Bill 2000/01:12.

117 Palmer, E., Congress appears ready to allow additional foreign workers to fill high-tech jobs, CQ Weekly, Vol. 58, Issue 8, 19.2.2000, pp. 360-361.

incentives, but also by e.g. social aspects. Thus, enlightenment, information and formation of opinion seem to be important. In this respect, the European Union and the Member States have taken intensified measures towards increasing the number of science and technology students and increasing the attractiveness of science as a career option.

Improving the education and training system is another pre-condition for increasing the supply of particular skills. This refers to different levels: Institutions, such as schools, universities or training centres of various types, programmes, and funds. For example, there are enormous efforts across Europe to increase in schools the number of PCs (also connected to the internet) per pupil and introduce informatics into curricula.

Acquiring 'new or modern' skills is often associated with a high-level educational path, taking a rather long period of time (university, etc.). In this context, it seems reasonable to bring down the learning of these modern skills to lower educational levels. This would have at least two effects: first, the respective training would be completed in a shorter period of time, thereby contributing to fill urgent skill gaps; second, additional individuals could be attracted to choose the occupational field in question, especially those being averse to long education periods. The introduction of training schemes related to IT or e-commerce into an apprenticeship system is an example.

Clearly, also, internal training in high-tech enterprises is an option. As mentioned above, the internal creation of skills and knowledge is of great importance especially in high-tech business, because the external training system might not be so 'mature' yet. Indeed, there is evidence that high-tech enterprises are comparably more active in terms of training. Empirically, the introduction of new technologies is strongly associated with the decision to train¹¹⁸. Further, the Irish software industry invests exceptionally heavily in staff development and training compared to other sectors in Ireland¹¹⁹. A UK study shows that highly innovative enterprises placed great emphasis on human resource issues, employee development and training. Moreover, these enterprises emphasised industrial education of young people in their locality, through apprenticeships, year-in-industry, student placements and school visits¹²⁰. Nevertheless, basically there will always be underinvestment in internal training as businesses cannot assure fully retaining its benefits.

Actually, the distinction between external and internal to the firm training often becomes blurred. Especially in those areas where new and/or rather company specific skills are concerned, a strong involvement of enterprises in training programmes seems essential (and financially important). A study on European programmes tackling skill shortages identified the involvement of companies as key partners in the projects as one of the major success factors of the measures¹²¹. The German programme 'Arbeitsprozessorientierte Weiterbildung in der IT-Branche' (work process oriented training in the IT industry) is an example of a measure with significant involvement of the concerned firms.

Ensuring the adaptability of the educational system

Even though it is important to enable the educational system to provide a sufficient supply of specific skills required by high-tech SMEs today, it seems even more important, from a long-term perspective, to ensure the continuous adaptability of this system. In 10 or 20 years from now, new technologies and highly innovative firms will probably have different skill requirements than today, which are largely unknown at present. One major element in this respect is that innovative enterprises should not need to rely only on those (young) employees having attained the required skills via their initial education. Put differently, promoting life-long learning should increase the flexibility also of older employees to develop and alter their initial education and increase their adaptability to changed skill requirements. For this purpose, enough short training tracks have to be available as well. This strategy appears to be particularly crucial considering the future demographic developments in Europe with a remarkable decrease in the relative number of young people. The high potential to increase life-long learning is demonstrated by the huge differences in participation in life-long learning across European countries, ranging from 1.1 % of the working age population in Greece, an EU average of 8.4 % to 21.6 % in Sweden in 2000¹²².

118 OECD, Technology, Productivity and Job Creation, Vol. 2 Analytical Report, Paris, 1996, p. 150.

119 O'Gorman, C., E. O'Malley and J. Mooney, Clusters in Ireland - The Irish Indigenous Software Industry: An Application of Porter's Cluster Analysis, National Economic and Social Council, Research Series Paper No. 3, Dublin, 1997; and O'Malley, E. and C. O'Gorman, Competitive Advantage in the Irish Indigenous Software Industry and the Role of Inward Foreign Direct Investment, European Planning Studies, Vol. 9, No. 3, 2001.

120 Barnett, E. and J. Storey, Managers' Accounts of Innovation Processes in Small and Medium-Sized Enterprises, Journal of Small Business and Enterprise Development, Volume 7, No. 4, 2000, pp. 315-324.

121 Weber, F., B. Pilsel and T. Oberholzner, Fachkräftemangel - Lösungsmodelle in ausgewählten EU-Ländern und Australien (skill shortages - solution models in selected EU countries and Australia), Vienna, 2001.

122 European Commission, 2001 Innovation Scoreboard, Commission Staff Working Paper, SEC(2001) 1414, Brussels, 2001.

However, for individuals to take the 'right' decision regarding their education, the precise and quick communication of skill requirements between companies, the educational system and individuals is an essential prerequisite. This also includes the signalling via wage differentials. In this regard, EU labour markets are regarded to be less successful than labour markets in the USA¹²³.

In the context of compensation, share ownership and stock options are increasingly discussed (and also used) as an instrument of remuneration. Especially for enterprises having a potential to grow and to increase the firm's value, as is the case for many high-tech companies, this might represent an additional monetary incentive for employees. Furthermore, stock options might raise staff loyalty and thereby contribute to alleviating the fluctuation problem mentioned previously. Indeed, share options are already used quite often in a certain sub-population of enterprises: A survey of venture capital backed companies in the United Kingdom and continental Europe revealed that approximately a third of the young organisations (established in the last 10 years) retain share options for key employees¹²⁴. The vast majority of the surveyed companies believe that employee share ownership is important to recruiting, retaining and motivating key staff. In order to encourage the usage of this instrument businesses call for a more favourable treatment in the taxation system. For comparison, a recent report in the frame of the Observatory of European SMEs¹²⁵ reveals that in the total European SME population only 4 % actually use stock options and another 6 % are considering to do so. This report also shows that the entrepreneurs' main reason to use the instrument is to motivate employees and retain key personnel, whereas *attracting new employees* is rarely aimed at.

4.3. Access to knowledge

Although it might appear at first glance that innovations and new technologies are created by small isolated systems, groups of persons or enterprises, such as inventors, one must not fail to see that an innovation, in the end, is made possible by and depends upon a multitude of events and actors external to this system. An innovation is based on an enormous amount of already existing knowledge and regularly benefits from many ideas and stimuli generated throughout the entire society. An inventive person or team or a patenting firm could then be understood as a point of crystallisation for this innovation process and, in turn, provides a contribution for the next innovation crystallising at another place. This is the reason why so-called innovation *systems* (emphasising the 'systemic' view) are ranked high in the context of improving the innovation performance of economies. Consequently, from the viewpoint of the individual firm, its innovation performance depends a lot on its access and relations to relevant external knowledge and knowledge holders. Put differently, the more, and better, relevant strands of knowledge are converging in a high-tech firm, the more likely it is to become a point of crystallisation for successful innovations.

Knowledge is occurring in different settings and is held by different organisations. For example, relevant knowledge may be held by and accessed through (new) skilled employees. This part of the story has been discussed in the previous section. The following section is focused on three specific and important aspects related to the acquisition of knowledge by high-tech SMEs: (i) the role of universities and similar institutions, (ii) the role of networks, and (iii) management competencies as a particular type of knowledge.

4.3.1. Role of universities and research institutions

Universities and similar research institutions hold, and continually create, an enormous stock of knowledge. However, empirical investigations show that the co-operation and knowledge exchange between high-tech firms, the small ones in particular, and universities is poorly developed. Their importance as a source of expertise is quite limited:

- According to the 2nd Community Innovation Survey, only approximately 10 % of innovative firms in the EU had co-operation agreements with universities and government research institutes in 1996.
- German enterprises supported by a public technology-oriented venture capital institution consider technology transfer from public research institutions into the private business economy as being only modestly effective¹²⁶.

123 European Commission, European competitiveness report 2002, Luxembourg, 2002.

124 www.3i.com/pressoffice/archive situation on 25 June 2002.

125 European Commission, Observatory of European SMEs: Highlights from the 2001 Survey; Report submitted to the Enterprise Directorate General by KPMG Special Services, EIM Business & Policy Research, and ENSR; Brussels, 2002.

126 Technologiebeteiligungsgesellschaft (tbG), tbG-Umfrage 2000, Boom in der New Economy hält an (tbG-survey 2000, persistent boom in the New Economy), Bonn, 2001.

- Almost no Italian SME considers universities to be an important source of information and knowledge. This is seen to indicate that Italian enterprises underrate the scientific and technological potential offered by universities and research institutes¹²⁷.
- In Switzerland, systematic R&D co-operation with universities or other public bodies is fairly rare for high-tech companies¹²⁸.

The poor university-industry linkages are also demonstrated by a rather small number of spin-offs from universities. Generally, the rate of spin-off formation was about three to four times higher in North America than in most European OECD countries in the 1990s¹²⁹. In Austria, for example, only 14 % of surveyed university departments name 'spin-off formation of new enterprises' as a form of interaction with industry they actively engage in¹³⁰. A lack of spin-offs from universities and a low propensity of researchers to set up knowledge-intensive enterprises were also identified in Denmark. This is seen to result, firstly, from the entrepreneurial climate in the country, i.e. the lack of entrepreneurial spirit and the very explicit egalitarian tradition and, secondly, from a lack of long-term financing (see also Section 4.1)¹³¹. Spin-offs from universities in Iceland have been few also, which the managers of innovative enterprises perceive as an obstacle for innovation in their enterprises and in the economy as a whole¹³².

The main reasons for the rather poor university-business interaction are seen in the following factors¹³³:

- Awareness/quality valuation: Small high-tech enterprises are not aware of the potential offered by universities, or do not understand what universities actually do and how this could be beneficial to the enterprise, or do not value the quality. This in turn appears to be rooted in the subsequent characteristics.
- Different objectives: Universities and research institutions aim at academic and not at practical research results, whereas for high-tech business the opposite is true.
- Different organisational culture: There are differences in organisational culture between universities and companies. Universities are considered unable to think entrepreneurially and enterprises are considered unable to think academically. There are differences in language and appreciation of time scales and differing attitudes concerning the required financial resources.
- Intricate structure of the university and research system: In addition, from the enterprise point of view the multitude of small units and departments, often highly specialised and difficult to distinguish, constituting the university system may be confusing. The same holds for the variety of public, semi-public and private research services, which are numerous and competent help cannot always be located.
- Insufficient resources of SMEs: Some studies point to the fact that, in the frame of university co-operation, considerable resources, in terms of (scientific) personnel, funds and technical equipment would be necessary on the side of firms, which, however, smaller companies are often lacking.

Those few cases where high-tech SMEs make effective and efficient use of universities' knowledge suggest some central prerequisites for a fruitful business-university co-operation. Based on Norwegian¹³⁴ and Portuguese¹³⁵ evidence, it seems that enterprises situated in science parks are better able to take advantage of research institutions. This may result from the fact that they themselves are often spin-offs, which is confirmed by the case of German biotechnology enterprises¹³⁶. In fact, most of the existing successful linkages are based on personal relationships¹³⁷. This is clearly demonstrated by an Austrian case, which also shows the risk-taking capacity of small enterprises (see Box 4.2). Thus, physical proximity and personal relationships seem to be a basic prerequisite for developing efficient university-business exchange.

127 Sobrero, M., *Technological Innovation and Relations Between Enterprises*, La nuova Italia scientifica, 1996.

128 Dembinski, P.H. et al., *Les entreprises 'High Tech' en Suisse: Leur capital intellectuel et leur financement (The High-Tech Enterprises of Switzerland: Their Intellectual Capital and Financing)*, Rapport de synthèse, Geneva, 1998.

129 OECD, *Benchmarking Industry-Science Relationships*, Paris 2002, p. 41.

130 Scharfetter, D. et al., *Knowledge Spillovers from Universities within the Austrian Innovation System*, Vienna, 2000.

131 Erhvervsfremme Styrelsen, *Global Entrepreneurship Monitor: Danish National Executive report*, Erhvervsfremme Styrelsen: 12, 2000, Erhvervsministeriet, *Innovation-smiljøer-udvikling gennem nye innovative virksomheder (Ministry of Trade and Industry, Development of Innovation-Oriented Environment Through New Innovative Businesses)*, 1998.

132 Hindranir við nýsköpunarstarf íslenskra fyrirtækja (Obstacles to innovation in enterprises), Icelandic Chamber of Commerce and New Business Venture Fund, <http://www.chamber.is/Frettapunktur/Skyrslur/skyrsla.pdf>, 1999, situation on 11.7.2001.

133 Scharfetter, D., H. Gassler and A. Schibany, *Benchmarking Industry - Science Relations. National Report - Austria. Austrian Research Centers Seibersdorf and Joanneum Research*, Vienna, 2000, p. 52 (n=17); OECD, *Technology and the Competitiveness of Small and Medium-sized Enterprises*, OECD Publications, October 1993, Paris; *Teknologian siirto osana pk-yritysten kansainvälistymistä (Technology transfer as a part of the internationalisation of SMEs)*, Itkonen, R., H. Pohjonen, H. Puurunen, M. Tervonen, P. Tola and K. Tuominen, *Teknologiakatsaus 83/2000, TEKES*, Finland, 2000; Hindranir við nýsköpunarstarf íslenskra fyrirtækja (Obstacles to innovation in enterprises), Icelandic Chamber of Commerce and New Business Venture Fund, <http://www.chamber.is/Frettapunktur/Skyrslur/skyrsla.pdf>, 1999, situation on 11.7.2001; Schibany, A., *Co-operative Behaviour of Innovative Firms in Austria*, Study Prepared for The OECD Project on National Innovations Systems (NIS), Vienna, 1998.

134 Isaksen, A., *Innovasjoner, næringsutvikling og regionalpolitikk (Innovations, Trade Development and Regional Politics)*, Høyskoleforlaget, 1997.

135 Laranja, M., *Small Firm Entrepreneurial Innovation in Portugal: The Case of Electronic and Information Technologies*, Doctoral thesis, University of Sussex, 1995.

136 *Technologiebeteiligungsgesellschaft (tbG)*, *tbG-Umfrage 2000, Boom in der New Economy hält an (tbG-survey 2000, persistent boom in the New Economy)*, Bonn, 2001.

137 Schibany, A., L. Jörg and W. Polt, *Towards Realistic Expectations - The Science System as a Contributor to Industrial Innovation*, Vienna, 1999.

However, the previously discussed contradictory aims and organisational cultures in firms and universities respectively also point to some underlying weaknesses of the structure of the European university system. A comparison with the US system, where industry-university interaction seems to be much more developed, reveals the following relevant differences¹³⁸:

- The US university organisation is more decentralised and allows for more flexibility in research.
- The US system is characterised by higher inter-disciplinarity.
- There is more competition among research units in the US.
- Institutional framework conditions allow for higher labour mobility between academia and industry.
- Altogether, these factors lead to higher ability of the US university system to interact with industry.

Measures are required to bridge the gap between SMEs and universities, in order not to leave untapped a rich source of knowledge and new technologies. Amongst others there is a need for a reshape in the traditionally perceived role of universities to increase their involvement in developing business innovations. For examples of respective services and initiatives see Chapter 5.

Box 4.2: Sanochemia Pharmazeutika AG, Vienna, Austria

The enterprise has marketed a trademark Nivalin since 1961 to treat malfunctions of the peripheral nervous system. The main problem was to extract the raw material (from 'Snowdrops' - *Galanthus nivalis*) in high purity, which led to delivery problems. Also origin, prices and quality of the raw materials could not be assured. The relatively small market size of this niche product constituted a problem for the future turnover of the product.

Then one person in the technical department started investigating multiple uses for this substance and made first contacts with a scientist who was a former fellow student. At the same time international journal articles indicated first promising results in relation to synthetic substances for Alzheimer medication. Also a multinational enterprise was attracted by this idea and shared some further research work, but it cancelled its commitment, as the first results were not promising enough.

With one recruit from a university in Switzerland and another scientist and committed employee the enterprise set up an R&D laboratory as well as a pilot plant. Due to insufficient resources the enterprise decided to collaborate with the local university through contacts of one of the post-doc scientists. The university was responsible for the basic research and Sanochemia for the applied one. With further maturity of the project more and more resources were devoted to it. During the final phase about 30 persons worked on the project. With this concentrated effort, two competitors could be beaten. One, a UK based enterprise applied for a patent with a similar solution 4 months later. Sanochemia expects a yearly growth in turnover of about EUR 7.27 million.

An important precondition for the success of the project was the financial support by the Austrian Industrial Research Promotion Fund (FFF), which enabled the collaboration with the university. Enterprise-internal success factors were mostly the commitment of the management to the project as well as the social relationships with the research partners, which led to a high degree of commitment by all partners.

Source: Leitner K.H., Gründorfer, St., Hölzl, W., Von der Idee zum Markt: 50 der besten Innovationen Österreichs (From the Idea to the Market: 50 of the Best Innovations in Austria), study by the Austrian Research Center Seibersdorf, Vienna, to be published in Summer 2001.

4.3.2. Role of networks

Systematic access to knowledge, competencies and capabilities available in other firms and organisations - in the same industry, in complementary and related industries, in industries functioning as suppliers and customers, or in the (semi-)public sphere - can be assured via networks. Due to the increasing complexity of technological solutions and the manifold resources required, innovation projects are increasingly developed, managed and commercialised in networks of businesses rather than by individuals or single companies. Also, networks make possible the sharing of risks and high cost associated with R&D. It seems that the importance of networking is measurable in terms of success at the firm level, too. Studies on high-tech SMEs in Denmark and Switzerland show that

138 European Commission, European competitiveness report 2001, Luxembourg, 2001, Chapter V.

external interaction and knowledge sharing correlates positively with the success of innovation and provides easier access to finance¹³⁹. Ultimately, networking may give birth to phenomena like e.g. the Silicon Valley.¹⁴⁰

Commonality of networking and networking partners

Overall, co-operation and networking activities appear to be rather common among high-tech SMEs already. However, this statement has to be qualified insofar as one might assume that almost all high-tech firms should be involved in some sort of network. Moreover, co-operations are often somewhat one-sided with respect to the type of partner. In the following an overview of relevant study results is presented:

- According to a European survey of 351 technology SMEs, repeatedly cited above, 75 % of respondents reported that they had formed at least one strategic alliance. These alliances enable enterprises to spread high costs of R&D, to bring in additional capability and to enter new markets¹⁴¹.
- In a survey of about 3 000 enterprises across the EU, although not focussed solely on high-tech companies, 63 % of SMEs (20-249 employees) regarded networking methods between innovators as important or very important for their company¹⁴².
- In Austria, the most important co-operation partners in innovation activities are suppliers of materials/components and technical services as well as private customers, although there is a growing trend to co-operate with research institutes, too¹⁴³.
- In Italy, similarly, suppliers of equipment and materials are in all sectors the most important channels for accessing knowledge and technology for SMEs¹⁴⁴.
- A comparative study for Italy and Portugal shows that, for young technological firms, family and friends as well as informal relations with customers are particularly important¹⁴⁵.
- In Luxembourg, about half the enterprises carrying out R&D activities in 1992 had established co-operation agreements with other enterprises for that purpose; most commonly with enterprises of the same sector or group or with their suppliers or clients¹⁴⁶.
- According to evidence from the Netherlands, about a half of young, small and innovative IT enterprises co-operate in innovation activities, and they do this mostly with other enterprises in the same sector. Many high-tech start-up enterprises rely on vertical networks, and contacts outside these networks are mostly accidental and not planned¹⁴⁷.
- In Spain, almost half of the SMEs report to have achieved their innovation results through co-operation with suppliers or clients. However, only about 15 % of SMEs have done it exclusively in this way. Similarly, the degree of co-operation with specialised institutions is very low¹⁴⁸.

By and large, these results suggest that customers and suppliers are by far the most frequent networking partners of high-tech SMEs. Co-operation with companies from the same industry seem to be important as well, but is probably less frequent than the former type. Collaboration with 'specialised institutions' appear to be relatively rare, which is in line with what has been discussed in Section 4.3.1. However, even though a lot of high-tech SMEs are engaged in networking and collaboration, there is still a number of firms, and the very small ones in particular, that refrain from such activities. Furthermore, the above results do not indicate whether the potential for networking is fully exploited in terms of extent, quality, and depth of network relations. Also, the attitude of

139 Erhvervsfremme Styrelsen: Det danske innovationssystem- et forskningsbaseret debatoplæg om innovationspolitiske udfordringer og handlemuligheder: DISKO-projektet: Sammenfattende rapport (The Danish innovation system - a science-based discussion paper of the challenges in the innovation policy: Disco-project, a consolidated report), 1999, Erhvervsfremme Styrelsen: Innovation i danske industrivirksomheder (Innovation in the Danish industrial businesses), 1994; Erhvervsfremme Styrelsen: Innovation og erhvervsudviklinglværksættere: En analyse af industriel innovation i perioden 1990-1992 (Innovation and business development - an analysis of the industrial innovation under the period of 1990-1992), del 2, 1995; Spotlight BioValley, nature - international weekly journal of science, published 23.03.00 issue: 6776 volume: 404, <http://www.nature.com/naturejobs/spotlight/biovalley/> (situation on 11.7.2001), <http://www.biovalley.com> (situation on 11.7.2001).

140 Clusters can be seen as a form of networking. The issue of 'science-based clusters' and clustering in the new economy and in the ICT industry are discussed in: European Commission, Observatory of European SMEs; Regional Clusters in Europe; Report submitted to the Enterprise Directorate General by KPMG Special Services, EIM Business & Policy Research, and ENSR; Brussels, 2002.

141 Achieving the Dream, The 1999 European Benchmarking Study for Technology Enterprises (up to 250 employees). PricewaterhouseCoopers. <http://www.pwcglobal.com/uk/eng/ins-sol/survey-rep/dream.html>, situation on 11.7.2001.

142 EOS Gallup Europe, Flash Eurobarometre 100, Innobarometer, Results and Comments, 2001.

143 Scharfing, D., H. Gassler and A. Schibany, Benchmarking Industry - Science Relations. National Report - Austria, Austrian Research Centers Seibersdorf and Joanneum Research, Vienna, 2000, p. 14.

144 Sobrero, M., Technological innovation and relations between enterprises, La nuova Italia scientifica, 1996.

145 Fontes, M. and G. Capaldo, Young technological entrepreneurship in less developed European regions: preliminary results of a comparative study of software firms in Portugal and Southern Italy, 1999.

146 STATEC, L'innovation dans le secteur des industries au Grand-Duché de Luxembourg (Innovation in the industrial sector in the Grand-Duchy of Luxembourg) - Bulletin du Statec No. 6, 1994.

147 Ministerie van Economische Zaken, De ondernemende samenleving (The entrepreneurial society), 1999; Eck van der Sluijs, P.A. van, H.E. Hulshoff and Y.M. Prince, Jonge, kleine, innovatieve ICT-bedrijven in Nederland (Young, small, innovative IT firms in the Netherlands), EIM, 1998.

148 Yagüe, M.J., La Actividad Innovadora de la Pyme Industrial Española (Innovation Activities within Spanish SMEs), in: *Economía Industrial*, No. 284, 1992, p. 137-149.

smaller innovative enterprises towards co-operation and networking, which is not always too favourable¹⁴⁹, suggests that networking could still be developed.

Barriers to networking

Studies dealing with barriers to networking and co-operation in the area of high-tech SMEs identify a number of reasons hampering the formation of networks among these enterprises. Many of these factors are the same as for SMEs in general, e.g. different objectives and expectations among partners and differences in enterprise culture¹⁵⁰. Also, the lack (or the importance respectively) of a 'co-ordinator', e.g. a larger leading firm or an agency, is relevant for the networking among high-tech SMEs, too¹⁵¹. Taking over such a co-ordination function is a common field of activity for economic policy today. In the following section, two issues will be discussed which are more specific to high-tech firms and, respectively, where small innovative companies differ from larger R&D performing enterprises. These factors can also be understood as underlying reasons for the sometimes negative attitude of businesses towards collaboration.

First, small and large high-tech enterprises seem to have different motives to engage in networking¹⁵²: for high-tech SMEs the main motivator is to achieve (quick) access to markets and credibility. Hence, networking is seen to be a 'necessity' for high-tech SMEs. In contrast, for large high-tech firms the reasons to engage in networks include primarily access to competitive R&D and technology. For large enterprises, networking represents more an opportunity (strategy) than a direct 'necessity', which is facilitated by their extensive internal resources. Thus, networks can be seen either as a source for resources or for learning and it seems that most SMEs are attracted rather by the first. These fundamentally different approaches imply that smaller firms are rather oriented towards short term and concrete results. SMEs want projects to have a quick path to market and achieve returns as quickly as possible. However, networking often requires a lot of time-consuming communication and efforts before actual results are achieved and benefits are not visible immediately. But SMEs have difficulties in allowing time and delays for different processes and exchange of information. A further consequence is that SMEs prefer to form one to one collaborations rather than collaborations between groups of enterprises.¹⁵³

Second, a main barrier identified, for instance, for French¹⁵⁴ SMEs is the difficulty to find a balance between the privacy of certain information and a necessary diffusion of information for the network to function. Also, biotechnology SMEs have found networking with larger enterprises to be a double-edged sword, as is shown in a British study on the biotechnology sector¹⁵⁵: a common large-enterprise strategy is to use their networking relationships to keep a 'watching brief' on their small enterprise counterparts. Therefore, especially small biotechnology firms are seeing risks involved in co-operation and have to make sure that the patents and intellectual property rights (IPR) of their enterprise are secured. Naturally intellectual property rights are of great importance in protecting the gains from innovations. However, in the long-run it is wise to turn attention to building and sustaining the dynamic capabilities that permit the company to track and lead the portions of technological frontier that are most relevant to its business. Enterprises that succeed in doing this create a moving target for the competition that is much harder to hit than the stationary targets represented by the individual innovative achievements. Also, the subtle internal dynamics of a successful R&D organisation are much harder to reverse-engineer and imitate than the specific products the lab turns out¹⁵⁶.

4.3.3. Management competencies in high-tech SMEs

The business environment is more dynamic for high-tech SMEs than for traditional SMEs with respect to markets, product development, production methods, organisational change, etc. For high-tech firms risk involved in business is higher, too. These conditions demand a great deal from managerial competences in those companies. Excellent management skills are, therefore, of highest importance in order to lead an innovative firm to success.

149 See, for example, Camarero, M., P. Lázaro, La opinión de cien PYMES españolas preocupadas por la Innovación (The opinion of one hundred Spanish SMEs concerned with Innovation), Estudio No. 5, Fundación COTEC, Madrid, 1995.

150 See, for example, EIM (2000) unpublished regional studies on IT firms.

151 European Commission, Observatory of European SMEs; Regional Clusters in Europe; Report submitted to the Enterprise Directorate General by KPMG Special Services, EIM Business & Policy Research, and ENSR; Brussels, 2002.

152 Blomqvist, K. Asymmetric partnerships. Different Characteristics and Motivation of Small and Large Technology Firms. Lappeenranta University of Technology. Telecom Business Research Center Lappeenranta, Working papers, 1999.

153 Les PME dans les réseaux de recherche (SMEs in Research Networks), Industries, number 55, 03/2000; Evaluation of the Link Optoelectronics Systems Programme (1997) DTI Assessment Unit, Au No. 33, May 1997.

154 Les PME dans les réseaux de recherche (SMEs in Research Networks), Industries, number 55, 03/2000.

155 Oakey, R.P., Predatory Networking: The Role of Small Firms in the Development of the British Biotechnology Industry. International Small Business Journal, Vol. 11, No. 4, p. 9-22, 1994.

156 Winter, Sidney G., Appropriating the Gains from Innovation, in: Wharton on Managing Emerging Technologies (Eds. George S. Day, Paul J.H. Schoemaker, Robert E. Gunther), John Wiley & Sons, Inc. New York, 2000, pp. 242-265.

However, many small high-tech firms are founded by individuals having a good education, and also experience, in a specialised scientific area, but lacking sufficient business management capabilities. This is demonstrated in a number of empirical studies. A study of Finnish biotechnology enterprises shows that the technological and scientific competencies are remarkable within the enterprises, but there is a lack of business management skills, which forms the biggest threat for their existence and future prospects¹⁵⁷. According to a German study, missing management experience and knowledge was a factor in nearly all financing problems faced by technology-based enterprises in their start-up phase¹⁵⁸. Similarly, in Italy, the lack of suitable managerial competencies is seen to prevent high-tech SMEs from growing and it is suggested to provide the academics starting a business with not only a high scientific education, but also entrepreneurial training¹⁵⁹. Many Dutch technology based start-ups are seen to have too little expertise and experience in the fields of management, organisation and marketing. A higher than average need for professional assistance in information, counselling and coaching is identified for these companies¹⁶⁰. Portuguese findings show that, once in business, all new technology enterprises experience a lack of managerial, marketing and recruitment capabilities¹⁶¹.

The lack of business management competencies appears to be an important problem for European high-tech enterprises. It constitutes a threat for their existence and is a major constraint and obstacle for their growth and development, which often prevents them from transforming the excellent scientific and technological competencies into the real economy. Finding market information, launching new products, marketing, recruiting, networking and understanding customer needs are the critical problem areas. This result is in line with the fact that customer-orientation has been identified as an important success factor in Section 3.2.4. Especially in the early stage careful cash management is a necessity for survival.

Consequently, there is an urgent need for continuous training and development programmes especially for those founders with no business experience. Across Europe, several business incubators have been set up to fulfil this particular need. When designing training programmes for technology entrepreneurs there are some specific areas that should be addressed¹⁶²: market evaluation of existing products and services, human resources management in fast-growing enterprises, managing knowledge workers, partnering technologists with management teams, understanding the evolution from a technical solution to a marketable product, global marketing, patent management, know-how transfer and licensing negotiations, to name only a few. The challenge of assessing future markets for high-tech SMEs is to determine the demand for products that do not exist from customers who do not yet know about them. At the same time, the trajectory of technology development and speed of market acceptance are also uncertain. Under these circumstances the traditional methods of market assessment are not suitable. In assessing the markets, methods such as experimentation and probe-and-learn approaches, as well as latent-need research and lead users analysis can be useful¹⁶³.

157 Brännback, M., J. Näsi and M. Renko, Technological, Structural, and Strategic Change in the Global Pharmaceutical Industry - the Finnish Biotechnology Industry, Innomarket, Turku School of Economics and Business Administration, Department of Marketing, Technical Reports, No. 8, February 2001.

158 Lessat, V. et al., Beteiligungskapital und technologieorientierte Unternehmensgründungen: Markt - Finanzierung - Rahmenbedingungen (Venture (Private Equity) Capital and Technology-Based Start-ups: Market - Finance - Business Environment), Wiesbaden, 1999; and Domdey, H., Early stage - ökonomische Wunderwaffe oder Eintagsfliege? (Early stage - A Major Economic Booster or a Drop in the Ocean?), in: Bundesverband Deutscher Kapitalbeteiligungsgesellschaften: Jahrbuch, Berlin, 2000.

159 Chiesa, V. and A. Piccalunga, The Birth of High-Tech Firms, *Impresa & Stato*, No. 43, 1999.

160 Ministerie van Economische Zaken, De ondernemende samenleving (The Entrepreneurial Society), The Netherlands, 1999.

161 Laranja Duarte Mendes Monteiro, M., Small firm entrepreneurial innovation in Portugal: the case of electronic and information technologies, Doctoral thesis, University of Sussex, 1995; and Laranja, M., J.M.A. Marques, Information Technology and Electronics in Portugal: Their Importance, Current Reality and Prospects, Directorate-General of Industry, 1994.

162 FIT Project, The Development and Implementation of European Entrepreneurship Curricula. European Commission, Enterprise Directorate-General, Innovation Policy Unit. Analysis Background Paper.

163 Day, George S. and Paul J.H. Shoemaker, A Different Game, in: Wharton on Managing Emerging Technologies (Eds. George S. Day, Paul J.H. Shoemaker, Robert E. Gunther), John Wiley & Sons, Inc. New York, 2000, pp. 1-23.

Chapter 5

Policy measures facilitating access to crucial resources

As discussed at the beginning of this report, innovation and the innovation system in general, and highly innovative, high-tech (small and medium-sized) firms as specific actors in this system, constitute a key factor for economic growth and welfare. A prosperous development of this type of enterprise is a prerequisite for a favourable development of the economy as a whole. Apart from high growth rates in the concerned businesses themselves, there can be important spill-over effects to the rest of the economy. High-tech enterprises act as 'first movers' inducing technology diffusion leading to the usage of innovations and new technology also in traditional sectors. This means that social returns on innovation are exceeding private returns.

However, different indicators show that, in Europe, the innovation performance and the performance of innovative companies lags behind when compared to its main competitors. In Europe, certain framework conditions appear to hamper the functioning of the innovation system. At least part of these problems seems to be rooted in market failures, or an absence or a limited effectiveness of market co-ordination. The provision of finance and the supply of skilled labour might serve as examples.

Under the conditions of significant social returns as well as dysfunctions or absence of market co-ordination, public intervention is not only justified but even called for, in order to ensure that the innovation system delivers its best possible contribution to the social and economic development. Therefore, specific policy measures are required in various areas to facilitate and foster the development of innovative enterprise and improve its interaction with the economic framework.

High-tech and innovative enterprises, and innovation in general, have received increased attention in policy at both EU and Member State level. This is reflected by a general shift of focus in enterprise policy and research policy respectively towards innovation, thus bridging the gap between these policy areas and also raising the importance of an 'innovation policy' on its own. The high ranking of innovation policy in Europe was also demonstrated, for example, at the March 2000 European Council in Lisbon, calling for a better environment for high technology start-ups, and for starting up and developing innovative enterprises in general. In 2000, a programmatic document has been devoted to innovation policy by the European Commission¹⁶⁴. Today, a vast number of policies and measures to foster innovation and high-tech firms have been taken or are currently in force, at both Member State and EU level. These measures are covering a broad spectrum of issues, including: patent systems and intellectual property rights in general, administrative and regulatory procedures, innovation financing, fiscal and tax measures, technology transfer from public research to businesses, support and advisory services, science parks and technology centres, education and training.

The number of actions related to high-tech firms and innovation, at EU level and at country level in particular, is too large and developments are too dynamic to provide a comprehensive and up-to-date overview in this report¹⁶⁵. A few central measures at Union level are mentioned as examples. First, innovative SMEs are promoted through SME specific measures within the RTD Framework Programmes and through the intervention of Structural Funds, which comprise extensive innovation-related elements. Second, there are a number of activities re-

164 COM (2000) 567: Innovation in a knowledge-driven economy. Communication from the Commission to the Council and the European Parliament. Brussels 20.9.2000.

165 It shall be noted that the European Commission is collecting and analysing information on innovation policies in the Union through the so-called 'Trend chart on innovation in Europe'; see <http://trendchart.cordis.lu/>.

lated to overcoming the problems of accessing some of the crucial resources discussed in this report - finance, skilled labour, and knowledge. With reference to finance there are several significant initiatives of the European Investment Fund and the European Investment Bank in the field of innovation finance and venture capital in particular (e.g. ETF, CREA, ITEC). Furthermore, networking of business angels is also supported by the EU. Support networks such as the Innovation Relay Centres and Business and Innovation Centres are improving the access to knowledge. The same holds for innovation-related instruments for assisted regions like RIS and RITTS. The pilot action 'Mechanisms to facilitate the setting-up and development of innovative firms' includes, amongst others, the fostering of networks, the stimulation of knowledge transfer and the preparation of business plans. The European Social Fund and the Leonardo programme provide support in the field of training and skills.

Moreover, recent innovation policy trends at the level of the Member States suggest that some of the problem areas discussed in this report are increasingly taken into account by policy actions. Amongst others, intensifying the co-operation between research, universities and companies, the promotion of clustering and networking, and, more generally, a system approach to innovation policy is becoming more important in the framework of innovation policies. In this context, so-called 'competence networks' and 'technology valleys' are increasingly pursued concepts in Member States. Furthermore, innovation financing is regarded as an ongoing priority.¹⁶⁶

In the following part, a few concrete examples of national/regional measures are presented. Based on evaluations, these programmes are seen to address successfully the difficulties faced by high-tech SMEs in accessing the previously discussed resources. Clearly, policy schemes usually target several problem areas at the same time, since the problem areas are often highly interrelated. For example, supporting co-operation between SMEs and research institutions is also expected to affect access to high-quality labour and human resources. Nevertheless, for this current purpose an attempt is made to relate the schemes to one specific problem area.

Co-operation with research institutions:

PRO-INNO (PROgramme 'Competence of SMEs in INNOvation')

Germany

The Federal Ministry of Economics and Technology in Germany together with the Arbeitsgemeinschaft industrieller Forschungsvereinigungen 'Otto von Guericke' e.V. (AiF) (Working Group of Industrial Research Associations; in charge of the practical implementation of the programme) are running the PRO-INNO Programme. PRO-INNO was launched in June 1999, and it runs till the end of 2003. The general aim is to increase the innovative capabilities and competitiveness of SMEs by fostering the use of new technological opportunities. This is done by supporting the technology transfer between SMEs and research institutions via co-operation projects. The common characteristic of all types of co-operation is that they apply modern technologies such as ICT. The support consists of grants of about 35 % to 50 % of expenses, 83 % of the financial support granted has been delivered directly to SMEs and 17 % to research institutions co-operating with them.

Various types of SMEs have participated in PRO-INNO: from high-tech to craft enterprises, from young small firms of the 'New Economy' to traditional medium-sized production enterprises, from manufacturing to technical services. More than 80 % of participating SMEs have less than 50 employees, indicating that PRO-INNO is especially appropriate for smaller enterprises. SMEs not only increase their ability for co-operation, but they also enter new technology fields and realise remarkable innovation leaps (and this in the context of partitioned and thus lower R&D expenses).

- Each year approximately 2 000 projects are operating, employing 6 000 R&D-experts (10 % of them are newly hired).
- More than 40 % are young (less than five years old) innovative enterprises.
- 35 % of the enterprises are aged between six and ten years.

PRO-INNO has a particular significance for the new German Länder as almost 60 % of all grants has been spent in this part of Germany. Due to the very strong response by enterprises and research institutions and to its broad effects PRO-INNO has quickly developed into an important and strong instrument for the support of innovation activities by SMEs. The programme successfully addresses a major problem in SME-Science relationships, namely the missing capabilities and resources of small enterprises to engage in joint projects with research institutions.

¹⁶⁶ European Commission, Trends in European innovation policy and the climate for innovation in the Union, Commission Staff Working Paper, SEC(2000) 1564, Brussels, 2000.

The reasons for the success of the programme include the following aspects:

- The strategic set-up of the project is defined by businesses.
- In co-operation projects with research institutions, SMEs are strongly involved in product development (R&D is not merely contracted out to the research organisation).
- Attention is paid to the market relevance of the innovation project.
- Often co-operation between SMEs takes place in a vertical manner, i.e. supplier-customer relationships are established.
- The projects are of interdisciplinary nature and designed across technology fields, i.e. they take into account the requirements of businesses rather than focussing on specific categories of technology.

Source: Bundesministerium für Wirtschaft und Technologie (ed.), Gewinnung von Wissen und Technologietransfer in Aktion. Bilanz des Förderprogramms PRO INNO für das Jahr 2000 (Acquisition of Knowledge and Technology Transfer in Action. Results of the support programme PRO INNO for the year 2000), Berlin, 2001. Additional information was provided by Mr. Belter, responsible programme manager of the Federal Ministry of Economics and Technology.

Recruiting skilled labour:

ANVAR Support to recruitment for innovation

France

Since 1984, the public organisation ANVAR (l'Agence française pour l'innovation) has fostered innovation in all industrial sectors by supporting, amongst others, recruitment for innovation projects. ANVAR's support to recruitment for innovation is targeted at enterprises employing less than 2 000 persons if the enterprise has a new innovation to be launched. Support is given by moderating the costs of hiring 'innovative capacity' to the enterprise (e.g. engineers, doctors). Industrial SMEs with less than 50 employees represent about 50 % of the enterprises having benefited from this programme, and three out of four recruitments have involved graduates. Between 1983 and 2000 altogether about 1,047 subsidies amounting to approximately EUR 23.5 million have been awarded for innovative recruitments. The subsidy is up to 50 % of the recruitment costs during the first year. About 37 % of support has been given to ICT enterprises (innovative services, software, informatics services and material, telecommunications, and electronics) and about 24 % to enterprises in the life sciences (biomedical, pharmacy, agribusiness, agriculture and fishing).

Source: ANVAR, Dossier de presse, bilan 2000/objectives 2001, April 2001.

Encouraging spin-offs and facilitating access to venture capital:

CTI Start-up Programme

Switzerland

'CTI (Commission for Technology and Innovation) Start-up' is an initiative of the Federal Department for Professional Education and Technology (Bundesamt für Berufsbildung und Technologie - BBT) in close co-operation with universities and industry. 'CTI Start-up' is an ongoing national programme launched in 1996 and focused mainly on high-tech SMEs. The target groups are students, doctoral students, graduate students, and inventors in the technology sector. The initiative encourages the further development of research findings in science by direct interaction with universities and colleges. An important feature is the CTI Start-up label ('worthy of support/venture capital'), which confirms the suitability for venture capital, stimulates interest, and simplifies the decision of potential investors. It thus addresses a central problem in obtaining private equity, namely the difficulty for the investor to assess the venture. When the label is granted, CTI Start-up co-finances the technological-scientific part of the project. Experienced consultants and specialists from management, research and development contribute their know-how and give guidance from the initial idea, right up to the market-ready product.

By March 2001, 300 projects had been checked, of which 46 CTI Start-up labels had been given. By the end of November 2000, the enterprises had created over 450 jobs and a turnover of more than EUR 30 million. Since 1996, only one enterprise had to be liquidated. Compared to their initial business plan, 30 % of the enterprises were perfectly on track and 37 % of the enterprises had performed even better (turnover and employment) than initially planned. 18 % of the enterprises had more employees but less turnover than planned and only 12 % had both less employees and less turnover (balance at 03.09.1999). Supported enterprises were active in the following branches: microelectronics (22 %), process engineering (19 %), medical technology (19 %), software (14 %), biotechnology (12 %), information technology (7 %), e-commerce (5 %), others (2 %). The CTI Start-up Programme has annual funding of EUR 1.7 million for network costs over the period 2000-2003.

An important success factor of the programme is its strong market orientation throughout all phases. Applications are assessed, amongst others, with respect to marketability and competence in marketing. Subsequently, market research, analysis of distribution channels and developing business plans are important elements of CTI support.

Source: Bericht über die Förderung von Unternehmen vom 18. September 2000 (Report on the Promotion of Enterprises, September 18, 2000); <http://www.admin.ch/ch/d/ff/2000/5547.pdf>, situation on 11.7.2001.

Joining high-tech firms and business angels:

i2 - The Business Angel Network

Austria

The i2 programme was established in 1997 and is run by the Innovationsagentur (Innovation Agency), an institution of the Federal Ministry for Economic Affairs and Labour and the social partners. The aim of i2 is to close the equity gap for rapidly growing companies - from all sectors and life cycle phases - with smart money. The Network matches promising ideas of innovative entrepreneurs with private investors who, not only provide their own capital, but also their know-how and contacts. Investors may be individuals, incubators, investment houses or larger enterprises.

The applicant firm has to provide a business plan and within only two weeks from the first contact with i2, potential investors are presented to the entrepreneur. The subsequent procedure is then agreed upon by the involved parties themselves. Entrepreneurs, as well as investors, have to pay a fee for the matching service, however, if no investor can be found the money is repaid to the entrepreneur. A large part of the costs of the matching service is nevertheless covered by public funds (national and European) and sponsors.

In the period up to October 2002 about 340 innovative projects have been handled. The majority of the innovative firms were in the seed or start-up phase. Information and communication technology accounted for a quarter of innovation projects. The most important success factors of the programme include the speed of establishing contacts, the discretion throughout the whole process and the professional supervision of the negotiation procedure (e.g. structured presentations, mediation, etc.).

Source: Innovationsagentur, www.innovation.co.at (situation on 10 October 2002).

Facilitating network building and co-operation:

The Innovation and New Technology (NT-) Programme

Norway

The NT-Programme run in Northern Norway is a regional scheme directed at the 150-200 most innovative enterprises in the region, which have the ability and willingness to move their location to the northern part of Norway. Almost all the participants are SMEs. The NT-Programme was launched in 1987 and has the following components: First, it offers financial assistance to enterprises for the development and marketing of new products. Second, the programme promotes co-operation between competence milieus and enterprises through interactions based on scholarships. Participating companies have to establish contacts with external resource people who have a high level of competence and a well-established network. Third, the scheme aims at increasing competence and networking via seminars and meetings.

According to the evaluation, the programme has been successful in identifying a group of firms with high innovative potential. Customer orientation is seen as one of the major success factors, i.e. the needs of the enterprises are given high priority. A considerable number of product innovations have been commercialised and sales have increased. This is partly due to the heavy involvement of the companies, as the contact person of the company pushes the progress in the projects. The NT-Programme has also been able to increase the ability and opportunity of the enterprises to explore new markets (e.g. market investigation), to integrate innovation as an internal process within the companies, and to achieve effective leadership. Location in the northern part of Norway makes the programme well suited to the economic conditions and traditions of the region.

The NT-Programme is run by an independent organisation located in the Tromsø Science Park and is financed by the Norwegian Industrial and Regional Development Fund (SND), which was founded by the government. In 1999 and 2000 it had a budget of about 3.3 to 3.6 million Euro.

Source: Isaksen, A., Evaluering av nyskappings- og teknologiprogrammet for Nord-Norge (NT-programmet) (Evaluation of the Innovation and Technology Programme in Northern Norway (NT-Programme)). STEP rapport 1996:1, Oslo.

Chapter 6

Conclusions and policy issues

High-tech firms play an important role for the competitiveness and growth of economies and for ensuring and improving high living standards. Society and governments are responsible for appropriate framework conditions and environments guaranteeing the potential economic contributions of these enterprises to materialise. High-tech SMEs are therefore an essential field of activity for economic policy. This chapter attempts to work out some policy implications from the results of the report.

Insufficient data available on high-tech SMEs

The discussion on the definition of and data availability for high-tech SMEs in this report suggests that commonly used and accepted definitions are either too broad, e.g. the 'innovative' firm, or too narrow, e.g. the patenting firm, or both at the same time, e.g. sector approaches. Ad hoc and national statistical exercises might sporadically apply more appropriate definitions and methods, which of course are not directly comparable with each other. Consequently a unique empirical database on European high-tech enterprises is lacking. Clear, unambiguous and comparable information and data are, however, a prerequisite for making decisions and taking action in policy. An improvement of the degree and quality of information on high-tech firms calls for more coherent and tailored databases (definitions, methods, data up-raising, etc.) and a co-ordination of such efforts at European level.

Consideration of external effects is important when assessing the economic impact of high-tech SMEs

The data available show that variation in performance among high-tech SMEs is high, which reflects the risk involved in innovation activities. Only a very small fraction of high-tech firms are rapid growers. The size and weight of high-tech enterprise relative to the entire economy in terms of number of enterprises and employment is not overwhelming. Due to this, the overall direct impact on the economy seems to be limited.

However, the importance of new technologies and highly innovative businesses probably goes far beyond their direct contribution to value added and employment. Significant spill-over effects to the rest of the economy, multiplier effects and considerable social returns on innovation are assumed to exist, but also negative external effects of introducing new technologies and innovation might prevail. Consequently, for an adequate assessment of the economic impact of the activities of high-tech SMEs external effects have to be taken into account. Although capturing external effects is difficult from a methodological point of view, further research into this area could deliver additional valuable knowledge.

Making skilled labour available

The empirical data available confirms that skill shortages (mostly for highly educated technicians, engineers, e-business professionals) indeed represent a top barrier to development for European high-tech SMEs. As shown in this report, the problem is definitely rooted in a supply or availability gap rather than in a mere mismatch situation. Therefore, mobilising a possible hidden potential is limited (because it does not really exist), and encouraging European cross-border mobility and improving labour market information (vacancies and job seekers) will have minor effects only, even though these measures are still important. The main strategy has to be seen in making available a workforce with the required competences and knowledge.

One option is to take in experts from outside Europe, although, however, the externalisation of education and training should not be regarded as the core strategy in the long term. With respect to the European (future) workforce, the up-take of the required qualifications by the population has to be stimulated. This can be done by economic incentives but has to be supplemented by information activities and formation of opinion. The education system and institutions have to be adjusted to the requirements (curricula, PCs in schools, etc.). Furthermore, it seems reasonable to bring down the learning of modern skills to lower educational levels in order to reduce the period of training and to attract additional individuals being averse to longer education periods. Firms have to be supported in their efforts to conduct internal training and it appears to be highly important to involve them as much as possible in training programmes, especially when new and/or rather company specific skills are concerned. This has shown to be a success factor in some of the support measures analysed in this report.

Considering the future demographic trends in Europe, promoting further life-long learning seems a necessity. In a dynamic environment people should be given the chance to alter their initial education. Sufficient, fairly short training tracks have to be available for that purpose.

Improving the functioning of external equity financing

The situation of highly innovative SMEs with regard to obtaining finance is characterised by a number of specific features, which in principle make it more difficult for them to access finance and which may cause market failures (e.g. high risk/uncertainty, long development periods, intangible rather than tangible assets, information asymmetry). These conditions make debt/bank financing appear less appropriate. In contrast, private equity and venture capital is a frequently mentioned financing option. However, empirical data put forward in this report show that venture capital remains an option only for a small elite of enterprises. Also, raising capital from stock markets ('new markets') is by no means an option for the majority of (smaller) high-tech businesses. Business angels seem to be comparably more widespread and also more adequate for the smaller firms. But many entrepreneurs are reluctant to take in business angels in order to avoid a loss of independence (which also holds for venture capital) and it is difficult to match businesses with business angels.

In market economies, it is obviously not the function of governments to act as venture capitalists (due to conflicting goals/interests). What is more, policy measures may help to overcome prevailing barriers in the functioning of these financial markets, for instance, by assisting to develop and run a 'market' for business angels and businesses. Further, as enterprises using business angels or venture capital indeed value their non-financial support, distributing success stories could contribute to reduce respective objections of other entrepreneurs (and eventually also bring in urgently demanded management competences; see Section 4.3.3). Policies could also address the problem of information asymmetry by supporting technology and commercial appraisal (through independent experts) as shown in an example from Switzerland presented in this report. Providing framework conditions for reporting, documenting and assessing intangible assets of companies would also improve their situation with respect to obtaining finance.

Enhancing interaction with universities and research institutions

Universities and similar research bodies hold an enormous stock of knowledge, however, their importance as a source of know-how for smaller high-tech firms is still quite limited. Fostering collaboration between small high-tech companies and universities primarily calls for a re-organisation of the university system, as the reason for the poor university-business interaction basically lies in incompatible structures on the side of firms and universities respectively (different aims, culture, etc.). A comparison with the US system suggests to strengthen decentralisation, competition and inter-disciplinarity within universities and to facilitate labour mobility between academia and business. Changing the framework for university funding and extending the funding possibilities of departments could encourage the entrepreneurial attitude in universities. Small scale projects could function as an entry and initiate first contacts to university members, as personal contacts seem to be a pre-condition for successful technology transfer and resources of SMEs are always limited. Moreover, the instrument of science parks has shown to provide a good basis for co-operation with research organisations and universities.

Facilitating network establishment and co-operation

For high-tech SMEs networks are an important success factor in performing innovation projects and tapping the required information and know-how. As this report has shown there are several business areas where economies of scale exist (e.g. R&D, internal training, etc.) and networks make possible the sharing of such costs as well as

risk sharing. However, the report also indicates that smaller innovative enterprises often express an unfavourable attitude towards co-operation and that there is often a lack of a 'co-ordinator' for the network.

Although establishing networks and co-operation among high-tech SMEs is primarily a duty of the businesses themselves, policy may facilitate the process by, reducing reservations against networking through examples of success stories (as in the case of business angels). Furthermore, agencies co-ordinating networking activities and instruments initiating collaboration are commonly used policy concepts already. Support programmes in the field of networking analysed in this report suggest that co-operations should include supplier-customer-relationships to be successful.

Developing management competences

In high-tech SMEs, the dynamic market conditions and the risk involved in high-tech business require excellent managerial skills. However, empirical evidence shows that many high-tech entrepreneurs have an excellent education and experience in their specific scientific area, but lack business management capabilities (mostly related to the management of exactly those crucial resources being subject to this report). This constitutes a serious threat to their survival and an obstacle to their development.

Basically this calls for respective training for the entrepreneurs and would-be entrepreneurs. Technical education paths at all levels should be enriched with managerial subjects. In this context it seems somewhat peculiar that it is mainly business universities and business schools where additional instruments like training firms and departments for entrepreneurship had been implemented. Clearly, management skills can be taught in the form of further training as well, e.g. in the frame of business incubators.

Relevant areas to be addressed are: market assessment and research, human resources, networking, patenting and licensing, cash management, etc. New marketing methods, such as market experimentation and probe-and-learn approaches, as well as latent-need research and lead users analysis are seen to be useful tools for high-tech SMEs¹⁶⁷. This seems to be particularly relevant when considering the importance of customer orientation as a success factor (see also below).

Moreover, insufficient skills and experience in management can be tackled by means of consulting and mentoring. Also, the relevance of managerial inputs from business angels becomes immediately apparent in this context.

Facilitating and supporting internationalisation

Internationalisation is crucial for high-tech firms since the national market, in particular in small economies, are often too small for a sophisticated niche product. Significant economies of scale in R&D are also playing a role in this respect (see Section 3.2.2). Internationalisation can be facilitated first through reducing administrative and legal barriers in entering new markets (legal harmonisation in different fields, e.g. product related) and second via financial assistance and support services.

Conclusions related to the design of support programmes

Emphasising customer orientation and service has been identified as an important and specific success factor of high-tech SMEs in general. It comes as no surprise therefore that, at the same time, customer orientation seems to be one of the major reasons for the success of the support programmes presented in this report. The Swiss programme CTI, for example, is giving high priority to the marketability of promoted projects through all phases (evaluation of application, developing business plans, etc.). Also PRO-INNO from Germany pays attention to the market orientation of projects and, as previously mentioned, to the involvement of customers in research and development co-operations.

Another important aspect for the success of some types of support programmes is a strong involvement of the businesses and an orientation towards company needs respectively. This holds especially for measure in the field of training as shown in Section 4.2.2, and in the above mentioned programme from Germany the set-up of co-operative projects with research institutions is mainly based upon the needs of the businesses.

¹⁶⁷ Day, George S., Paul J.H. Schoemaker, A Different Game. In Wharton on Managing Emerging Technologies (Eds. George S. Day, Paul J.H. Schoemaker, Robert E. Gunther). John Wiley & Sons, Inc.: New York, pp. 1-23, 2000.

Diversifying the product range at an early stage to reduce risk has been identified as a general success factor, too (Section 3.2.4). As for customer orientation, it might be reasonable to take the aspect of product diversification into account in different phases of support programmes.

Finally, attention should be paid to considering external effects (see the discussion above) in the context of designing, targeting, and selecting projects and applicants and evaluating policy measures. For example, direct job creation should not necessarily be given top priority as an eligibility criteria in measures promoting high-tech SMEs.

Annex I

Basis for classifications applied in the report

Manufacturing industries classified according to their global technological intensity
(Source: OECD 1997¹⁶⁸)

	NACE
High-technology sectors	
Space and aviation	353
Computers and office machinery	30
Electronics-communications	321-322
Pharmaceuticals	244
Medium-high technology sectors	
Scientific instruments	33
Electrical machines and equipment	2971, 31, 323
Motor vehicles	34, 352
Chemicals	24, excl. 244
Other transport equipment	354,355
Non-electrical machines	29, excl. 2971
Medium-low technology sectors	
Rubber and plastic products	25
Shipbuilding	351
Other manufacturing	36, excl. 361
Non-ferrous and ferrous metals	27
Non-metallic mineral products	26
Fabricated metal products	28
Petroleum refining	23
Low technology sectors	
Food, beverages and tobacco	15-16
Textile and clothing	17,18,19
Wood and furniture	20, 361
Paper printing	22

This OECD categorisation is based on both the level of technology specific to the sectors (measured by the ratio of R&D expenditure to added value) and the technology embodied in the purchases of intermediate and capital goods.

¹⁶⁸ OECD/Eurostat: The measurement of scientific and technological activities. Proposed guidelines for collecting and interpreting technological innovation data - Oslo Manual, Organisation for Economic Co-operation and Development (OECD) Paris: OECD, 1997.

Definition of the ICT sector (Source: Measuring the ICT Sector¹⁶⁹)

	ISIC rev 3
Manufacturing	
– Office, accounting and computing machinery	3000
– Insulated wire and cable	3130
– Electronic valves and tubes and other electronic components	3210
– Television and radio transmitters and apparatus for line telephony and line telegraphy	3220
– Television and radio receivers, sound or video recording or reproducing apparatus ...	3230
– Instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process equipment testing, navigating and other purposes, except ipe	3312
– Industrial process control equipment (ipe)	3313
Services	
– Wholesaling of machinery, equipment and supplies	5150
– Renting of office machinery and equipment (including computers)	7123
– Telecommunications	6420
– Computer and related activities	72
Biotechnology sectors (Source: elaborated from Stenholm 2000¹⁷⁰)	
– Food, beverages and tobacco (NACE 15, excluding 151,159)	
– Pharmaceuticals and chemicals (NACE 24)	
– Scientific instruments (33)	

169 *Measuring the ICT Sector* (2000) Information Society, OECD. Internet publication, http://www.oecd.org//dsti/sti/it/prod/measuring_ict.htm, situation on 11.7.2001.
 170 Stenholm, Pekka, *Elinvoimainen Turku - Turun ja Turun seutukunnan elinkeinoelämän kehittyminen 1990-luvulla* (Robust Turku - the development of the economic life in Turku and Turku region in the 1990s), Turku School of Economics and Business Administration, Business Research and Development Centre, Series B Research Reports B1, 2000.

Annex II

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