

# Public Research Spin-offs in Germany

## Summary Report

Jürgen Egel, Sandra Gottschalk,  
Christian Rammer and Alfred Spielkamp

Dokumentation Nr. 03-04

# ZEW

Zentrum für Europäische  
Wirtschaftsforschung GmbH

Centre for European  
Economic Research

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## Summary Report

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## 1. Introduction

Like all developed economies Germany has experienced deep **structural change** in the past decades. Service sectors are playing a much greater role than manufacturing sectors not only in terms of employment and value added but also with respect to growth. Simultaneously, there is a considerable shift towards technology-oriented and knowledge-based sectors both within manufacturing and in the service sector. Especially young, innovative firms are active in the new economic sectors. New start-ups in the corporate sector are a driving force influencing the speed of this structural change and the economy's timely orientation towards new and promising technological developments and fields.

The growing importance of knowledge and the ensuing need to translate research results, and especially **new scientific findings** as quickly as possible into economic activities are drawing the attention of academia and politicians increasingly towards what is referred to as academic **spin-off formations**. These business foundations from higher education institutions and off-campus research facilities are a route to knowledge and technology transfer, which can ensure that the research results gathered in these facilities are transferred directly into marketable products or processes. Policymakers are expected to create favourable framework conditions for the formation of spin-offs. Several initiatives of the Federal State and *Länder* (e.g. the EXIST Programme of the BMBF) were started with the express goal of promoting and aiding such new businesses.

Direct political interventions require reliable information about the scope and the development of new spin-offs, their structural characteristics such as the sector they occupy, institutional origin and their research field, or research intensity, about their links to the scientific community, and specific problems and incentives influencing these new ventures. Existing studies on this topic (ADT et al. 1998, Econ-Consult 2000, OECD 2001), however, do not allow any representative statements on actual spin-off activities in Germany.

Against this background, the Centre for European Economic Research (ZEW) conducted a study commissioned by the Federal Ministry for Education and Research (BMBF) aimed at determining the number of public research spin-offs. A **new data collection method** was developed for this study which allows the reliable determination of the absolute number of spin-offs created in Germany, their significance in overall spin-off activities, as well as important structural characteristics of spin-offs.

Following is a short description of the data collection method and the most important findings of the study. This study provides first-time data for Germany on

- The **number of spin-offs from public research institutions**,
- The quantitative **importance of spin-offs** compared to new businesses established by academic entrepreneurs and non-academic entrepreneurs.
- Spin-off activities in the **EXIST regions**,
- **Technology sources** of spin-offs and the **market sectors** they occupy,
- Spin-offs broken down according to different publicly funded research **institutions** and the **propensity** of scientists from these institutions to **form new businesses**,

- The **research-orientation** of spin-offs, their ongoing **contacts** to scientific institutions and their exploitation of **patents**,
- The **motivations** for and **barriers** to spin-offs and the **assistance** provided by scientific institutions,
- The **choice of location** of spin-offs (proximity to the incubator, region of the location),
- The impact of spin-offs on **employment and job creation**, and their **success factors**.

## 2. Data collection method

Parallel to the attention that scientific spin-offs have captured in recent years, efforts were made to keep track of the quantitative magnitude of this phenomenon. Until recently, studies focused on specific regions or institutions, which attempted to gather data on the number and structure of spin-off formations for individual institutions or locations by way of case studies (cf. e.g. Backes-Gellner 1998, Otten 2000, Knecht 1997, Technologiefabrik Karlsruhe 1997, Volmerig and Knaup 1999). There are, however, only few nation-wide studies, and they do not allow for any extrapolations of spin-off figures for Germany as a whole because of their focus on specific subsectors or types of spin-offs (e.g. Richert and Schiller 1994 for data on the *Deutsche Ausgleichsbank*; Schmude and Übelacker 2001 for German universities; Holtkamp and Imsande 2001 for specific university and college graduate classes). The 1998 **ATHENE** study was the first comprehensive attempt to establish the number and structure of academic spin-offs (cf. ADT et al. 1998). But even this study yielded only rough quantitative findings and many relevant issues were not investigated.

The main **drawback** of these studies is the **methodology** that was applied to gather data on spin-off formations. Similar to nearly all the other empirical studies on spin-off formations – and even international studies (cf. OECD 2000) – ATHENE focused primarily on scientific institutions (heads of institutions etc.) or intermediaries (transfer offices, technology and start-up centres) and attempted to gather information about spin-off activities there. In general, however, heads of institutions and transfer offices only have information about one facet of new business formations in their area of responsibility. Heads of institutions are probably well informed about new ventures established by academic staff members who left the facility only recently. But often they do not have enough information about staff that left the facility not so recently, about start-ups established by former employees who were then in dependent employment, or about new businesses initiated by graduates or students. Transfer offices and incubators can only provide limited information, because of the simple fact that many spin-offs are established without any links to transfer offices or outside an incubator. Even if heads of institutions or intermediaries know about emerging spin-offs, they nevertheless have hardly any information about relevant characteristics of the companies and aspects of the spin-off process (e.g. barriers, motivations, performance).

In most cases, therefore, interviews with heads of institutions or intermediaries will yield a rate of spin-offs from the respective facilities that is too low. Here are two examples to illustrate this finding: during an analysis of 47 regional start-up networks at higher education institutions that took part in the EXIST competition but did not belong to the winning networks the transfer offices stated that a total of 1,400 spin-offs emerged from higher education institutions from 1997 to 1999 (cf. Econ-Consult 2000, 14), whereas this study (with a much

narrower definition of the term “spin-off”) elicited a total of 12,000 spin-offs generated by these institutions in the respective period, i.e. a number that is eight times as high as the previous result. In interviews on the new business climate at universities (Schmude and Uebelacker 2001) transfer offices of 53 universities reported a total of approximately 900 spin-offs, while this study generated a figure of more than 8,000 spin-offs. For this reason, conclusions based on information provided by intermediaries result in a **considerable underestimation** of spin-off activities at Germany’s higher education institutions.

This study pursues a **new path** for data collection on spin-off formations which avoids the drawbacks of former studies:

- Instead of scientific institutions or transfer offices and incubators the **new businesses** are used as information base (panel).
- A random sample was selected from the **population** of all new businesses for interviews. Since spin-offs are very likely to focus on activities that demand a high degree of research and knowledge, we only analysed start-ups in research and knowledge intensive industries (cf. Box 1). We applied such a broad definition that one can assume with good reason that the overwhelming majority of spin-off formations occurs in these industries.
- Data on the population of all start-ups in Germany in these industries are collected in the **ZEW Foundation Panels** (cf. Box 2). A stratified random sample is drawn according to the following criteria: year of foundation (1996 to 2000), sector group (cf. Box 1) and region where

### *Box 1: Research and knowledge-intensive industries*

Research and knowledge-intensive sectors cover three groups of industries:

- Manufacturing sectors with a high share of research and development (R&D) expenditures in turnover, e.g. chemicals and pharmaceuticals, mechanical engineering, electronics and communication equipment, computers, automobile and transport equipment, precision and optical instruments, and technology-intensive subsectors within traditional manufacturing such as technical textiles, technical ceramics, technical plastics, special metals etc. (**high-tech manufacturing**).
- Service sectors which strongly rely on the use of new technologies, e.g. software/IT consulting, technical offices, physical and chemical analysis, research services, telecommunications, media technology (**technology-oriented services**).
- Service sectors where highly qualified staff or generally the exploitation of (new) knowledge are decisive for a competitive edge, e.g. business and tax consulting, education, media and publishing, health services, advertising (**knowledge-intensive services**).

In the second half of the nineties one fourth of all start-ups in Germany were established in research and knowledge-intensive sectors.

### *Box 2: ZEW Foundation Panels and definition of business foundations*

In cooperation with the German credit rating agency CREDITREFORM the ZEW has developed panels on firm foundations in West and East Germany since 1989. CREDITREFORM provides the base data every six months which are obtained from corporate information that is regularly collected by its approximately 135 regional offices. The ZEW integrates these data into a panel structure, carries out quality controls and analyses the number of start-up figures for different kinds of sectors and regions (cf. Engel and Fryges 2002, Almus et al. 2000).

In the ZEW Foundation Panel all **business foundations** are regarded as new business foundations in legal terms if

- They perform corporate activities that have not been carried out before, and
- if they are economically active on the market to such an extent that corresponds at a minimum to the full-time activity of one person (“economically active new firms”).

Company conversions, the establishment of associated companies, new business establishments due to relocations, secondary occupations, bogus self-employment etc. are not regarded as business foundations. For the purpose of this study self-employment (doctors, lawyers, architects etc.) is not defined as a business.



the start-up is located (winning regions in EXIST, regions that participated in the EXIST competition with a follow-up on the idea outlines [see Econ-Consult 2000], and the remaining regions).

- We interviewed entrepreneurs who had established start-ups from 1996 to 2000. Interviews with more than **20,000 new businesses** (conducted interviews) rendered a large enough absolute number of observations in order to **project** the results with a sufficiently small statistical error probability onto the population.
- The interviews were conducted by means of **Computer Assisted Telephone Interviews (CATI)**. This method ensured a high willingness to participate and data quality. Companies that responded to the questions accounted for 68% of all companies where successful contacts were established. In addition, the CATI method allows data collection from companies that did not want to participate in the interviews (non-response analysis).
- Spin-off formations are identified with a combination of filter questions about the **academic background** of the entrepreneurs (higher education, scientific activities) and the role of new **research results** from science, new **scientific methods** or special **skills** acquired in science (cf. Box 3) to start new businesses. This methodology allows us to classify start-ups according to their science orientation, and according to the type of knowledge and technology transfer, and the importance of knowledge and technology transfer for the business formation.
- Data gathered on every spin-off also include the **concrete public research institutions** (higher education institutions, research institutes/centres) from where the knowledge for the formation originated, or where the founders worked in the scientific field. This allows us to determine the propensity to create spin-offs at different public research institutions in Germany (cf. Box 4).

*Box 3: Questions used for the identification of spin-off formations*

The following questions were asked concerning a spin-off founded by a scientist:

- Were **special skills** which you acquired during your activities at the scientific institution (a) indispensable, (b) of high importance (c) of low or even no importance for starting your business?
- Were **new, scientific methods or techniques** which you acquired during your activities at the scientific institution (a) indispensable, (b) of high importance (c) of low or even no importance for starting your business?
- Were the **results of your own research activities** at the scientific institution, for instance, the development of a new product or new services (a) indispensable, (b) of high importance (c) of low or even no importance for starting your business?

The wording of the questions was adapted to other start-up contexts (start-ups established by academic teams, graduates or students, or by other companies).

*Box 4: Public research institutions in Germany*

- **Higher education institutions** (universities, technical colleges, other higher education institutions)
- **External research institutions** (Fraunhofer Society, Max Planck Society, Helmholtz Society of German Research Centers, Leibniz Society ["Blue List"])
- **Research labs affiliated with government ministries, research institutions of the Länder** (incl. Academies of Sciences) and other research institutions that are largely publicly funded.
- Vocational colleges and academies for administration

The survey was conducted by the company *Sample QM – Gesellschaft für Qualitätsmanagement* from October to December 2001.

### 3. Public research spin-offs

Germany - as well as all other highly developed countries - is evolving towards a **knowledge-intensive economy** (cf. BMBF 2000a, 2001, 2002a). This development has created a greater awareness of "knowledge" as a production factor among companies and policy makers. In this context, it is particularly the knowledge that is generated in publicly funded research institutions that is found to play a vital role for the economic disposition of companies. The economic exploitation of insights, results, methods or know-how from the scientific sector is expected to increase corporate competence, boost companies' technical performance, and improve their opportunities on international markets. In the past few years, a lively debate with the catchwords "Knowledge creates Markets" has been going on about the different facets of knowledge and technology transfer between science and economy with the purpose of improving the exploitation of knowledge generated in science.<sup>1</sup>

But to actually realise such a **transfer**, public research institutions need to generate first of all new scientific findings which can then be developed into new ideas, new products, new services, new technologies, new processes, or new types of organisation. Furthermore, these innovations need to be transferred from science to the corporate sector so as to be integrated into the economic development and to promote this very development, if necessary. In principle, many different routes can be used to exploit scientific insights (cf. Schmoch et al. 2000). Scientists involved in research can follow one of these routes by starting a company – a **spin-off** – to commercialise their insights.

The issue of "spin-offs" is part of the lively debate on "new business foundations" which has been going on for years in economic policy. It focuses particularly on new business ventures in research and knowledge-intensive manufacturing or service industries. Start-ups in these industries, and especially spin-offs generated from publicly funded institutions, are regarded as playing an important role for economic restructuring. Policymakers have diverse and demanding expectations towards spin-offs:

- They are expected to rapidly disseminate scientific insights and methods in industry (**diffusion**).
- They are regarded as an important route to knowledge and technology transfer which may also stimulate direct cooperation between academia and industry (**transfer**).
- They are seen as an important medium in the public research sector that facilitates the commercial exploitation of research results (**commercialisation**).
- They are viewed as an important element in the structural change towards a knowledge-intensive economy and are expected to tap new employment potentials in rapidly growing industries (**employment**).

In the political discussion spin-offs are seen as an **efficiency benchmark** for the science sector, because they can be used as a vehicle to directly transfer the results of scientific

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<sup>1</sup> The action programme of the federal government "Knowledge creates Markets" describes four fields of action: proactive exploitation, spin-offs, partnerships and competence. The programme was launched in 2001 jointly by the Federal Ministry for Economy and Technology (BMWi) and the Federal Ministry for Education and Research (BMBWF).

work into economic sectors which are believed to have high growth potential throughout the world. Especially in times of increasing importance of knowledge it has become crucial to provide the economy with original (knowledge-based) products and business ideas. If this mechanism really works as hoped and produces the expected effects, spin-offs might sweep through the economy like a wind of change, thus inducing yet another structural change.

#### 4. The role of spin-offs in new business activities

Scientific spin-offs are a heterogeneous group of new businesses. Depending on the aspect you focus on spin-offs are defined as new businesses created to exploit new research results or patents developed by research institutions, or as all new businesses created by scientists, or as all new businesses created by students or graduates of higher education institutions (cf. OECD 2000, Callan 2001). The purpose of this study is to differentiate between these new business types and to determine their quantitative importance in Germany as well as their specific characteristics.

##### Classification of business foundations and business start-up figures

This study focuses particularly on new businesses emerging from **research and knowledge-intensive industries** (cf. Box 1). They comprise new firms started by at least one person who has studied or worked at higher education or other public research institutions – here referred to as **academic new businesses** – and others where no graduates or academics were involved. These **non-academic new businesses** are subdivided into non-academic businesses carrying out R&D continuously or occasionally (with R&D activities) and non-academic businesses without R&D activities.

Academic start-ups, in turn, are divided into **spin-offs** where new, concrete insights, methods or special skills, which the founders acquired in the science sector were **indispensable** (cf. Box 3), and **academic start-ups** where these factors were not regarded as an essential prerequisite to start a new business. Some of the academic start-ups did not require any new scientific insights or methods. They are based on business ideas and concepts which were developed independently from science and are thus referred to as **start-ups without transfer effects**. Start-ups where links to science played a major role, but were not indispensable for a new business are classified as **academic start-ups with transfer effects**.

Spin-offs, namely firms whose links to science were the vehicle for their formation are distinguished as to whether

##### Box 5: Spin-offs and academic start-ups

Spin-offs are firms where **new knowledge** or the **specific competencies of public research institutions** were **indispensable** for their formation.

- **Transfer spin-offs:** one of the founders was involved in producing new research results or scientific methods which were indispensable to create a spin-off.
- **Competence spin-offs:** special skills which one of the founders acquired at a scientific institution were indispensable to create a spin-off.

Spin-offs are first and foremost started by scientists, graduates, or students. Transfer spin-offs, on the other hand, may also be generated by persons outside of academia or by other companies (knowledge acquisition via cooperation or licenses). These spin-offs, however, have only minor importance in terms of quantity.

**Academic start-ups** comprise all firms started by persons with higher education exclusive of spin-offs. "Start-ups with transfer effects" are started by academics for whom new research results from science were of high importance, although they were not indispensable. Together, spin-offs and academic start-ups constitute the group of **academic new businesses**.

concrete research results or new methods were part of the spin-off project (**transfer spin-offs**) or whether special skills and knowledge which one of the founders acquired in science were indispensable for the new business venture (**competence spin-offs**). If the business shows both characteristics it is classified as transfer spin-off.

Based on the average of the years 1996 to 2000, slightly more than 250,000 firms were started in Germany **each year** (Fig. 1; see Box 2 for a definition of business foundations). One fourth of these business foundations (just under 65,000) were established in research and knowledge-intensive industries, while three fourths (more than 190,000) emerged in the distribution sector, hotels and restaurants, the construction industry, transportation, non-knowledge-intensive business services, consumer-related services and the non-research-intensive manufacturing.

Fig. 1: Different types of business foundations and business start-up figures in the second half of the 1990s (average annual number of business foundations in Germany)

Business foundations in all sectors (255,800)					
Business foundations in research and knowledge-intensive sectors <sup>1</sup> (64,400)				Business foundations in other sectors (191,400)	
Academic new businesses (37,700) <i>classified as...</i>			Non-academic new businesses (26,700)		
<b>Spin-offs</b> (6,800) <i>Based on new knowledge / new technologies from public research. which are transferred through ...:</i>		Academic Start-ups (30,900) <i>Knowledge/technology is a side-effect. For the business it is of...</i>			
<b>Transfer spin-offs</b> (2,600) <i>... exploiting research results</i>	<b>Competence spin-offs</b> (4,200) <i>... exploiting competencies</i>	Start-ups with transfer effects (7,600) <i>... high importance</i>	Start-ups without transfer effects (23,300) <i>... low / no importance</i>	With R&D activities (4,700)	Without R&D activities (22,000)

<sup>1</sup> Research and knowledge-intensive sectors comprise high-tech manufacturing as well as technology-oriented and knowledge-intensive services.

Note: see Box 2 for a definition of the term "business foundation".

Source: ZEW Foundation Panels, ZEW Spin-off Survey 2001, expanded values.

In research and knowledge-intensive sectors **academic new businesses are dominating the new business activities**. In the second half of the 1990s academics were involved in the formation of nearly 38,000 firms each year, thus accounting for 60% of all new businesses in these sectors. By contrast, just under 27,000 firms were founded without the involvement of graduates or academics. These figures give proof to the fact that high qualifications are a prerequisite for entrepreneurial activities in sectors, where new knowledge and internal research activities are a crucial factor for competitiveness.

In the second half of the 1990s **approximately 6,800** spin-offs from public research institutions were founded in Germany each year. They transfer new knowledge, new research results, or special skills from publicly funded science (cf. Box 4 for a classification) to industry. They account for 18% of all academic new businesses. However, in most of the business foundations where graduates or academics are involved this transfer aspect is not the main purpose of the new business. Each year approximately 31,000 of these **academic start-ups** were generated, that is 82% of all academic new businesses.

### **Quantitative importance of spin-offs**

Out of the about 38,000 academic businesses founded each year **2,600** firms stated that new research results from public research institutions were indispensable for their formation (Fig. 2). These **transfer spin-offs** thus represent 1% of all new businesses set up in Germany. They account for a good 4% of all business formations in research and knowledge-intensive industries.

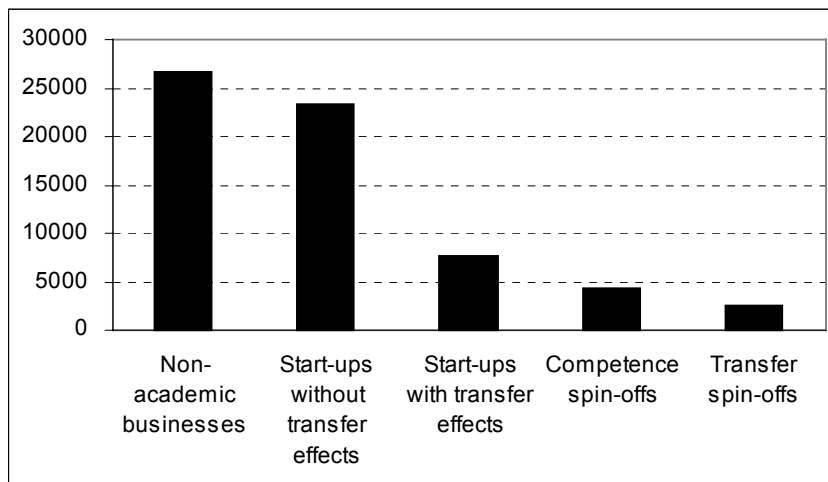
Transfer spin-offs make a vital contribution to **knowledge and technology transfer** between academia and industry. They serve as a vehicle to convert new research results directly into new jobs and more added value. This direct effect is complemented by an equally important indirect effect: the diffusion of new scientific insights. Transfer spin-offs take up research results and new scientific methods and attempt to fully develop and commercialise them as new products or services. They thus also play a part when it comes to disseminating these insights in industry. These innovation may lead other firms to develop more innovations, thus accelerating technological change as a whole. Although it is very difficult to quantify this indirect effect, it should not be neglected.

One needs to draw a line between transfer spin-offs and **competence spin-offs**: the latter are primarily based on specific skills and expertise which the founders have acquired during their studies or scientific activities. Competence spin-offs do not commercialise concrete, new research results. Nevertheless, they contribute to the diffusion of skills and methodological expertise acquired at higher education institutions and other public research institutions. In Germany approximately **4,200 competence spin-offs** are generated each year. In terms of quantity they are thus more important than transfer spin-offs.

All **spin-off formations** – i.e. the sum of exploitation and competence spin-offs – accounted for approximately 11% of all business foundations in research and knowledge-intensive industries and for nearly 3% of all business foundations in Germany in the second half of the 1990s. In addition to the spin-offs, some of the **academic start-ups** also contribute to the knowledge and technology transfer between academia and industry, even though this is not the primary intention of the founders. For the approximately 7,600 start-ups created by

academics (20% of all academic new businesses) the exploitation of new scientific insights assumed high importance for the decision to start a business.

Fig. 2: Annual business start-up figures in research and knowledge-intensive industries in Germany in the second half of the 1990s

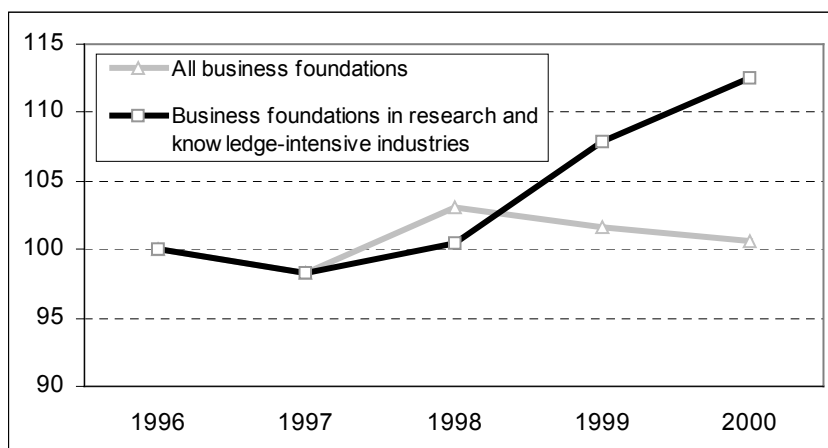


Source: ZEW Spin-off Survey 2001, expanded values.

### Development of spin-offs and academic start-ups from 1996 to 2000

During the study period from 1996 to 2000 the number of new businesses created each year in Germany in total, i.e. in **all industries**, did not change significantly. In line with the trend it remained constant with about 250,000 business foundations per year. Business foundations in the research and knowledge-intensive sectors show a different picture. Through the years 1999 to 2000 they recorded a notable annual average growth of about 6% (Fig. 3).

Fig. 3: Development of business start-up figures in Germany 1996-2000 (1996 = 100)f



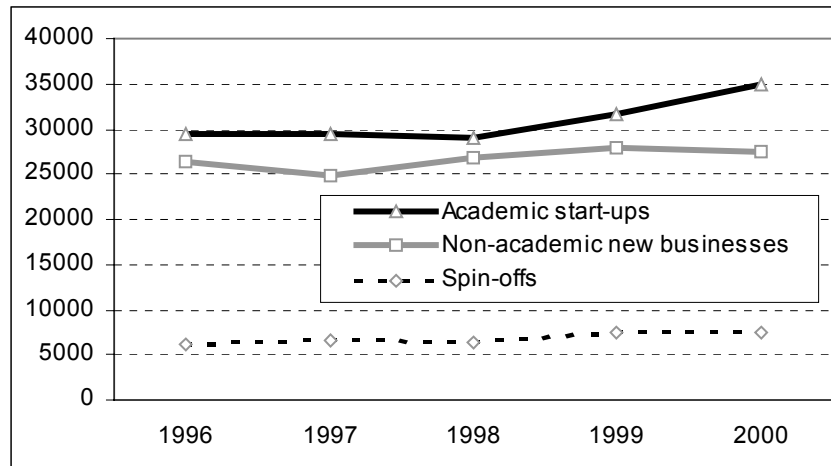
Source: ZEW Spin-off Survey 2001, expanded values.

Apparently, potential founders feel that these industries offer more profit opportunities than one would normally expect for the economy as a whole. This separate development is also reflected in the structural shift towards an increasingly knowledge-intensive economy (cf. BMFB 2001). In 2000, approximately 70,000 new businesses were started in research and



knowledge-intensive industries, in 1998 this figure was about 62,000 (Fig. 4). This “**start-up boom**” affected above all the knowledge-intensive services such as IT, multimedia, telecommunications and corporate services and was closely linked to the “New Economy” euphoria of that time.

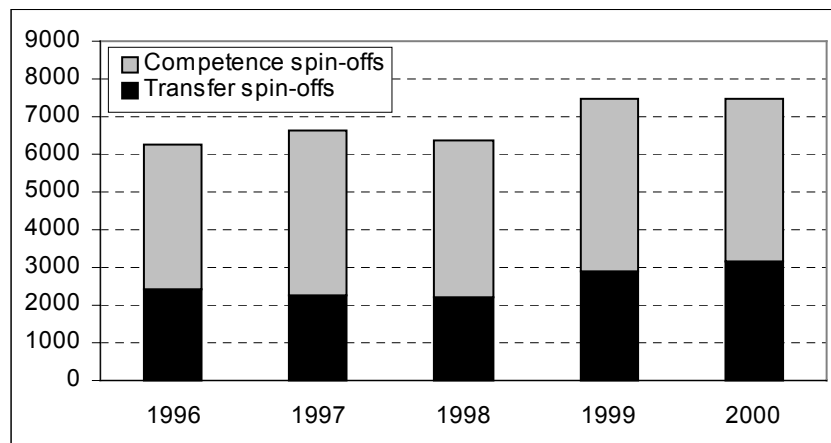
Fig. 4: Development of business start-up figures in research and knowledge-intensive industries in Germany 1996-2000



Source: ZEW Spin-off Survey 2001, expanded values.

In terms of quantity it was the **academic new businesses** that drove the boom. They are the main buttress for structural change towards research and knowledge-intensive industries that was driven by business foundations. The number of academic start-ups created each year increased from 30,000 (1998) to 35,000 (2000), i.e. by nearly 20%. On the other hand, the number of non-academic start-ups in these economic sectors remained nearly constant from 1996 (and thus also from 1998) to 2000.

Fig. 5: Number of spin-offs started in Germany from 1996-2000



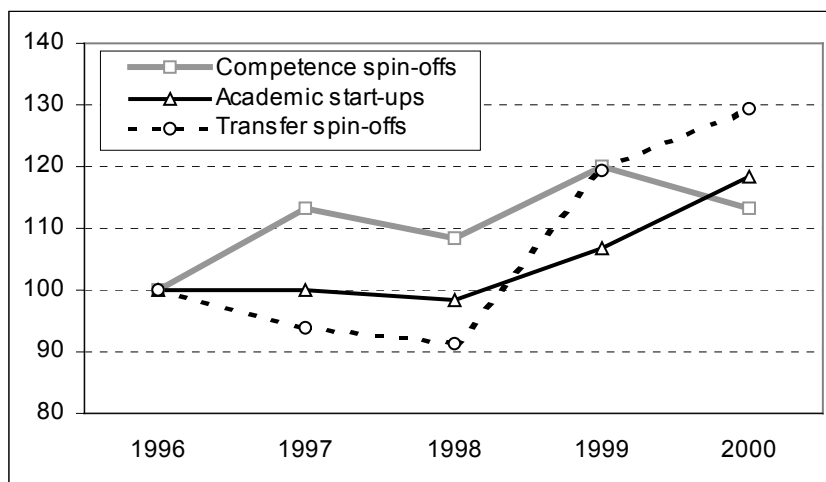
Source: ZEW Spin-off Survey 2001, expanded values.

Although the total number of new **spin-offs** (exploitation plus competence spin-offs) **rose** in the second half of the 1990s (from less than 6,300 in 1996 to nearly 7,500 in 2000, Fig. 5), they account only for a small part of the absolute increase in business start-up figures due to their small share in overall new business activities. In 1999 and 2000, however, the number

of new spin-offs soared. This reflects the general rise in business start-up figures in research and knowledge-intensive industries in these two years.

In the years 1999 and 2000 the number of **transfer spin-offs** showed an above-average increase. The year 2000 saw the creation of about 40% more transfer spin-offs than in 1998 (Fig. 6). In absolute terms the number climbed from 2,200 (1998) to more than 3,000 (2000). It seems as if these companies based on the commercialisation of new research results made special use of the particularly favourable growth opportunities of that time for new products and services derived from new technologies (IT, biotechnology etc.) to go on the market.

Fig. 6: Development of spin-offs and academic start-ups in Germany 1996-2000 (1996 = 100)



Source: ZEW Spin-off Survey 2001, expanded values.

By contrast, the number of **competence spin-offs** increased only slightly; in 2000 it even declined compared to 1999. The overall increase in the number of competence spin-offs between 1996 and 2000 was slightly lower than that of academic start-ups. Competence spin-offs were not so much affected by the start-up boom of the New Economy, since their competitive edges are based on the individual competencies of the founders and not so much on new developments of emerging technologies.

### Sectoral distribution

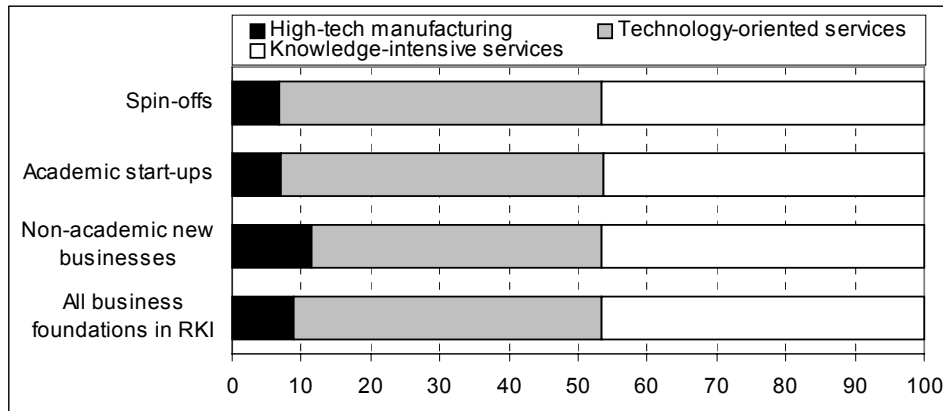
Start-up activities in research and knowledge-intensive sectors are focusing on the service sector. Business foundations in the research-intensive manufacturing sector ("high-tech manufacturing") account for no more than 10% of all new firms in these industries, whereas technology-oriented services (e.g. software, technical offices) and knowledge-intensive services (e.g. business consulting, advertising, media, education) each account for about 45% of all business foundations in research and knowledge-intensive industries. This pattern remained stable over time, even though knowledge-intensive services increased since 1998 to the detriment of **high-tech manufacturing**.

Spin-offs also show this general industry pattern (Fig. 7). The overwhelming majority of spin-offs is generated in the **service sector**. Nine out of ten spin-offs exploit new research findings or special skills acquired in science to launch new services on the market. New businesses in **high-tech manufacturing** account for 7% of all spin-offs, that is two



percentage points less than the average number in research and knowledge-intensive industries.

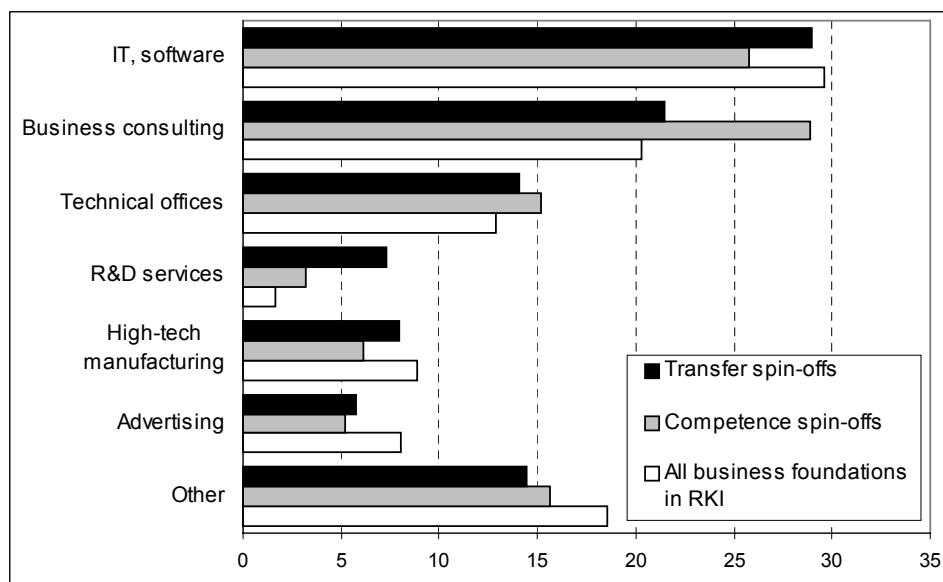
Fig. 7: Business foundations in research and knowledge-intensive industries (RKI) in Germany 1996-2000  
Percentage share in sector groups (% shares)



Source: ZEW Spin-off Survey 2001, expanded values.

**IT and business consulting** (Fig. 8) are the most important sectors for spin-offs. They are equally important for all types of business foundations in research and knowledge-intensive industries. An above average share of **transfer spin-offs** is founded in the R&D service sector. Here, new scientific processes and methods are used in order to implement research and development projects for other companies – in particular for those in high-tech manufacturing. **Competence spin-offs** are very frequently found in knowledge-intensive consulting services where they can excel in their specific skills.

Fig. 8: Sector composition of spin-offs started 1996-2000 in Germany in research and knowledge-intensive industries (RKI) (% shares)



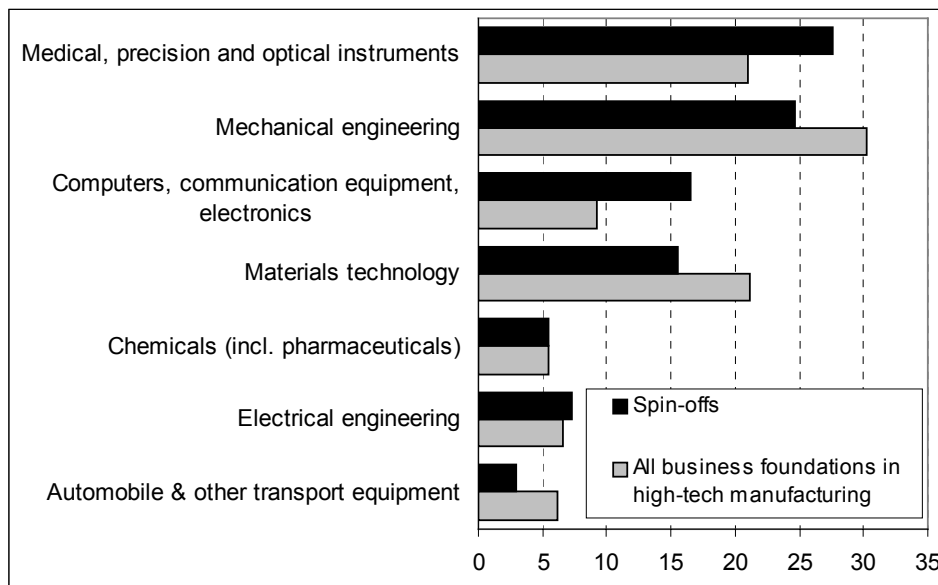
Source: ZEW Spin-off Survey 2001, expanded values.

In terms of absolute figures spin-offs in **high-tech manufacturing** only play a minor role. This, however, has to be seen against the background of the low total number of new

businesses started in these sectors. On the other hand, spin-offs are dominating business foundation activities in some sectors of high-tech manufacturing: at the end of the 1990s between 50 and 80 transfer spin-offs emerged in **biotechnology** each year, compared to about a total of 120 new businesses started annually in biotechnology (core companies and biotech users, see Ernst & Young 2000, 2002). Spin-offs assume similar importance for business start-up figures in the medical and optical instruments, or computer industry.

Spin-offs are represented above average (Fig. 9) in sectors referred to as "top-technology" manufacturing (cf. NIW and ISI 2000). In these sectors, technical progress is strongly based on new technology breakthroughs, especially and new scientific results. Spin-offs are less important in other high-tech sectors where technological advancements are promoted with cumulative technical progress on already existing technology paths and only to a lesser degree with new scientific insights. These sectors include, for instance, mechanical engineering, automobile and other transport equipment, materials technology, or electrical engineering.

Fig. 9: Sectoral distribution of business foundations in high-tech manufacturing in Germany started 1996-2000 (in %)



Source: ZEW Spin-off Survey 2001, expanded values.

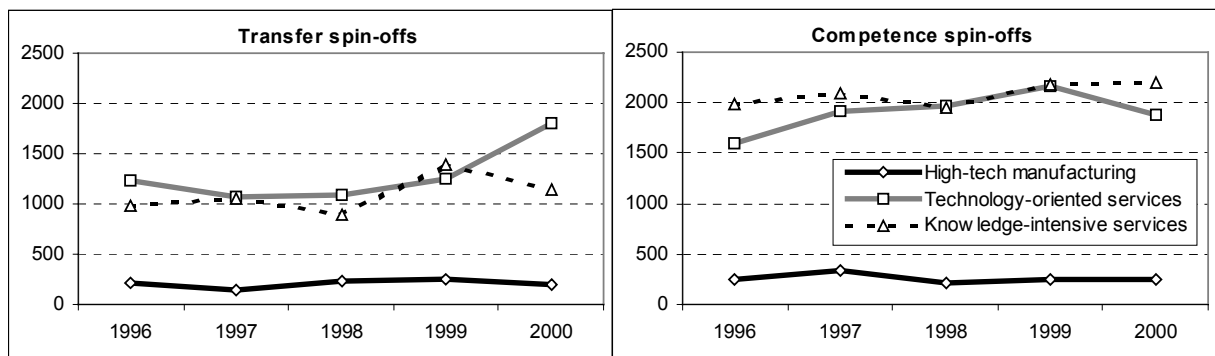
Whilst scientific spin-offs **do leave their mark** in start-up activities in **certain fields of high technology** the number of these spin-offs vanishes in the mass of spin-offs created in the service sectors. This is quite logical, as there is a much greater demand for new software, new methods of business consulting, services based on new measuring and laboratory technologies, or new training methods than - for example - for new biotechnological applications.

Spin-offs are thus not a phenomenon that is limited to only but a few technology areas. Actually, spin-offs providing new, knowledge-intensive services can be found in every commodity market in the research and knowledge-intensive industries. This also shows that new scientific research results cover a very **broad range of applications in industry**.

Limiting the phenomenon of spin-offs exclusively to new firms in high-tech manufacturing does not adequately reflect actual business start-up activities.

The annual **number of spin-offs** between 1996 and 2000 **developed** in different ways in the individual sector groups: in 1999 and 2000 many spin-offs were founded mainly in the **technology-oriented services** (software etc.) while knowledge-intensive and technology-oriented services experienced a rise in competence spin-offs, which lasted only until 1999 in the technology services sector. From 1996 to 2000 the number of business foundations in high-tech manufacturing remained constant for both spin-off types with approximately 200 to 300 new firms per year.

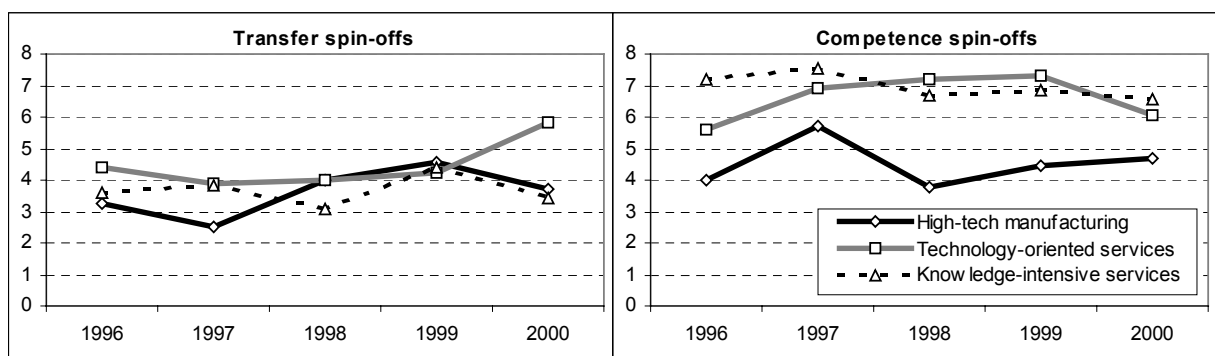
Fig. 10: Number of transfer and competence spin-offs by sector groups started 1996-2000



Source: ZEW Spin-off Survey 2001, expanded values.

The development of the number of spin-offs in the three sector groups reflects more or less the chronological start-up patterns in these sector groups. The relative importance of spin-offs (percentage share in all new businesses started in the sector groups) thus remained almost unchanged in the period under review: in each of the three sector groups transfer spin-offs account for about 4% of all new ventures, their share expanded only in 2000 in the **technology-oriented services**. In each year, competence spin-offs accounted for around 7% of all new business ventures in the knowledge-intensive and technology-oriented service sectors. In high-tech manufacturing they account for 4 to 5% of all business foundations. A marked increase of the importance of spin-offs in start-up activities in the analysed industries cannot be observed.

Fig. 11: Share of transfer and competence spin-offs in all businesses foundations by sector groups started 1996-2000 (in %)



Source: ZEW Spin-off Survey 2001, expanded values.

## 5. Excursus: spin-off activities in the EXIST regions

Various initiatives of the Federal Government and the *Länder* are aimed at stimulating and funding business foundations from higher education institutions and public research institutions in Germany. In this context, the **EXIST-Programme** (cf. Box 6) represents one of the main activities of the Federal Government. Initially it funded five start-up regions; since 2002 the number of EXIST networks has grown to 15.

For the purpose of the survey conducted in this study, the gross sample was stratified taking into account whether or not the new start-ups **were located** in one of the first five EXIST regions. This allows us to project start-up figures of different business foundation types (spin-offs, start-ups, non-academic new businesses) individually to the EXIST regions and to compare EXIST with non-EXIST regions.

It has to be **emphasised** that this investigation of start-up activities in the EXIST regions is essentially a description of the situation before the EXIST programme produced any effects. It was not until 1999 that first steps were taken to implement the concepts and the intended changes at higher education institutions. Approaches aimed at altering the entrepreneurial culture are thus hardly reflected in the actual number of new businesses started in 1999 and 2000, especially when taking into account that very often spin-offs are created many years after the founders left academia or took their degree (cf. Chapter 6). Seen from this perspective, this analysis describes the **initial situation** for EXIST activities rather than their effect.

### Start-up activities in the EXIST regions

An analysis of the **total number of new businesses** in research and knowledge-intensive industries in both the EXIST regions and other regions (non-EXIST regions) reveals that compared to 1996 both regions experienced declines in 1997 and that the number of start-ups has risen again since 1998 (cf. Fig. 12). The number of new businesses in the other regions showed a significantly higher increase than in the EXIST regions where it has been stagnating more or less since 1997. Thus, business start-up activities that were observed for Germany as a whole in the research and knowledge-intensive industries tended to occur outside the regions that had been selected as winners of the EXIST competition.

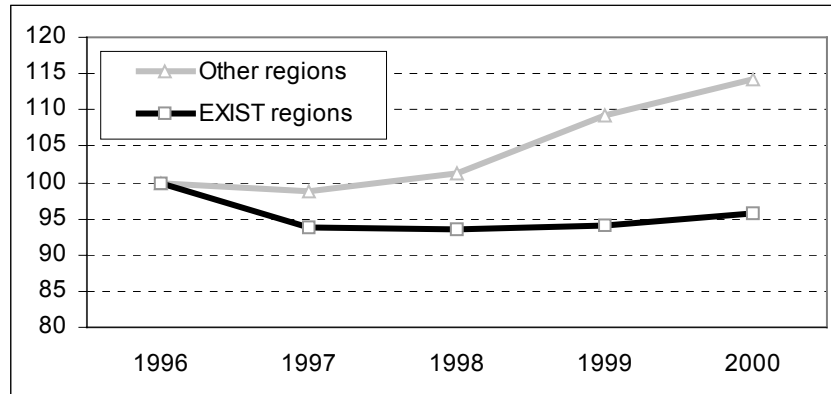
*Box 6: EXIST Programme of the Federal Ministry of Education and Research (BMBF)*

EXIST intends to improve the start-up climate at higher education institutions and to increase the number of business start-ups from academic institutions and by university and college graduates. Next to the goals of the “permanent establishment of a culture of entrepreneurship” and the targeted encouragement of the great potential of business ideas and entrepreneurial personalities” at higher education and scientific institutions, the programme initiated by the BMBF in 1997 aims at “the consistent translation of academic research findings into additional economic value” and a “marked rise in the number of innovative start-ups”.

At the end of 1997 regional networks and their partners in academia, industry and politics had the opportunity to participate in a competition where the winners would receive funding from the EXIST Programme. In total, over 200 higher education institutions took part and presented 109 idea outlines for regional networks. In a two-stage procedure, an independent jury selected five model regions with very convincing concepts as winners of the competition. **bizeps** (Wuppertal - Hagen), **Dresden exists**, **GET UP** (Ilmenau - Jena - Schmalkalden - Weimar), **KEIM** (Karlsruhe - Pforzheim) and **PUSH!** (Stuttgart).

The follow-up programme EXIST-Transfer has funded ten more regional start-up networks at higher education institutions and external research institutions. Please find further information at [www.exist.de](http://www.exist.de)

Fig. 12: New businesses started in research and knowledge-intensive industries in EXIST and other regions 1996-2000 (1996 = 100)

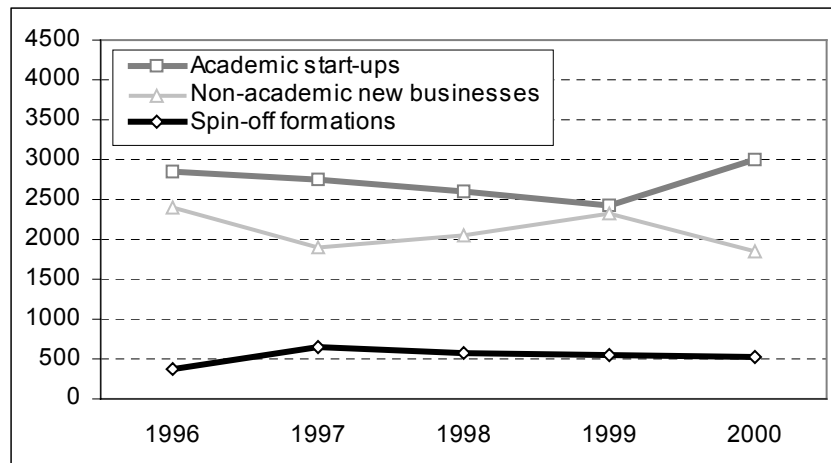


Source: ZEW Foundation Panels, expanded values.

An analysis of the new businesses according to their different types reveals the effects that caused the disparities between EXIST and non-EXIST regions (cf. Fig. 13 and Fig. 14):

- Between 1997 and 2000 the number of **non-academic new businesses** slumped in the EXIST regions, yet in the other regions their number experienced a slight increase.
- Between 1996 and 1999 the number of **academic start-ups** in the EXIST regions continuously declined (and went up significantly in 2000). The other regions did not record declining number for this business foundation type, its start-up figures actually soared in 1999 and 2000.

Fig. 13: EXIST regions: business start-up figures in research and knowledge-intensive sectors by business foundation types

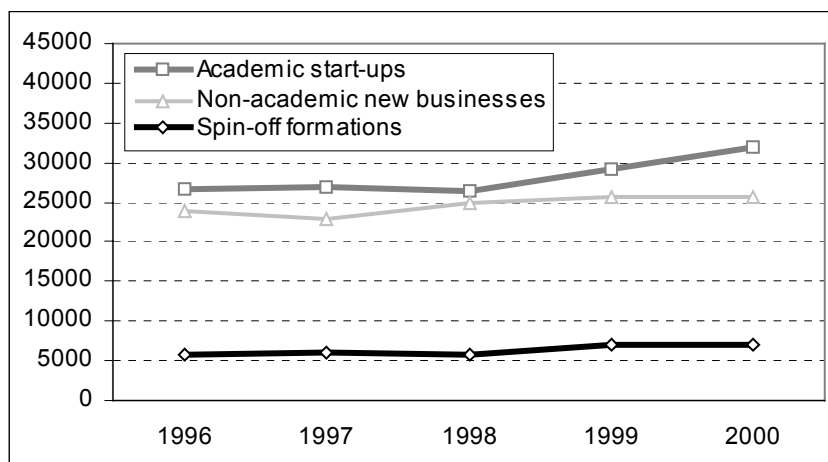


Source: ZEW Spin-off Survey 2001, expanded values.

In the period from 1996 to 2000 a total of approximately 3,500 academic start-ups were founded in the EXIST regions, slightly more than 500 of which were spin-offs. They account for about 8 to 9% of all business foundations in research and knowledge-intensive industries in Germany.

The chronological development of the **total number of new businesses** in research and knowledge-intensive industries is thus slightly lower in EXIST regions than in other regions. **Academic start-ups** in general and spin-offs in particular show a similar development which becomes apparent when looking individually at the number of spin-offs generated.

Fig. 14: *Non-EXIST regions: businesses start-up figures in research and knowledge-intensive sectors by business foundation types*

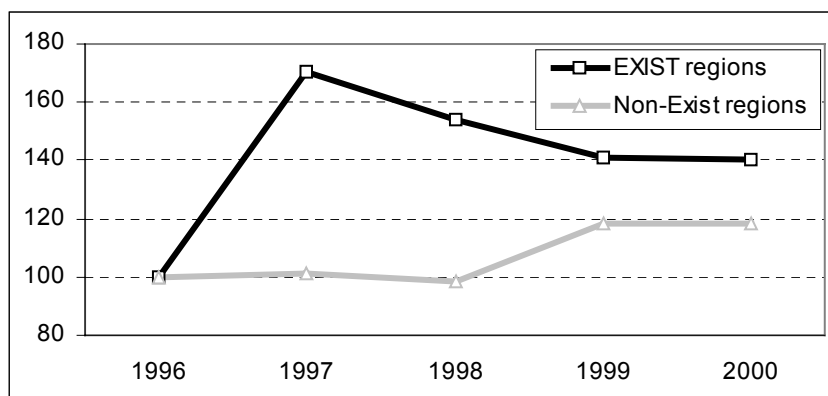


Source: ZEW Spin-off Survey 2001, expanded values.

### Spin-off activities in the EXIST regions

The chronological development of the number of exploitation and competence spin-offs established and located in EXIST regions is characterised by a considerable increase of spin-offs in 1997 and a slight decline in their formation in subsequent years (cf. Fig. 15). One can distinguish between two phases in the non-EXIST regions. The number of spin-offs created in these regions showed a more or less constant development until 1998, and then grew by nearly 20%. This level was also reached in the year 2000.

Fig. 15: *Number of spin-off formations with locations in EXIST and non-EXIST regions 1996-2000 (1996 = 100)*

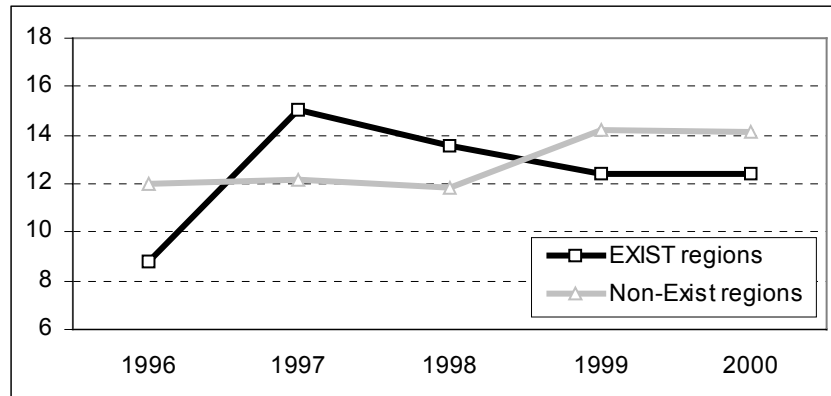


Source: ZEW Spin-off Survey 2001, expanded values.

Apart from the development over time, the **level** of spin-offs figures in both investigated regions was of interest. We calculated **intensities** relating the annual number of new spin-

offs to the number of gainfully employed residents in the regions (cf. Fig. 16) in order to compare these regions of varying sizes with each other.

Fig. 16: Intensities of spin-off formations (number of spin-offs per 100,000 employable persons) with locations in EXIST and non-EXIST regions 1996-2000 (1996 = 100)



Source: ZEW Spin-off Survey 2001, expanded values.

Following a marked increase in 1997, the (subsequent) EXIST-regions showed higher spin-off intensities in 1997 and 1998 (15 and 13.5 new spin-offs per 100,000 employable persons, respectively) than non-EXIST regions (12 new spin-offs, respectively, per 100,000 employable persons). Then, however, the relations were reversed again. In the EXIST regions the level of exploitation and competence spin-offs fell to an intensity of approximately 12.5. In the non-EXIST regions the spin-off intensity rose to 14.2 in 1999; this level remained unchanged in these regions in 2000. This marked increase outside the EXIST regions was caused by a higher number of both new exploitation and competence spin-offs.

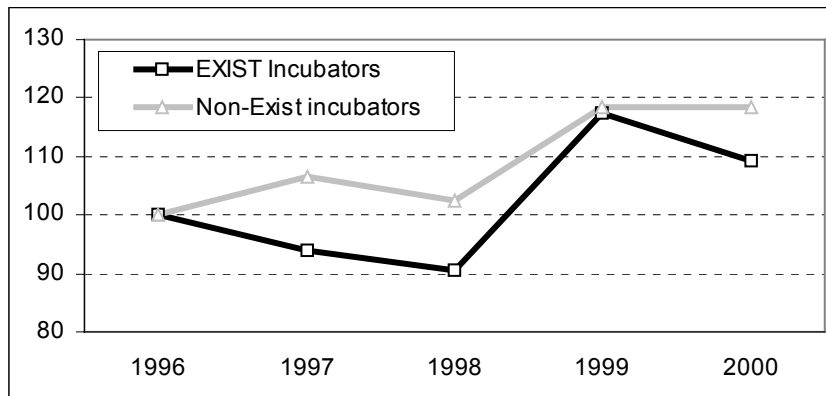
### Spin-off activities in EXIST incubators

Nevertheless, these findings should not lead to the conclusion that the dynamism as such of spin-off formations took place independently from the EXIST regions. An analysis of the locations selected for new spin-offs (cf. Chapter 9) reveals that proximity to the scientific institution from where the research results and competencies originated was not decisive. Their formation actually tended to follow the overall general pattern of the choice of locations when new businesses in research and knowledge-intensive industries are set up. Apparently, this also applies to new spin-offs based on findings of **scientific institutions in EXIST regions**. They are not necessarily created in the region itself.

The indexes in Fig. 17 separated the different developments of spin-off formations from 1996 to 2000 according to **incubator facilities** (of the respective spin-off) with locations in and outside EXIST-regions. The indexes reveal a marked increase of spin-off formations for incubators in both regional categories after 1998. When analysing the incubators according to regional categories the time pattern of spin-off formations is not as varied as the one in the analysis of spin-offs by locations.



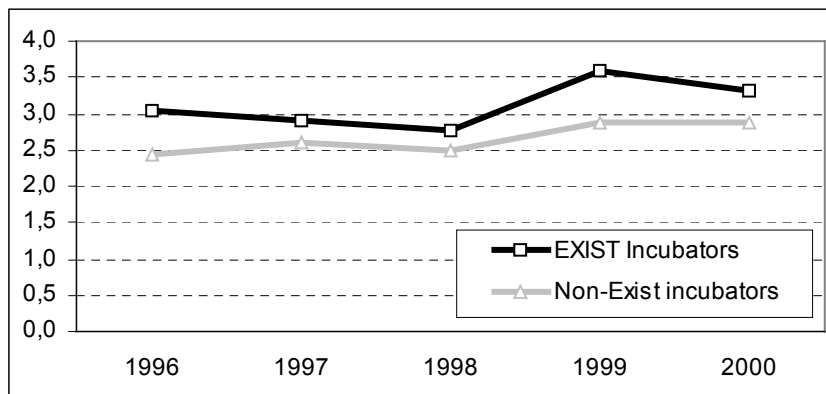
Fig. 17: Number of spin-off formations with incubators in EXIST and non-EXIST regions 1996-2000 (1996 = 100)



Source: ZEW Spin-off Survey 2001, expanded values.

It is also interesting to compare the **level** of spin-offs from incubator facilities in EXIST and non-EXIST regions. Judged by the potential of incubator facilities in EXIST regions – here approximated to the number of scientists in higher education and external research institutions, see also Chapter 7 – the number of these incubator facility spin-offs is higher than in incubator facilities outside EXIST regions (cf. Fig. 18). Whilst 100 scientists account for about 2.5 to 3.0 spin-offs (exploitation plus competence spin-offs) in non-EXIST facilities, they produce about 3.0 to 3.5 spin-offs in EXIST incubators.

Fig. 18: Spin-off intensities by EXIST incubators and non-EXIST incubators (number of spin-offs per 100 scientists)



Source: ZEW Spin-off Survey 2001, expanded values.

An analysis of absolute spin-off foundation figures reveals that the **number of spin-offs induced** by incubator facilities in EXIST regions is **higher** than the number of spin-offs settling down in EXIST regions. In the period from 1996 to 2000 an average annual number of approximately

- 750 to 800 spin-offs whose **incubators** were located in **EXIST regions**
- 500 to 550 spin-offs with a **location in EXIST regions**,
- 5,600 spin-offs from **incubators in non-EXIST regions**,



- 6,300 spin-offs with **locations in non-EXIST regions** were founded.<sup>2</sup>

The activities of scientific institutions in EXIST regions aimed at exploiting research findings via spin-offs indeed seem to bear fruit. This is also reflected in a higher number of new spin-offs. On the other hand, this does not inevitably lead to an increase in enterprises located in EXIST regions. To a great extent locations are chosen outside these regions. Nevertheless, this finding is not relevant when evaluating spin-off activities from EXIST incubator facilities with regard to the transfer of scientific findings into industry.

## 6. Status of spin-off founders

Students, graduates, academic members of staff and professors use their own companies to market their research findings, scientific methods and techniques, gained in the course of their research work and training. In the academic world, they belong to groups of different statuses. It is therefore of interest to ascertain the different posts those who founded the companies last held at the university or external research institute. It also raises the question of whether the transfer of this knowledge into a company occurred directly from the academic world (or directly from university studies) or whether the founders worked in another job between "academia" and "the business world". In order to obtain information on this, the amount of time between leaving the academic institution and founding the company has been examined.

### Position of the spin-off founders in academia

Academic business start-ups may have a very different "academic relationship" with reference to the position of the founder in the academic world. Depending on whether the company was founded by academics, graduates, students or non-academics (cf. Box 7), the length and intensity of the relationship between the founders and the organisation vary. It also changes the initial position as regards maintaining contacts to the academic institution. The personnel structure of the academic spin-offs in line with the academic origins of the founders is also an indicator of the "intensity of human capital" of the spin-offs.

**Scientists** account for a third of all founders of transfer spin-offs, but only 17% of founders of competence spin-offs and 12% of

#### *Box 7: Academics, graduates, students, non-academics*

The founders of spin-offs are assigned to one of four groups of persons, according to their academic status:

- **Academics** are all those who are or were employed by a publicly funded research institute. In this context, work as an assistant while still a student and internships do not count as employment. Academics include, firstly, **professors** and **senior research workers** at external research institutions and, secondly, **academic staff** (incl. technical employees and lecturers).
- **Graduates** is the term used for all those who have completed a university education but have not at any time been employed by a publicly funded research organisation.
- **Students** are those founders who were still studying when the survey was undertaken.
- **Non-academics** cover all founders who cannot be assigned to any of the other three groups.

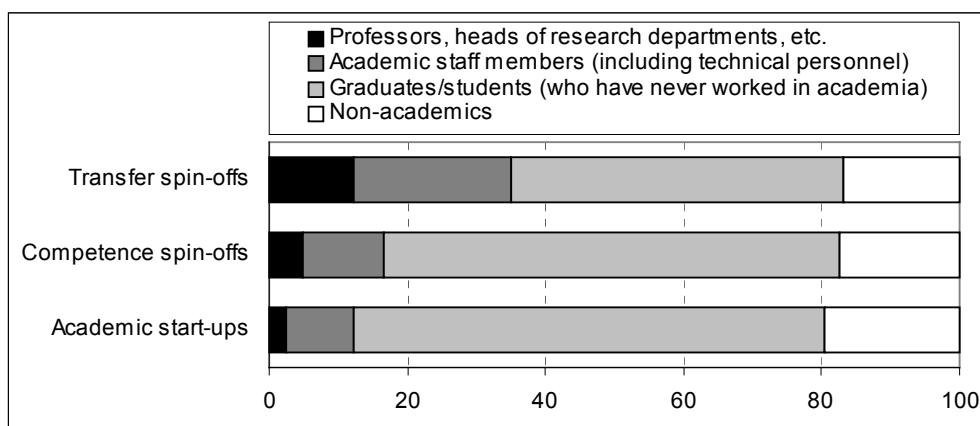
<sup>2</sup> Spin-offs with foreign incubators (400 to 450 per year, see Chapter 7) are the difference between the sum of spin-offs broken down by incubators and spin-offs broken down by location.

academic start-ups (Fig. 19). Transfer spin-offs differ from other academic spin-offs as they have a much higher proportion of **professors** (including heads of research departments at external research institutions) and **academic personnel**. 12% of founders of transfer spin-offs are university professors. Taking an average of all academic spin-offs, they account for a 3.5% share.

In the second half of the 1990s, each year an average of 700 professors and 1,300 academic personnel were involved in the foundation of transfer spin-offs in Germany. The total number of professors involved in academic business start-ups each year (spin-offs plus start-ups) is around 2,500 and the number of academic personnel is 7,800.

The group that accounts for the largest number of both spin-off founders as well as the founders of academic start-ups is **university graduates** without previous experience of working in academia. They make up 60% of all founders. At just under 50%, the proportion of this group in transfer spin-offs is slightly lower. In the second half of the 1990s, each year around 47,000 graduates without any work experience in academia (including those who were still studying) were involved as founders in company spin-offs in research and knowledge-intensive sectors of the economy. A fifth of these were spin-offs. Nearly 20% of those founding spin-offs were **non-academics**.

Fig. 19: Breakdown of founders of spin-offs and academic start-ups in Germany (in %)



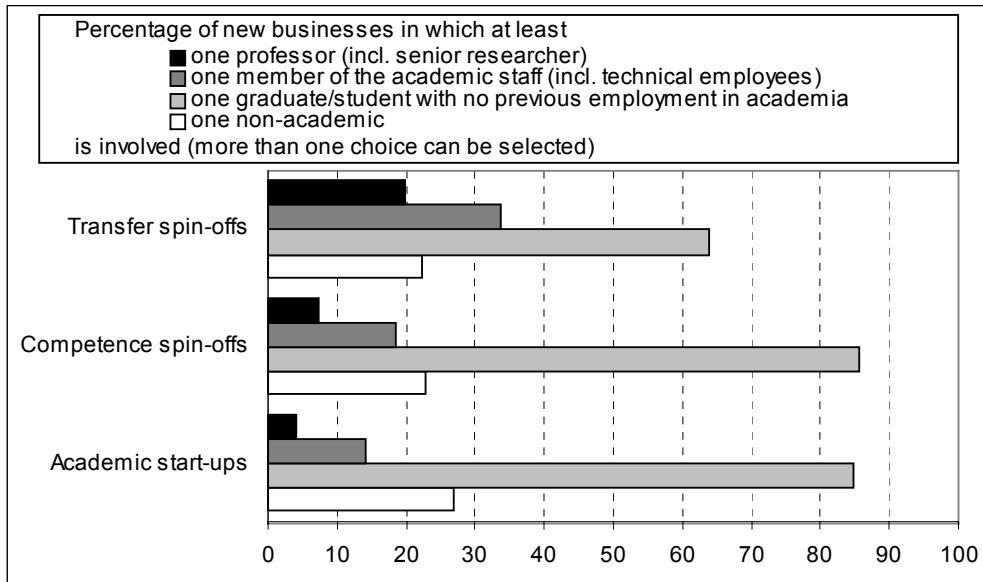
Source: ZEW - Spin-off Survey 2001, expanded values.

In the second half of the 1990s one in five transfer spin-offs involved at least one professor (Fig. 20). At 7.5%, the percentage of competence spin-offs in which a **professor was involved** is considerably lower. If one views all new businesses in research and knowledge-intensive industries, around 3% involved a professor. In absolute terms, this represents more than 2,000 firm foundations every year involving professors. It is here with transfer spin-offs that involvement of academic staff is also at its highest (one in three), whereas an academic member of staff is only a founder in one in seven academic start-ups.

Those setting up the new businesses include university graduates or students, who have never been employed in academia, in the case of more than 60% of transfer spin-offs and over 80% of competence spin-offs and academic start-ups. The proportion of spin-offs and start-ups, which were founded with the involvement of non-academics, is - at over 20% - also remarkable. Thus, the establishment of spin-offs definitely does not have to be limited to new

businesses set up by scientists. Even in the case of business start-ups that exploit new research findings, in the large majority of cases the founders also include graduates or those who are still studying and, in more than one in five transfer spin-offs, **persons "outside academia"** are involved. This shows that spin-offs include persons and thus know-how from outside the academic environment.

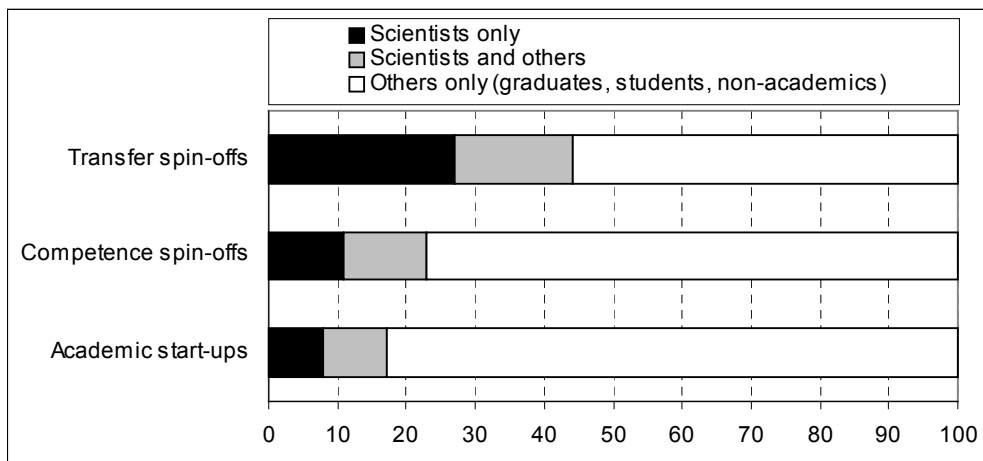
Fig. 20: Involvement of professors, academic members of staff, graduates/students and non-academics in spin-offs and start-ups in Germany (in %)



Source: ZEW - Spin-off Survey 2001, expanded values.

27% of transfer spin-offs are new businesses founded by scientists alone. In a further 17% of business start-ups, those involved are scientists together with graduates, students or non-academics (Fig. 21). This also means that over 50% of transfer spin-offs are founded **without the direct involvement of scientists**. In the case of competence spin-offs and academic start-ups this percentage even tops the 75% mark. Here, businesses founded by academics alone make up only 10% of all start-ups.

Fig. 21: Spin-offs and academic start-ups in Germany involving scientists (in %)



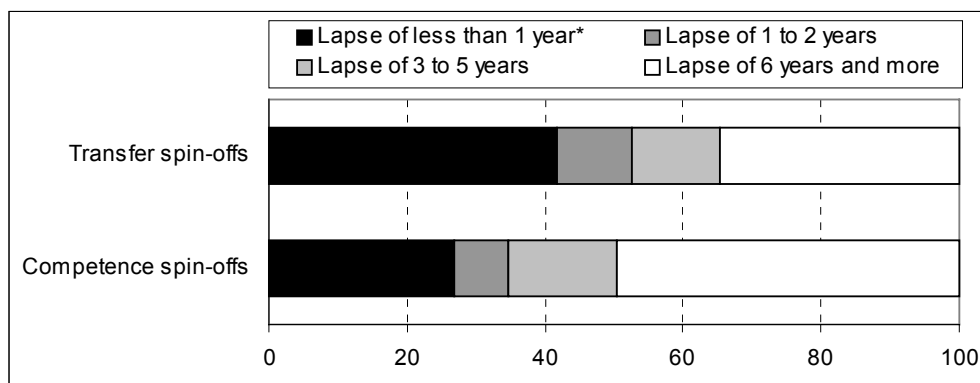
Source: ZEW - Spin-off Survey 2001, expanded values.

### Time between working in academia and starting a new business

Occasionally, a long period of time elapses between when a scientist is employed in academia or when the person concerned leaves university and the time when a spin-off is established. Fewer than 50% of transfer spin-offs and only one in four competence spin-offs are founded **immediately after "leaving" academia** (i.e. within less than a year) (Fig. 22)<sup>3</sup> "Leaving" academia is understood to mean the ending of an employment relationship (in the case of scientists) or completing a course of studies (in the case of graduates). It is plausible that transfer spin-offs are established less time after the person concerned left employment in academia than is the case for competence spin-offs, because the time factor is considerably more critical when exploiting research findings than it is for using specific skills linked to the person.

However, in the case of one in three transfer spin-offs and half of all competence spin-offs, the period between "leaving" the academic institution and founding a company is **more than 5 years**. For these spin-offs it must be assumed that they first acquire market skills and then combine these with the exploitation of new research findings or special skills, thus reducing the risk of setting up a business and improving the chance of successful exploitation. Indeed, many founders of these spin-offs worked for companies and were able to acquire knowledge of the market and customer contacts, whilst maintaining contact with the academic institution.

Fig. 22: Time that elapses between leaving academia and the establishment of spin-offs (in %)



\* Including those still employed in academia

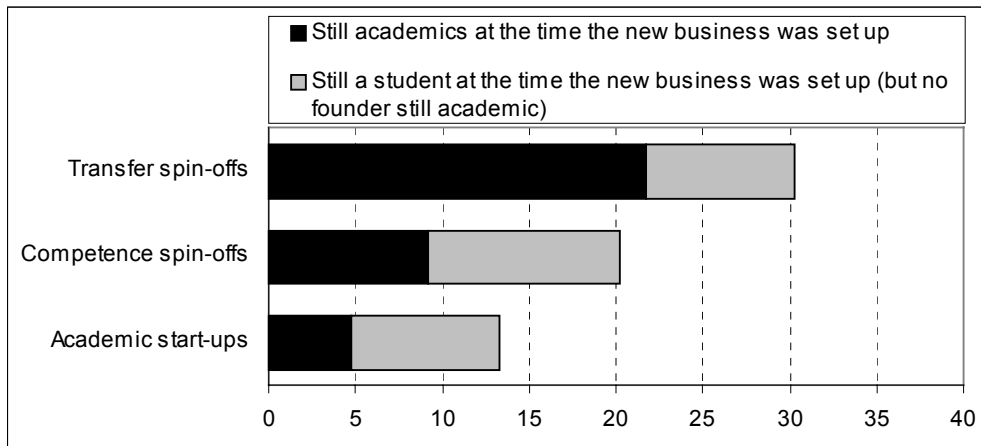
Source: ZEW - Spin-off Survey 2001, expanded values.

The new businesses set up immediately upon leaving academia include those where at least some of the founders were still **employed in academia** at the time the business was set up. In the case of 30% of all transfer spin-offs, at the time the new business was set up at least one founder was **still employed in academia** or was still studying, i.e. the dividing line between academia and business activities is fluid here (Fig. 23). For two-thirds of these "partial business start-ups" (these represent 22% of all transfer spin-offs) the founders include scientists who are still employed by the academic institution. This can be viewed as a strategy to reduce the risk to the individual's income should the new business fail. However,

<sup>3</sup> Where new businesses were started by teams, in each case the figure used is the one for the scientist who last "left" academia.

such a fluid dividing line also requires that the spin-off be linked to the academic institution and facilitates the exchange of knowledge. At 20%, the proportion of "partial business start-ups" is considerably lower for competence spin-offs. In this case, these are largely business start-ups by students, who continue with their studies after the business has been started up.

Fig. 23: Spin-offs established by those who, at the time the new business was founded, were still employed in academia (in %)

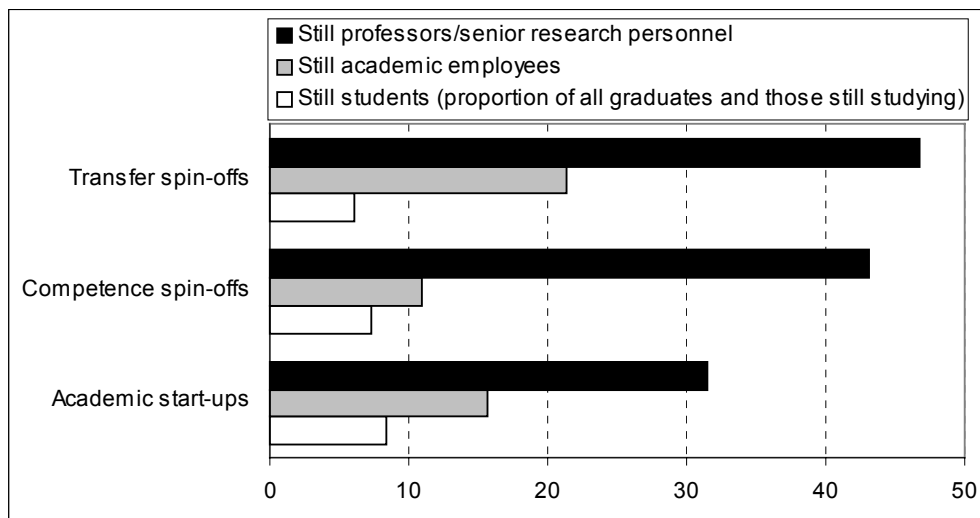


Source: ZEW - Spin-off Survey 2001, expanded values.

Of all the academics, who were involved in setting up a company in research and knowledge-intensive sectors of industry between 1996 and 2000, 22% were still **employed in academia** at the end of 2001. As one would expect, this proportion is higher for transfer spin-offs (30%) than for competence spin-offs (20%) and academic start-ups (19%). In particular, the group of scientists includes **(co)founding professors** (including senior research personnel in external research institutions), most of whom are still involved in academia and operate their business activities as a sideline (Fig. 24). In absolute terms, at the end of 2001 this represented over 4,500 professors, i.e. almost 40% of all professors were involved in setting up a business in the second half of the 1990s.

In the case of **academic members of staff**, the proportion of business founders still active in academia at the end of 2001 was, at 16%, much lower. In the case of both professors and academic members of staff, the proportion of persons employed in academia was much higher for transfer spin-offs than for competence spin-offs and academic start-ups. This is probably due to the fact that these companies are likely to be interested in maintaining close links to scientific institutions and participating in a lively exchange of ideas and knowledge in order to apply the new research findings and this is best achieved through direct personal relationships.

Fig. 24: Founders of spin-offs and start-ups, who are still employed in academia (in %)



Note: Proportion of founders who started new businesses in the years 1996 to 2000, who - at the time the survey was made (end of 2001) - were still employed in academia

Source: ZEW - Spin-off Survey 2001, expanded values.

## 7. Institutional origin and research field background

Publicly funded research in Germany is undertaken by many different kinds of institutions (cf. Box 4) and these institutions are characterised by a variety of objectives, tasks and framework conditions, which may also influence the atmosphere of the start-up company and the potential for establishing spin-offs (cf. Schmoch et al. 2000). When viewing the institutions from which spin-offs were founded, it is necessary to differentiate between two forms of "origin":

- The **incubator unit** is the academic institution (i.e. a certain university or research institute) from which the new research results or the new scientific methods originate or in which the special skills that were essential for the spin-off were acquired. From the point of view of knowledge and technology transfer, it is of crucial importance to consider incubators because they provide information on the institutions that generate the research findings that can be exploited commercially by establishing spin-offs. This allows spin-offs to be placed in the context of other channels of knowledge and technology transfer at these institutions (publications, patent applications, financial support from secondary sources, personal mobility, etc.).
- In contrast, the institution described as the **institution of origin** is where the founders were last employed in academia, are still employed, where they studied or where they are still studying. An examination of this kind is particularly useful when assessing the entrepreneurial atmosphere at these institutions and the question of what contribution an institution makes to the willingness of academics, graduates and students to start up a business.

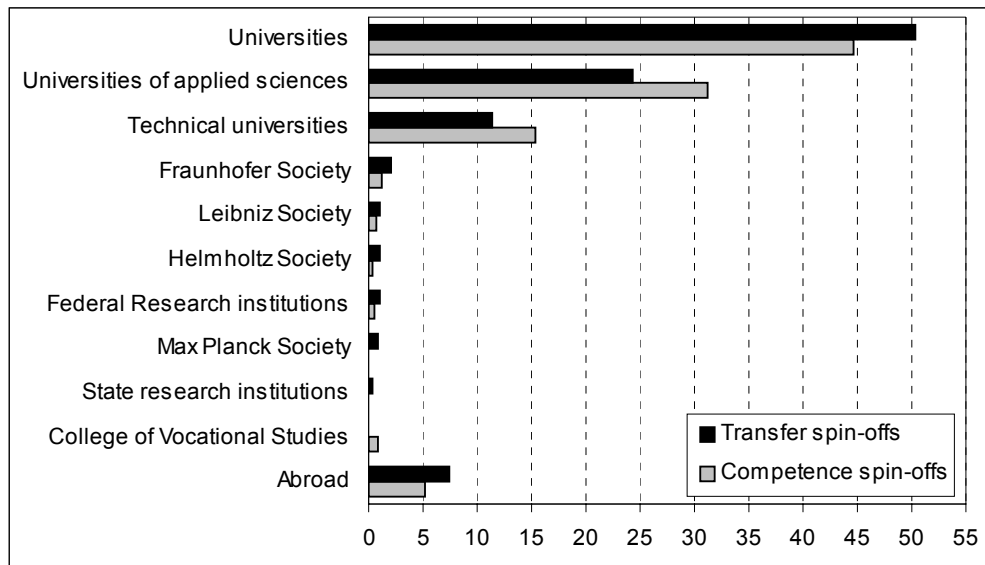
In over 80% of spin-offs, the incubator institution and the institution of origin are identical. They can, for example, "differ" if the enterprise was founded by people from different

institutions of origin but only one institution acted as an incubator or knowledge from other institutions is used via cooperation projects. Where different incubator institutions and institutions of origin are combined, the various publicly funded research institutions are both the "giver" (incubator) and the "receiver" (institution of origin) and thus the aggregated distribution of incubator institutions and institutions of origin is almost identical to the various publicly funded research institutions. In the case of spin-offs that have cited several incubator institutions, these have been added pro rata to the publicly funded research institutions to which they belong.

**Incubator institutions**

In Germany the majority of business spin-offs come from German **universities** (Fig. 25). Only around 5% are derived from **external research institutions** and a good 6% from **foreign** publicly funded research institutions. Within the university sector, the (general) **universities**<sup>4</sup> are the most important incubator institutions, according to the relative size of the institutions. Almost half of all spin-offs are based on the knowledge or skills of these institutions. One in four transfer spin-offs and nearly one in three competence spin-offs has a **University of Applied Sciences (Fachhochschule)** as its incubator. The thirteen technical universities are viewed as a separate group: they account for around one in seven spin-offs, although their share of competence spin-offs is higher than their share of transfer spin-offs.

Fig. 25: Incubator institutions spinning out start-ups in Germany 1996-2000 (in %)



Source: ZEW - Spin-off Survey 2001, expanded values.

Out of the external research institutions, the Institutes of the **Fraunhofer Society** are the most important incubators (1.5% of all spin-offs). The other institutions (Leibniz Society, Helmholtz Centres, Max Planck Society, German and State research institutions) each account for a share of just under 1%. The proportion of external research institutions is

<sup>4</sup> Including teaching, theological, art and music academies

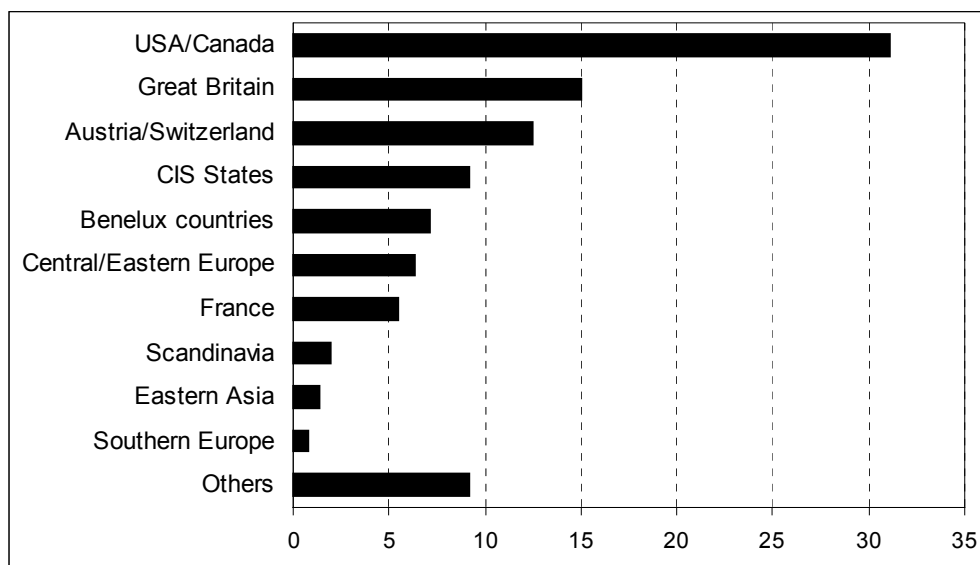


consistently higher for transfer spin-offs than for competence spin-offs. The reason for this is that start-ups by graduates or students account for a particularly high proportion of competence spin-offs, which by their very nature have a university as their incubator institution.

Over 7% of transfer spin-offs in Germany and 5% of competence spin-offs have **foreign publicly funded research institutions** as their incubator (Fig. 26). The most important countries of origin providing the source of knowledge and special skills essential for the start-up are (in descending order): USA/Canada, Great Britain, Austria/Switzerland, the CIS states, the Benelux countries, the EU accession states from Central and Eastern Europe and France.

The high proportion of universities as incubator institutions must be seen within the context of the large number of graduates (as indicated above) involved in the founding of spin-offs. Over 40% of transfer spin-offs and 60% of competence spin-offs have been founded exclusively by graduates and under-graduates, who have no previous employment experience in the academic world. These spin-offs nearly all have universities as their incubator institutions.

Fig. 26: Foreign incubator institutions of spin-offs established in Germany, classified according to countries (in %)



Source: ZEW - Spin-off Survey 2001, expanded values.

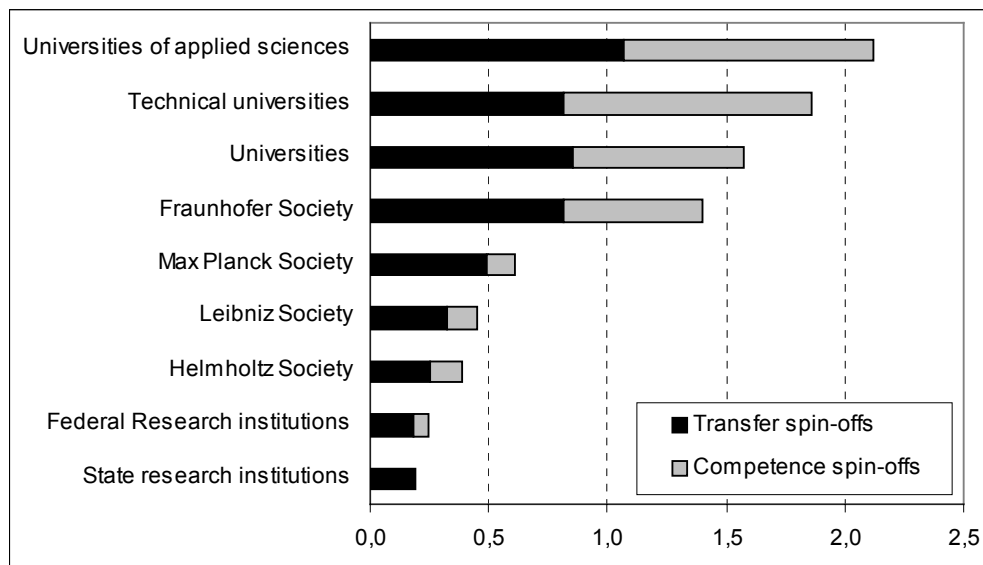
For a comparison of institutions involved in publicly funded research in Germany - in particular between universities and external research institutions - to ascertain their **spin-off intensity**, it is useful to examine those spin-offs founded with the **involvement of scientists**. The spin-off intensity is the ratio between the number of spin-offs founded each year in the



period 1996 to 2000 (exploitation plus competence spin-offs) that cited a certain institution as an incubator institution and the number of academics at this institution.<sup>5</sup>

The group of **universities of applied sciences (*Fachhochschulen*)** exhibited the greatest intensity, followed by the **technical universities**. The high level of start-ups at the universities of applied sciences is worthy of particular consideration, particularly as this type of university is often paid less attention in the discussion about knowledge and technology transfer. However, values for the (general) **universities** and the Institutes of the **Fraunhofer society** are also high (Fig. 27). The level of spin-offs at Max Planck Institutes is higher than those at the institutes of the Leibniz Society and the major research centres (Helmholtz Society).

Fig. 27: Intensity of spin-offs according to incubator institutions: Spin-offs involving scientists for every 100 scientists at the institution per year (during the period 1996-2000)



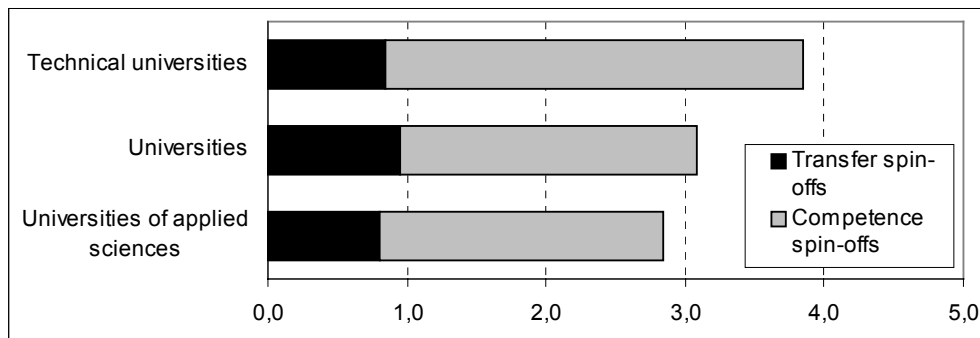
Source: ZEW - Spin-off Survey 2001, expanded values.

The extreme differences in the absolute significance of universities as incubators of spin-offs in comparison to external research institutions, as shown in Fig. 25, can no longer be ascertained when considering spin-off intensities yet the differences still do not disappear. Even when checking for the different sizes of institutions and when only considering the group of spin-offs established with the involvement of scientists, universities are the more important incubator institutions. At 1.5 (universities) and 2 (universities of applied sciences) spin-offs per year for each 100 scientists, intensities of their spin-offs are more than twice as high as in external research institutions (0.3 to 0.6). Only the Fraunhofer Society with a spin-off intensity of 1.4 bucks this trend somewhat.

<sup>5</sup> Those counted as "scientists" at universities are those full-time scientific and artistic university personnel, excluding lecturers assigned to specific tasks. At external research institutions, the personnel category of "researcher" is classed as a scientist. The number of scientists is recorded as the full-time equivalent for the year 1998. In order to allow for differences in the disciplines and the consequential varying potential for spin-offs, scientists working in the fields of medicine, the humanities, social sciences, law or the arts are assigned a weighting factor of 0.5. The data were obtained from a special analysis of statistics on personnel by Destatis (universities) and the *Bundesbericht Forschung 2000* and the *Faktenbericht Forschung 2002* by the BMBF (external research institutions) (BMBF 2000b, 2002b).

The spin-off intensities of universities in respect of spin-offs founded by **graduates or students** without the involvement of scientists do not show any substantial differences between universities, technical universities and universities of applied sciences (Fig. 28). Overall, the technical universities take the top position because of the relatively large number of competence spin-offs founded by graduates/students. For every 100 graduates, one transfer spin-off is founded by graduates/students whereas the rate for competence spin-offs is between two and three.

Fig. 28: Spin-off intensities according to incubator institutions: Spin-offs by graduates or students for every 100 graduates of the institution per year (during the period 1996-2000)\*



\* Excluding spin-offs established with the involvement of scientists

Source: ZEW - Spin-off Survey 2001, expanded values.

### Entrepreneurial attitudes by incubator institutions

It is possible to gain a picture of **the tendency of scientists to establish businesses** if one takes the number of scientists who leave an institution of origin each year and immediately afterwards found a company in a research and knowledge-intensive sector of the economy and examine it in the context of the overall number of scientists in each institution. In this context, both spin-offs and academic start-ups are taken into account.<sup>6</sup> The tendency of scientists to set up businesses indicates the average percentage of academics who left the academic institution where they worked each year between 1996 and 2000 in order to set up a company.

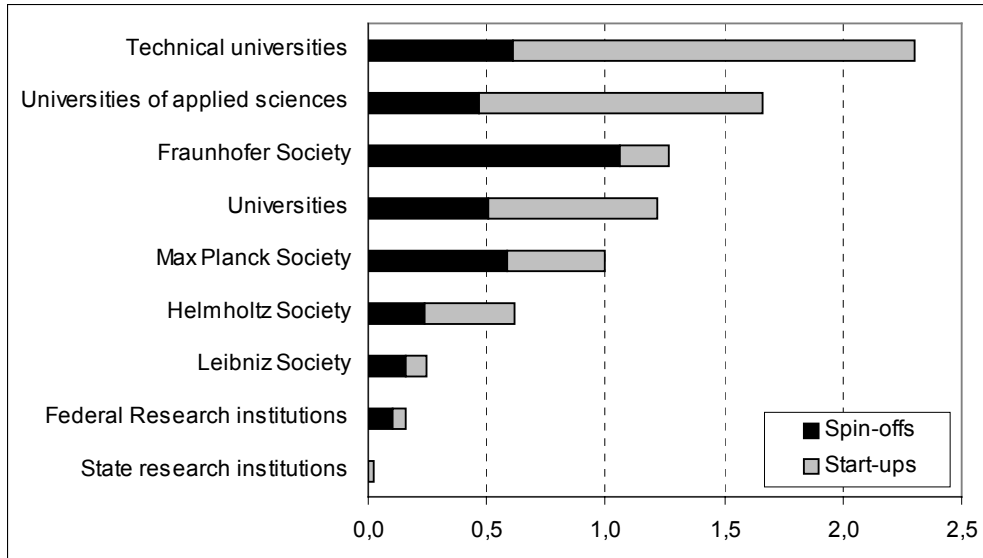
Scientists at **technical universities** are the most likely to set up businesses: this tendency is considerably lower at universities. **Universities of applied sciences** lie somewhere between the two (Fig. 29). The fact that the tendency of universities of applied sciences to set up businesses trails behind the figure for technical universities, although the spin-off intensity is greater, can be attributed to the high proportion of founders who still work at the university of applied sciences (e.g. involvement of professors in spin-offs) or who left the university a long time ago.

Of all the external research institutions, it is the Institutes of the **Fraunhofer Society** that show by far the greatest tendency to set up businesses. The propensity of Max Planck Institutes to establish businesses is, at 1%, nearly as great as for universities (1.2%). Overall,

<sup>6</sup> In contrast to spin-off intensity, what is considered here is the number of founders, who were previously scientists in academic institutions, and not the number of companies founded in which scientists are involved.

in the second half of the 1990s each year around 1.25% of scientists at publicly funded research facilities left their institution and set up a company: slightly more than one third of these (0.5% of all scientists) was a spin-off.

Fig. 29: Tendency of scientists working at publicly funded research institutions in Germany to set up companies, 1996-2000: Number of scientists leaving the academic institution to set-up companies\* as a proportion of all scientists (in %)



\* Only spin-offs established in research and knowledge-intensive industries.

Source: ZEW - Spin-off Survey 2001, expanded values.

If one only looks at the **spin-offs**, then it can be seen that the scientists working at institutes of the Fraunhofer Society are most likely to set up a new business. If an employee of a Fraunhofer institute is involved in establishing a business, in the very great majority of cases it is a spin-off, i.e. new research findings or special skills are transferred for commercial exploitation. In contrast, at universities the transfer aspect is not the key feature of the new business in the case of the majority of scientists who set up businesses.

In order to **assess** how **likely scientists are to establish a business**, a useful comparative benchmark is to measure the personal mobility of scientists in selective fields or within the publicly funded research sector as a whole and the tendency of academics to set up businesses in the event of a change of job. As no direct information is available in Germany on the proportion of scientists who leave their scientific institution each year in order to take up another paid position, irrespective of whether it is in academia, business, the public services or even as a self-employed person, a comparison of this kind can yield useful information.

- When, in 2000, ZEW surveyed research units operating in the fields of natural sciences and engineering at German universities and external research institutions (cf. Czarnitzki et al. 2000), the results showed that in these particular areas the rate of scientists leaving institutions was just under 12% a year. The figure was higher for universities than for external research institutions. The tendency to establish new businesses as calculated above would indicate that slightly more than one in ten academics leave to start a business. In actual fact, however, the rate is higher because the propensity to

establish new businesses measured above only covers research and knowledge-intensive sectors of the economy. If one also takes into account scientists who set up businesses in other sectors of the economy (e.g. trade, some other manufacturing industry or the construction industry),<sup>7</sup> it can be seen that approx. **15% of scientists who leave their institution establish a new business.**

- The proportion of 15% for scientists who left an academic institution to establish a business broadly corresponds to the proportion of self-employed among academics in paid employment: the 1997 figure was 15.8%.<sup>8</sup> However, this also includes those academics who became self-employed after their university studies, e.g. as a doctor of medicine, lawyer or architect.
- A further basis on which to make a comparison of the likelihood that scientists employed by a publicly funded research institution will establish a business is the proportion of academics in salaried posts, who move from paid employment to become self-employed. Again using the 1997 micro census as a basis, the proportion is just under 10%, i.e. each year out of every 100 academics who leave their previous jobs (where they were salaried employees), ten will become self-employed. With a figure of fifteen scientists who leave to set up their own businesses, scientists working in the field of publicly funded research, who account for a proportion of these academics, exceed the reference value and thus are **more likely to set up a new business.**

### Research fields of spin-off founders

The field of specialisation indicates the main academic subject in which the founder has been able to accumulate the knowledge that is now to be exploited in the market place. In the case of scientists, it is the field of specialisation in which they have most recently been undertaking research work, whereas in the case of graduates/students it is their main subject or course of studies. The **academic backgrounds** of the founders are just as varied as the range of industries. Spin-offs are not concentrated in a few specialist areas: indeed, the commercial exploitation of new research findings for setting up a new company can be seen in all fields, even if the frequency varies.

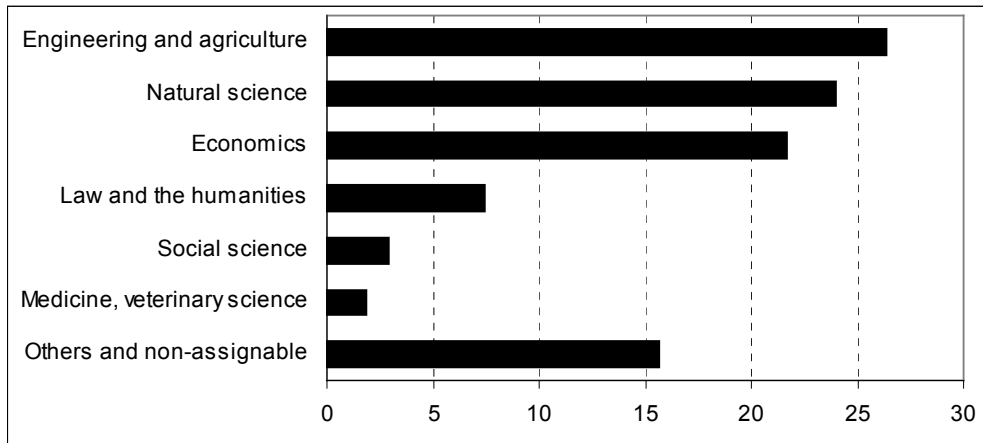
A relatively large number of spin-offs have an engineering background (including agriculture) (Fig. 30). Here the most important groups of subjects are electrical engineering, telecommunications engineering, and mechanical/process engineering. To a similar extent as engineering, **natural sciences** are represented among spin-offs, although information technology is the single most important field. Spin-offs from engineering and natural sciences account for an above-average number of new business in high-tech industries and in technology services (in particular, IT and technical consultancies).

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<sup>7</sup> On the basis of analyses made by the ZEW foundation panel concerning the involvement of professors and doctors in establishing new companies, the proportion can be assessed at just under one third of all new companies set up by scientists.

<sup>8</sup> Calculated on the basis of the 1997 micro census (cf. NIW et al. 2001, 37).

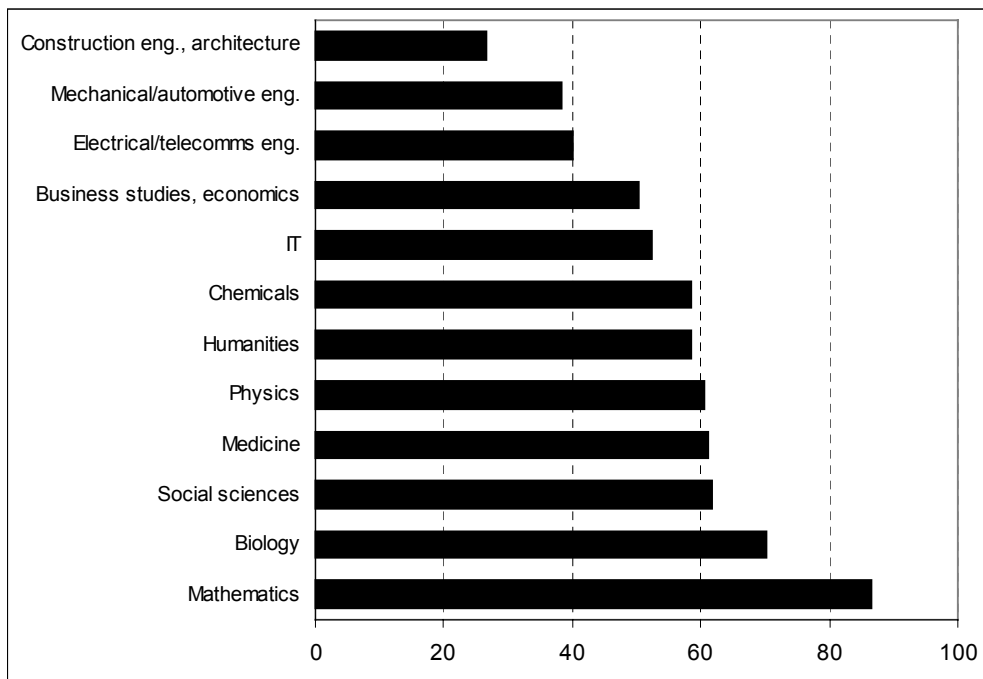
Fig. 30: Research background of spin-off founders, 1996-2000 in Germany (proportions in %)



Source: ZEW - Spin-off Survey 2001, expanded values.

The third most important subject is **business studies and economics**. These spin-offs are mainly formed in the knowledge-intensive service sector (management consultancy). Nevertheless, one in ten spin-off foundations comes from the field of social sciences and humanities. Medicine is the field that produces very few spin-offs, accounting for a share of around 2%. Here it must be noted that self-employed doctors, lawyers and similar are not counted as enterprises.

Fig. 31: Research background of spin-offs: Combination with other specialist areas (in %)



Source: ZEW - Spin-off Survey 2001, expanded values

At least two different subject areas are represented in a good 50% of new spin-offs. Subjects that are very often **combined with other specialist areas** are mathematics and biology (Fig. 31). Above all, they are often combined with other social science specialisms. In contrast, spin-offs with an engineering background are much more likely to be established without being combined with another specialist area. This applies, in particular, to construction

engineering and architecture. A combination of subjects that often occurs is also information technology and business studies/economics.

## 8. R&D activity, academic contacts and use of patents

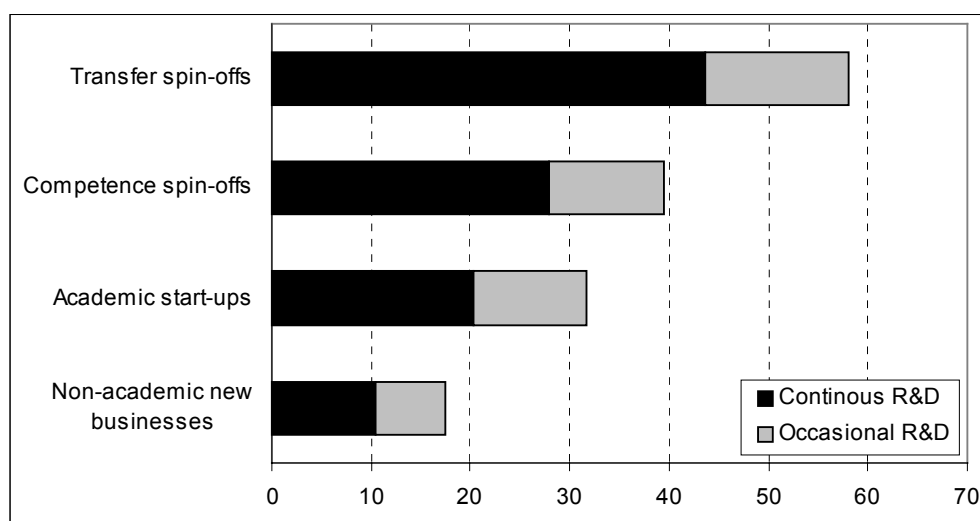
An important competitive parameter for founding start-ups is the focus on research and development (R&D) and the use of external knowledge. In order to maintain over an extensive period the competitive edge that is derived from exclusive use of new research findings or new scientific methods, continuous renewal of one's own pool of knowledge is of key importance. Because technical change and market dynamics are particularly relevant in research and knowledge-intensive sectors of the economy, existing technical knowledge soon becomes outdated. A way to replace this lost knowledge is, firstly, the individual's own efforts (R&D) or, secondly, "buying in" knowledge from outside.

R&D activities undertaken by the company itself are often essential for efficient application of knowledge within the company, i.e. adaptation of external knowledge to the specific framework conditions within the company. In addition, contacts to academia are an obvious way of harnessing new knowledge from outside for further development of the company. As they have their roots in academia, spin-offs have personal points of contact for direct cooperation in research or recruiting and further training of employees. The use of patents from academic institutions is a specific way of converting new knowledge into a commercial application.

### Research and development

The exploitation of new research findings when setting up the company also goes hand-in-hand with a substantial **focus on R&D** within the company. Nearly 60% of all transfer spin-offs undertake their own R&D and three-quarters of these do so continuously. In the case of competence spin-offs, the proportion of new businesses that undertake R&D is 40%, for academic start-ups it is 30% and for non-academic start-ups it is less than 20% (Fig. 32).

Fig. 32: Proportion of business start-ups that undertake R&D in research and knowledge-intensive sectors of the economy (in %)



Source: ZEW - Spin-off Survey 2001, expanded values.

The high proportion of new businesses with research focus is not surprising since here only business start-ups are considered in those sectors of the economy that are characterised by an above-average concentration on R&D and knowledge. However, what is worth noting is that the **above-average R&D focus** stems exclusively from **academic foundations**. This is backed up by the fact that, in the economy as a whole, the proportion of companies with continuous R&D activities at the end of the 1990s was 20% (manufacturing sector), and 12% (knowledge-intensive services with a focus on technology)<sup>9</sup>. It was thus at a similar level as for non-academic start-ups in research and knowledge-intensive sectors.

The tendency to undertake R&D was particularly high among new businesses in the high-tech manufacturing, where over 85% of all transfer spin-offs and 40% of all new businesses do R&D.

### **On-going contacts with academia**

Contacts with universities and publicly funded research institutions can be an important competitive factor for young companies in research and knowledge-intensive sectors of the economy. Both spin-offs and academic institutions can derive benefits from a permanent link because ultimately various competencies meet in the case of this university-spin-off network constellation - the market, production or service expertise, on the one hand, and research know-how, on the other. Here, in many cases the networks are simply a continuation of contacts that have existed since university days or the time the founders spent working as research assistants. In order to be able to gain a competitive edge through the exclusive use of new research findings or new academic methods and maintain this over a long period of time, a permanent link to academia and a link between the company's own R&D work and the R&D activity at the institution can be crucial.

The pattern of **scientific contacts** of different types of business start-ups concurs with these considerations. The highest proportion of companies which maintain contacts to academic institutions as part of routine business can be found within the group of transfer spin-offs (60%). This is followed by academic start-ups, for which new research findings were highly significant for the new business (52%) (Fig. 33). Competence spin-offs, in contrast, trail somewhat at 45%. The lowest proportion of companies with academic contacts can be found among non-academic new businesses without R&D activity (18%).

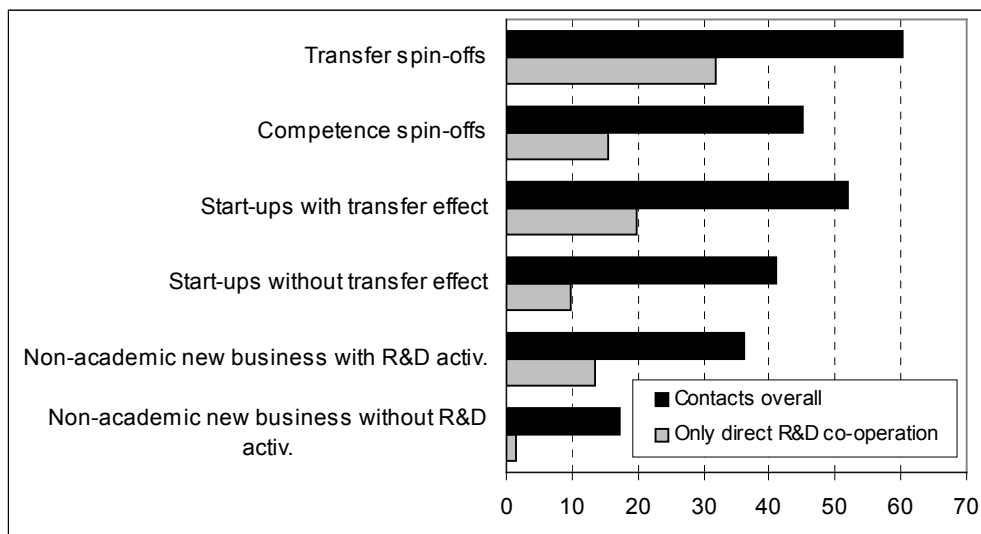
The pattern is the same if only the presence of **direct R&D cooperation** (on joint projects or research under contract) is taken into account. 32% of transfer spin-offs, 20% of start-ups with transfer effect and 16% of competence spin-offs maintain direct research-related contact to academia as part of their routine business operations.

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<sup>9</sup> Evaluations from the Mannheim Innovation Panels by the ZEW (cf. Janz et al. 2002).



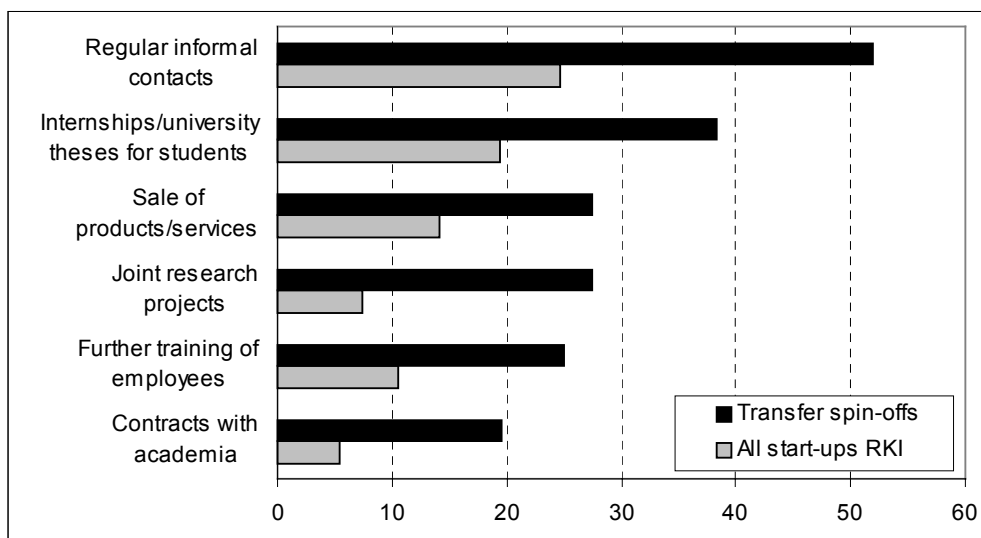
Fig. 33: On-going contacts to academia according to business foundation types (in %)



Source: ZEW - Spin-off Survey 2001, expanded values.

The most frequent **form of contact** between young companies and academic institutions are regular **informal contacts** (Fig. 34). One in four business start-ups in research and knowledge-intensive sectors of the economy lists this kind of contact, with the figure rising to one out of every two in the case of transfer spin-offs. Other important channels of contact are the employment of students within the context of internships or through support when writing university theses, and also the sale of products or services to academic institutions. One in four transfer spin-offs **operates joint research projects** with academic institutions. The average for all new businesses in research and knowledge-intensive sectors of the economy is only 8% of companies.

Fig. 34: Nature of on-going contacts to academia: Transfer spin-offs and all business start-ups in research and knowledge-intensive sectors (RKI) (in %)



Source: ZEW - Spin-off Survey 2001, expanded values.



The presence of on-going contacts to academia primarily depends on the **"knowledge base" of the business start-ups themselves**: companies that actually undertake R&D and companies that were founded by scientists are more likely to maintain contacts to academia. In contrast, the period between leaving academia and setting up a business is of no relevance. The great importance of their own knowledge base as a prerequisite for academic contacts applies equally to spin-offs, start-ups and new non-academic businesses. Thus, 57% of new businesses which continuously undertake R&D projects maintain on-going contacts with academia but the figure for businesses that do not carry out any R&D work is only 27%. Also, 65% of all academic business start-ups in which scientists were involved maintain contact to academia but the figure is only 40% for companies founded by graduates or students only.

However, the results also show that an appreciable **proportion of spin-offs operate at a less knowledge-intensive level**. Over 40% of transfer spin-offs do not undertake R&D themselves and also 40% do not maintain any contact to academia. So, a quarter of transfer spin-offs neither undertake their own R&D work nor maintain contact to academia as part of routine business operations. Although these companies obtained "an impetus through knowledge" as a result of working with academia when they were founded, later on this was neither refreshed through generating knowledge on their own account (R&D) nor through cooperating with academia. It would appear that they only concentrate on the commercial exploitation of this knowledge. Here it must be noted that these companies are still young businesses (three years old, on average) and the question of further or new development of products or services is often not posed immediately after a business is set-up.

### **Use of patents from academia**

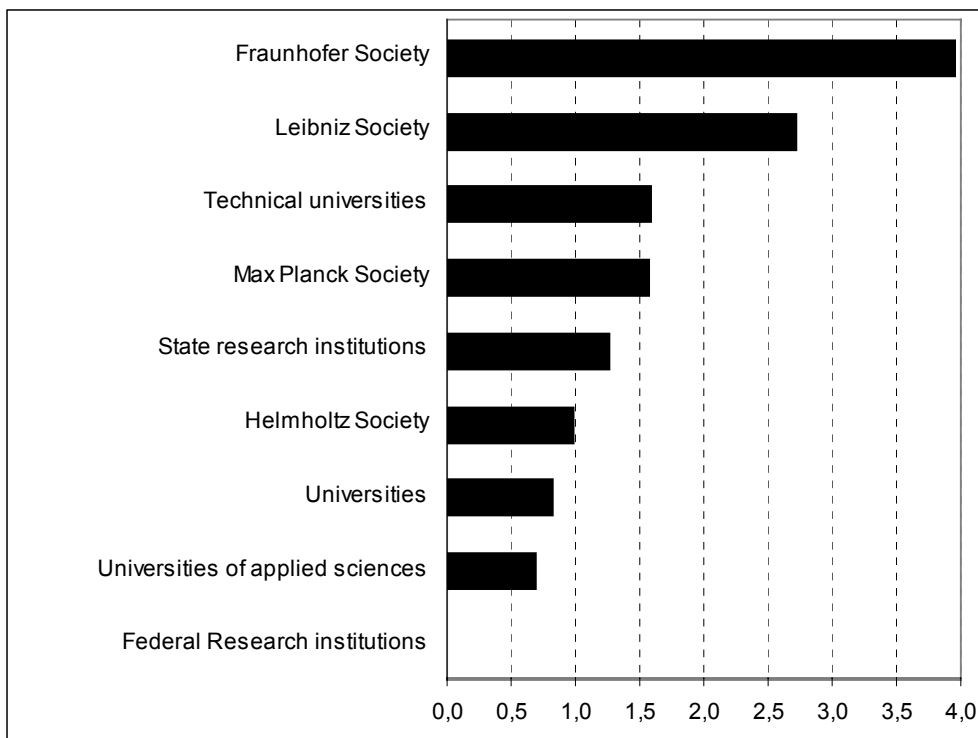
A specific form of transferring new research findings in respect of commercial exploitation is the use of patents resulting from work in publicly funded research institutions by spin-offs. This transfer channel is viewed as being particularly effective, as new technical knowledge is applied by those researchers who were involved in gaining the knowledge in the first place. The further development of the technology is thus promoted in the spin-off, especially as the spin-off can - through direct contacts to the incubator institution - easily acquire fresh knowledge from the same source.

Overall, the use of patents as an initial basis for founding a spin-off only plays a **minor role**. Just 5% of all transfer spin-offs and fewer than 1% of competence spin-offs use their own patents acquired during the time they were employed in academia or patents, which are held by the incubator institution. In spite of this, the absolute figures are impressive. In the period 1996 to 2000, nearly 900 spin-offs exploiting patents from academia were founded. Over 750 spin-offs used patents from academic institutions in Germany and around 150 exploited patents from foreign academic institutions. If one breaks down the use of patents according to sectors of the economy, then it can be seen that patents are primarily used by transfer spin-offs in the fields of technological services. This high proportion is based on the R&D service companies, which carry out R&D work for other companies in fields such as biotechnology or optical technologies.

Thus, every year around 150 spin-offs exploit a patent from a public research institution in Germany. In the second half of the 1990s, around 2,500 patent applications per year were made by university professors and public research institutions (cf. Schmoch 2000, 24ff). This means that **between 6 and 12% of patents were exploited via spin-offs** (under the realistic assumption that not more than two patents were used per business established). By way of comparison, the rate for the same period in the USA was between 7 and 14% and is thus only slightly higher.<sup>10</sup>

Over half (56%) of all patents used by German spin-offs are derived from universities, 29% come from external research institutions and 15% from abroad. If one compares these to the research potential of the institutions (number of scientists), it can be seen that the institutes of the **Fraunhofer Society** account for the highest proportion of patent-based spin-offs (Fig. 35). For every 1,000 scientists there are four spin-offs each year that use Fraunhofer patents. These are not only used for their "own" new businesses but are also used by spin-offs from other institutions of origin. The "patent-based spin-off" transfer channel is also of above average significance for institutions of the **Leibniz Society** as well as technical universities and Max Planck institutes. In contrast, at universities and universities of applied sciences they are of almost no relevance at all.

Fig. 35: Patent exploitation through spin-offs: Start-ups with patents from the respective institution per 1,000 scientists at the institution

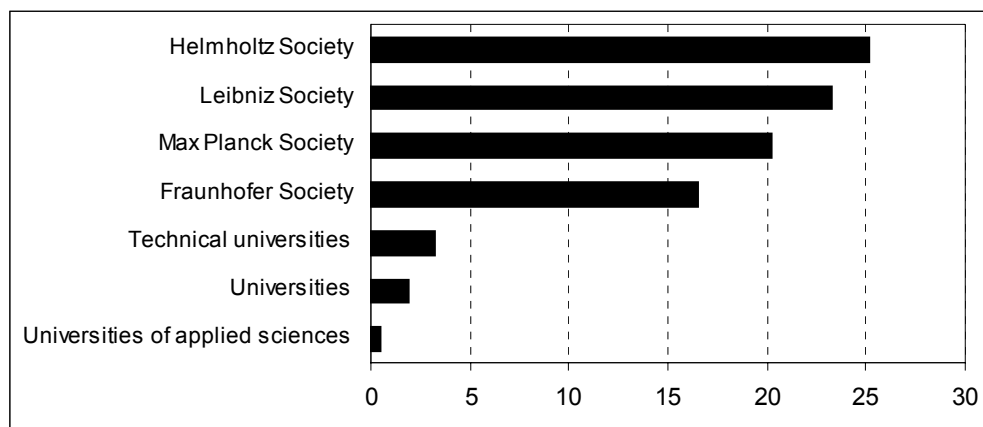


Source: ZEW - Spin-off Survey 2001, expanded values.

<sup>10</sup> Calculation for the USA on the basis of data from AUTM (2002).

The use of patents marks an important difference between spin-offs from external research institutions and spin-offs from universities: whereas at universities only 1.7% of all spin-offs exploit patents from publicly funded research (including patents held by professors), the figure is around 20% at external research institutions. Thus one in four spin-offs from a **major research centre** makes use of a patent (Fig. 36). However, these differences should not be interpreted as simply the effect of different patent policies (institutional ownership of patents at external research institutions, individual ownership of patents at universities up to 2001). Here, too, the low proportions of patent-based spin-offs at universities are linked to the high proportion of spin-offs founded by graduates. However, even when referred to spin-off foundations by scientists, striking differences remain between university and external research.

Fig. 36: *Proportion of spin-offs that exploit patents (in %)*



Source: ZEW - Spin-off Survey 2001, expanded values.

## 9. Choice of location of spin-offs

It is generally assumed that for innovation networks to operate effectively it is fundamental that those involved know and trust each other. We tend to suppose that it is easier to establish trusting relationships if those involved work in the same environment enabling them to share ideas fast and without any detours. Moreover, people are more likely to establish social contacts, so that the emergence of regional networks offering the possibility to build up and maintain informal relationships is regarded as highly important (cf. Grabher 1993, Jaffe et al. 1993, Beise and Stahl 1999, Koschatzky 2002).

### Distance between spin-off and incubator

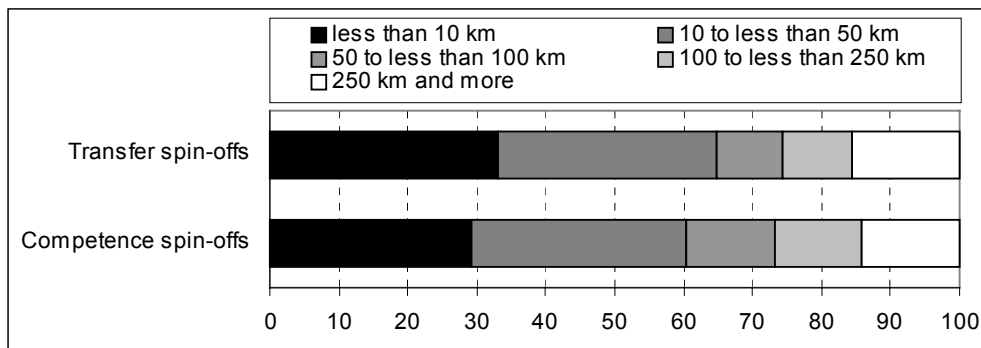
It is therefore very likely that a short distance between the partners, which facilitates personal contacts while reducing some components of the transaction costs in the event of a cooperation, would also be very helpful for the relationship between the research incubator and its spin-offs. Proximity to the spin-off is sometimes even regarded as indispensable, above all for the continuation of joint research work, but also for other sorts of support provided to new businesses by the incubator. This is why numerous scientific institutions have arranged for space in their vicinity ready to be used by spin-offs, for example in the form of start-up centres or technology parks, or sometimes also on the campus itself.

Programmes supporting the setting up of new businesses by researchers and graduates tend to pursue a regional approach, too (cf. the individual EXIST networks).

In fact, two in three spin-offs are founded **in the vicinity of the incubator location**, i.e. at a distance of less than 10 km from the incubator (Fig. 37). Almost two thirds of all spin-offs stay in the same region, i.e. within a radius of 50 km. One in four spin-offs sets up at a distance to the incubator exceeding 100 km, and more than 15% are in excess of 250 km from the incubator.<sup>11</sup> Exploitation and competence spin-offs do not differ very much in this respect.

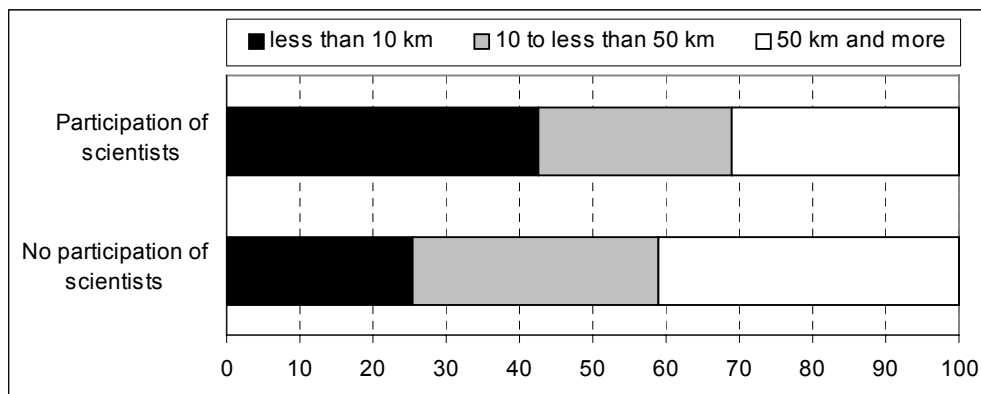
Spin-offs whose founders include **scientists** are more likely to set up closer to the incubator than spin-offs founded exclusively by graduates, students or non-academics (Fig. 38). This is mostly due to the fact that a higher percentage of scientists continue to be active at the scientific institution and therefore prefer their company to be close to the institution.

Fig. 37: Distance between location of spin-off and location of incubator facility (% shares).



Source: ZEW Spin-off Survey 2001, expanded values.

Fig. 38: Distance between spin-off and incubator as a function of the participation of scientists in the spin-off (% shares).



Source: ZEW Spin-off Survey 2001, expanded values.

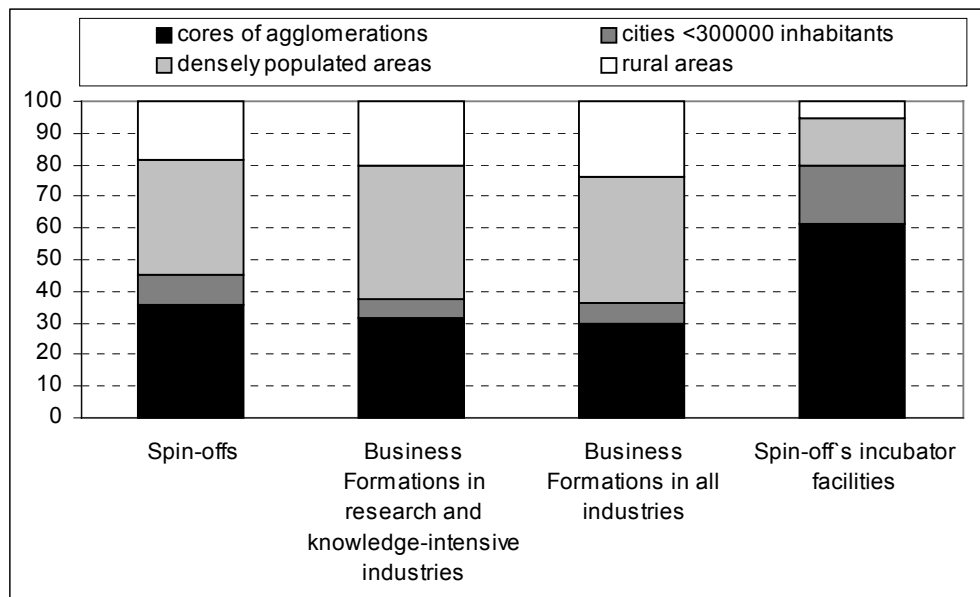
<sup>11</sup> The distance to the closest incubator applies for spin-offs with more than one incubator.

## Location patterns according to types of regions

The fact that most spin-offs set up in the same region as the incubator is not necessarily due to their choosing to be close to the scientific institution. For the incubators are almost always located in the **most attractive regions** in terms of economic activity and infrastructure, i.e. at cores of agglomerations or in urban areas. These are locations where knowledge-intensive companies find favorable conditions like proximity to customers, a highly qualified workforce, high-tech infrastructure and excellent transport connections. We can therefore expect that spin-offs – but also other companies active in research and knowledge intensive industries – are attracted by locations of this kind, as disadvantages typical of agglomerations, like high prices for buying land or renting space or high transport costs due to traffic jams, are less relevant for small businesses.

In fact, the **location** pattern of spin-offs – i.e. the distribution of new businesses by spatial type and regional structure – tends to correspond to that of all start-ups in the research and knowledge-intensive industries. Almost 50% of all spin-offs are located at centres of large cities and agglomerations, but there are still 20% in rural areas (Fig. 39). However, the location pattern here does not differ much from the location pattern found among all start-ups. Thus, spin-offs cannot be said to concentrate in specific regions of locations, but their spatial distribution resembles that of new businesses in all industries.

Fig. 39: Distribution of new businesses by type of region (% shares)



Source: ZEW Spin-off Survey 2001, expanded values.

The location pattern of spin-offs does, however, differ much from that of those public research institutions from which they were spun off. The spin-offs' incubator facilities tend to concentrate in cores of agglomerations and cities, where 80% of all incubators (weighted with the number of spin-offs created by the respective incubator) are located. Less than 5% of all incubators are located in rural areas. On balance, the **regional distribution of spin-offs** located at a certain distance to the incubator is **more even** than for start-ups in close vicinity of the incubator. This balance can also be regarded as a **flow of knowledge** from the centres to the surrounding and peripheral areas.

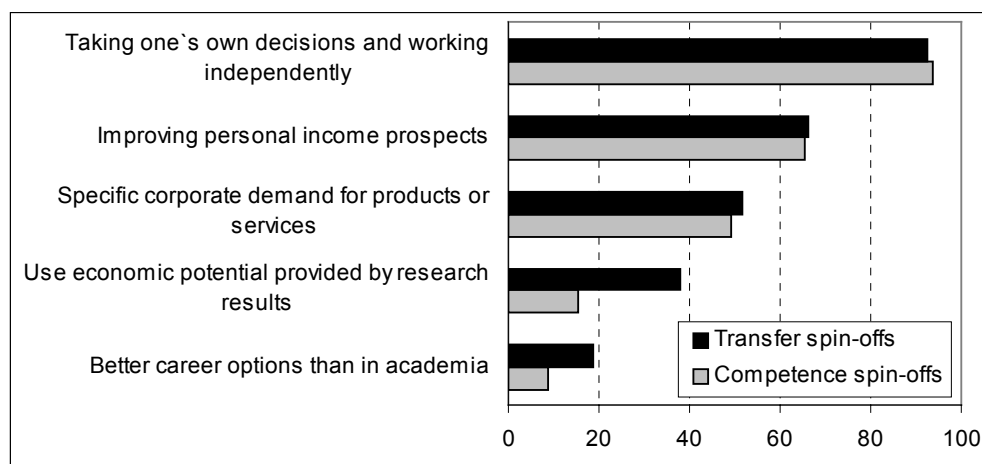
## 10. Motivations, barriers and support

To provide targeted support for the formation of businesses it is necessary, among other things, to know the reasons for the business formation and the specific barriers faced by founders who make their first step as entrepreneurs. Looking at the motivations for setting up a business reveals the relative importance of individual preferences, the demand of the market or specific customers and the (projected) commercial potentials of research results (and the associated income prospects) when deciding to found a business. Barriers to starting up reflect the obstacles that had to be overcome by the founders. They can result from e.g. lack of resources, scarcity at factor markets, general regulatory conditions, the founders' lack of information or expertise or – in the case of spin-offs – conflicts between scientific work and being self-employed. By offering support services public research institutions and innovation policy attempt to counter these barriers and promote the readiness to found a business.

### Motivations for creating spin-offs

The **motivations** for starting a business stated by spin-off founders strongly correspond with the general motivations for being self-employed: **taking one's own decisions** and **working independently** is an important motivation for almost every spin-off founder (Fig. 40). For around two thirds of spin-offs the aim of improving **individual income prospects** is the main reason for setting up one's own business. This holds true for business formations by graduates and students in particular.

Fig. 40: Motivations for spin-off formations (% shares, multiple responses allowed)



Source: ZEW Spin-off Survey 2001, expanded values.

For at least one out of two spin-offs **specific corporate demand** for the products or services offered by the enterprise is another motivation for founding a business. This shows that spin-offs largely are founded because of some market impetus. By contrast, the use of economic potential of research results was stated clearly less often albeit being a motivation for a quarter of all spin-offs. The minor importance of the motivation to achieve „better career options than in academia“ is explained by the fact that this motivation has relevance primarily for those scientists who actually are able to choose between continuing to work as a scientist

and being self-employed whereas many graduates are not offered any opportunities for embarking on a scientific career at all.

Transfer spin-offs and competence spin-offs only differ with regard to the two motivations mentioned least: there is a clearly higher percentage of transfer spin-offs (just under 40%) aiming at **using the economic potential** of research results. This was to be expected due to the differentiation between the spin-off types. But nearly one in five transfer spin-offs (but less than one in ten competence spin-offs) state better **career options** as an important motivation for founding a business as well.

### **Barriers to founding a spin-off**

The present survey questioned only those enterprises that were successful start-ups in terms of having survived in the market for at least one year. The average of all businesses questioned has been on the market for three years. Barriers to founding a spin-off therefore are obstacles that have hindered the formation of the new business but could not prevent it. The barriers of business formations, which shortly after their foundation disappeared from the market again, can clearly differ from barriers of “successful” business formations. This factor should be considered when examining the barriers. According to the enterprises questioned, a weak capital base is the most important barrier to setting up a business. More than 40% of the exploitation and competence spin-offs feel affected by **financing constraints** and say the “lack of appropriate sources of finance” is a problem when setting up an enterprise (Fig. 41). The lack of **qualified personnel** constitutes the second largest barrier and slows down the process according to nearly a third of the new businesses. This reflects the tightness of the German market for highly qualified workers at the end of the 90s. The main barriers include **permit procedures and legislation** which are restrictions that hinder the start phase of transfer spin-offs to an even larger extent (just under 35%) than the start of competence spin-offs (29 %). In this context the respondents mention above all the bureaucratic red tape of registering a company and to some extent also specific problems when applying for the approval of new procedures. At least one fourth of the spin-offs state that **insufficient economic and commercial skills** are a hindrance to building up the enterprise. On the other hand, insufficient technological information as well as any conflicts with academia are not considered as obstacles.

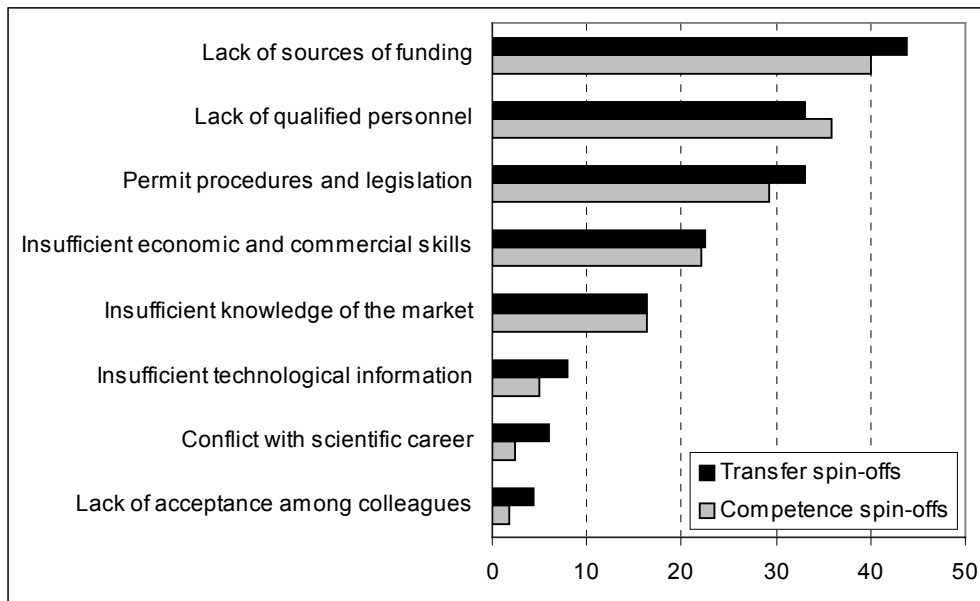
A **comparison** of the barriers faced by spin-offs and by already established, innovative small- and medium-sized enterprises (SMEs) - the latter facing barriers when starting innovation projects – is revealing. A “lack of sources of funding” and “legislation” are obstacles of similar importance and affect a similarly large part of innovative SMEs and spin-offs. The barriers „insufficient knowledge of the market“ and „insufficient technological information“, by contrast, affect innovating SMEs to a markedly higher degree than spin-offs.<sup>12</sup> This was to be expected regarding technological information as spin-offs should in fact have a broader base of technological knowledge due to their academic background.

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<sup>12</sup> Results of a special evaluation from the Mannheim Innovation Panels of the ZEW (cf. Janz et al., 2002).



Fig. 41: Barriers to founding a spin-off (% shares, multiple responses allowed)



Source: ZEW Spin-off Survey 2001, expanded values.

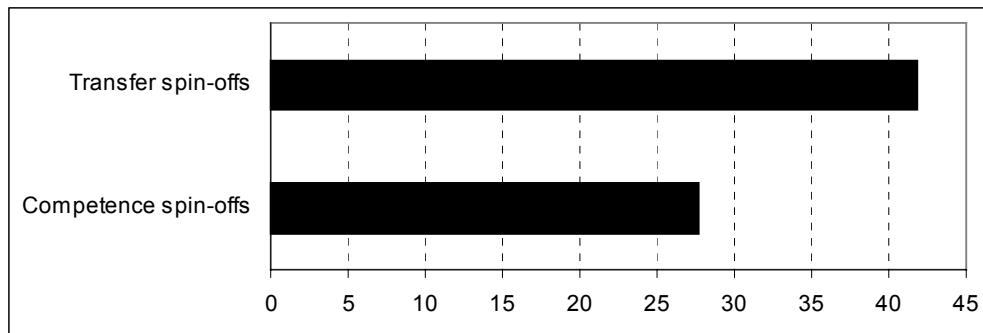
The lack of qualified personnel also is an obstacle mentioned less by spin-offs (innovating SMEs: 40-50%, spin-offs: 35%). At the end of the 90s this barrier became more and more significant in the group of innovating SMEs and by 2000 it had become the most important innovation obstacle (cf. Janz et al., 2002). The fact that spin-offs have better access to university and college graduates due to existing (personal) contacts to academia may have an effect here: nearly 40% of the transfer spin-offs employ students through internships or offer them to conduct studies for their theses in the company. This facilitates finding new, qualified employees, even at times of a tight market for highly qualified workers.

### Scientific institutions support spin-offs

In order to counter the various barriers spin-offs are faced with, more and more scientific institutions offer special **support services to founders of businesses**. This resources include all kinds of support, from teaching events for topics related to business formation and individual consulting to the provision of infrastructure (offices, access to laboratories, secretarial services, etc.). The support resources that were built up in many centres over the past years have different objectives and aim at different target groups: on the one hand, these actions are to increase scientists' and students' awareness and motivation to deal with the idea of becoming self-employed. Furthermore, there is support in the form of strengthening the qualification basis of potential founders of enterprises and providing individual consulting to prepare the foundation of a business. There is also a „soft“ type of support, i.e. establishing useful contacts or consulting centres. Moreover, some incubators have specific offers that can help cover property risks and/or reduce costs and uncertainty in the start phase, e.g. low-cost offices and service offers for founders.

Overall, around **a third** of all the spin-offs founded between 1996 and 2000 received **support** from their scientific establishment, the share of transfer spin-offs (40%) being much higher than that of competence spin-offs (28%) (Fig. 42).

Fig. 42: Spin-offs that received support from their scientific institution during their formation (in %)

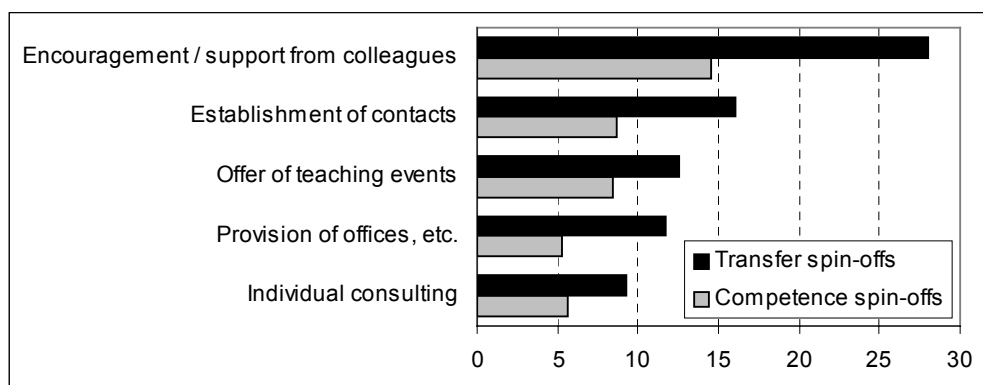


Source: ZEW Spin-off Survey 2001, expanded values.

It is worthwhile noting that many higher education and external research institutions started offering such forms of support only two to three years ago whereas the enterprises questioned in this study had already been founded before the expansion of the support offer. Thus we can assume that in many cases several forms of support were not available to the founders of businesses. In addition, it should be noted that many spin-offs are only founded some considerable time after leaving academia. The contact to their former institutes therefore is less close and it is more obvious to them to use the support services offered by private consulting firms or other providers (Chambers of Commerce, facilities promoting the regional economy, etc.).

The **form of support** mentioned most is the encouragement and support from colleagues (Fig. 43). Less than 10% of the spin-offs made use of the more formal support offer such as teaching events relevant for the founding process, the provision of infrastructure (offices, secretarial services, access to laboratories, etc.) or individual consulting. Among all forms of support, transfer spin-offs clearly received more support from their scientific institutions than competence spin-offs.

Fig. 43: Forms of support received by spin-offs (% shares, multiple responses allowed)

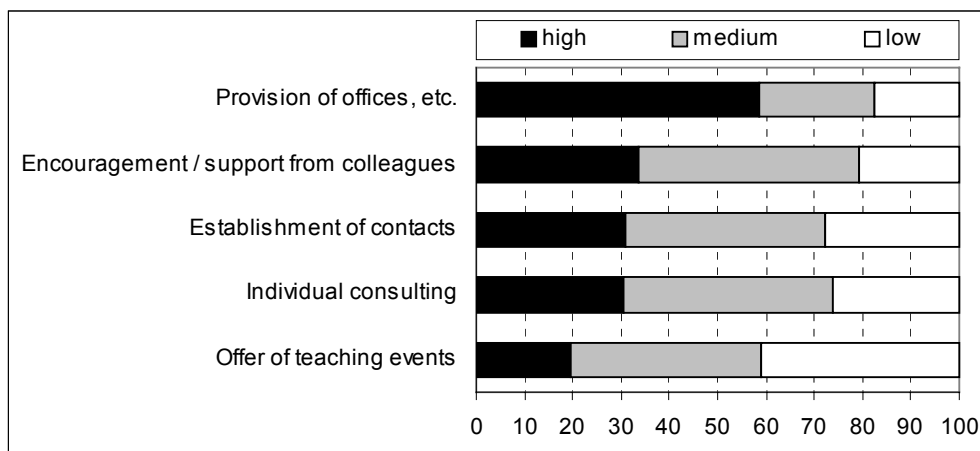


Source: ZEW Spin-off Survey 2001, expanded values.

The **provision of offices or other infrastructure** was evaluated as the most positive of all forms of support for its important contribution to the business success (Fig. 44). More than half of the spin-offs who benefited from such material support, which has an immediate effect on the cost situation of a business, ascribed a high importance of the support for the success

of the enterprise. By contrast, 40% of the spin-offs who had benefited from teaching events considered that form of support as contributing little to their success.

Fig. 44: Importance of the forms of support for the business success from the perspective of spin-offs



Source: ZEW Spin-off Survey 2001, expanded values.

It seems worthwhile, against this background, to consider different approaches when looking at the orientation of support resources and their utilisation:

- The **first** approach is to find out how potential entrepreneurs can be better informed about existing support resources and the benefit the measures can have for their specific venture. This is important because businesses that benefited from support services evaluate the help and services provided mainly in a positive way, i.e. according to their experience they attach great to medium importance for business success. Transfer spin-offs attach more importance to support measures than competence spin-offs. The ranking of the concrete support services is comparable for both types of spin-offs.
- **Second**, it should be considered which services need to be provided by incubators and which can also be rendered by other facilities. According to the founders, the provision of offices, access to equipment, technical infrastructure, secretarial services, etc. have the highest priority. Almost two thirds of transfer spin-offs think that this is highly important for the business success. This form of material support reduces risks, lowers especially the fixed costs associated with building up the enterprise, noticeably increases the spin-off's liquidity and additionally offers scientists and students/graduates an opportunity to continue working at their former place of activity and in the environment they are used to.

Spin-off founders call on encouragement and support from professors or colleagues relatively often, which is of "high" importance for the business success in 35% of the cases. This is a channel for the founders get impetus for their own research work, rapidly obtain professional advice and profit from the network of professors and colleagues. Customised consulting on economic and commercial or legal issues is of high relevance when founding a business. For the person seeking advice it is important, however, that the consulting is specific to their needs and not just non-committal general assistance.

Moreover, establishing contacts with other centres offering support can have a positive influence on the firm's development.

- **Third**, in certain cases it might prove helpful to offer initial consulting that prepares founders, points out the risks to them and teaches them skills to analyse and assess information that might be interpreted ambiguously or situations entailing risk when they are faced with uncertainty. General teaching events that are unspecific from the founders' point of view and cover topics such as self-employment, management of the formation process, business administration, etc. are viewed sceptically by transfer spin-offs and even more so by competence spin-offs. 37% and 52% respectively of spin-off founders say that this support is only of minor importance for the business success. Normally, teaching events cannot substitute individual coaching that often is necessary for a successful start. However, as a rule, direct assistance in the founding process is not the aim of such teaching events. On the contrary, their purpose is to create a "culture of independence" in which the option of becoming self-employed is considered a "normal" option. It is not possible in the scope of the present study to assess to what extent such teaching events contribute to this purpose.

## 11. Performance of spin-offs: size, growth and success

There are various indicators that help to evaluate the performance of spin-offs. The number of jobs created by a spin-off and the increase in the number of employees working in the new businesses is an often-used measure. Other measures for success are the productivity and credit rating that serve as indicators of profitability and entrepreneurial risk. Success factors for spin-offs can be derived from the factors explaining the performance of the new businesses.

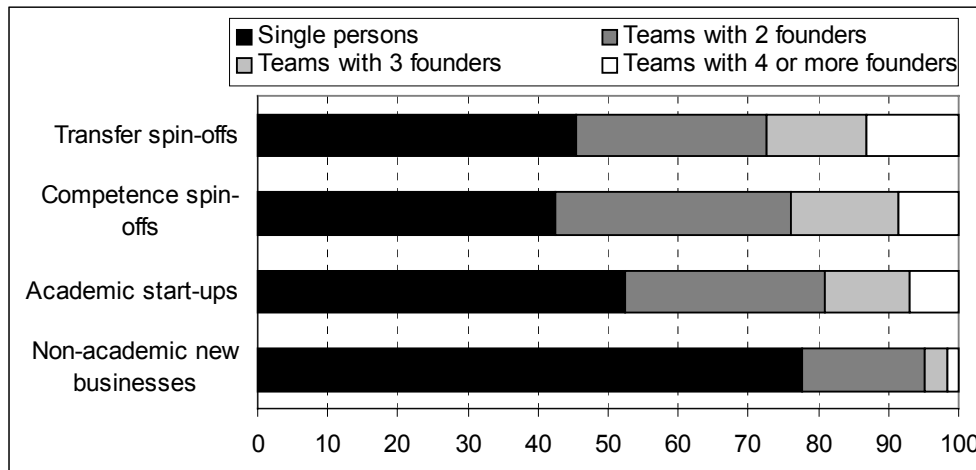
### Size of the new business

The **size** of a new business is often considered as an indicator of its potential for success. If the initial size of the new business is too small this often leads to inefficiencies and an unfavourable cost structure. Moreover, many resources are channelled into growth for achieving an optimum company size. On the other hand, if the initial size of a new business is too large fixed costs are high and in addition internal organisation work may cause high coordination expense and restrict flexibility. In general, the assumption prevails that it is due to information asymmetries, the founders' risk aversion and idiosyncratic behaviour that the initial size of new businesses is **below the optimum size**. Thus, if the products and services offered by the enterprise find acceptance on the market, many businesses experience rapid growth in the first years after their formation. There is no reliable empirical data about the optimum size for a business to be founded. Such data would probably differ strongly between sectors. Empirical studies show, that as a rule, **new businesses founded by a team** are **more successful** than such founded by a single person, both in terms of the survivorship probability and growth and the ability to attract risk capital. There is also evidence that an initial business size of more than 20 employees is not optimal (cf. Almus and Nerlinger 1998, 1999, Almus et al. 1999a,b, Almus 2002).

When looking at the distribution between **new businesses founded by a single person and such founded by a team**. The academic new businesses have a higher share of team

foundations than the average of the new businesses in the research and knowledge-intensive industries (Fig. 45). About one in two new firms with academic background is founded by a team, in the case of non-academic new businesses it is less than one in four. In approximately 20% of all academic start-ups the team consists of more than two people whereas only 5% of non-academic new businesses are founded by three or more persons.

Fig. 45: Size of founders teams in research and knowledge-intensive industries (in %)

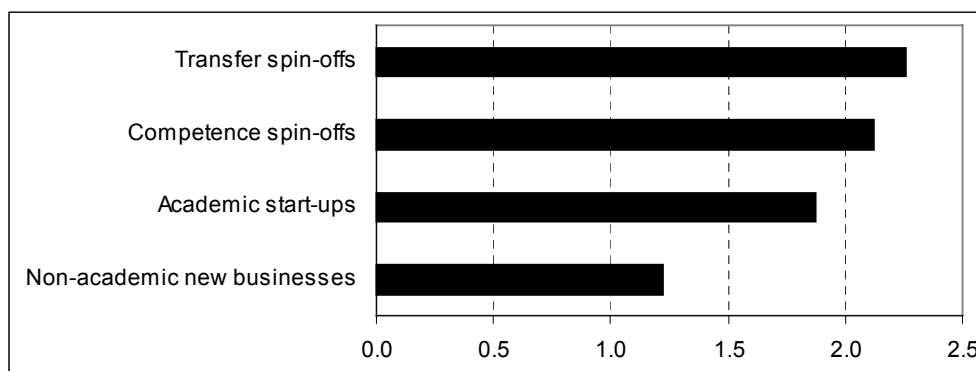


Source: ZEW Spin-off Survey 2001, expanded values.

**Transfer spin-offs** are characterised by a particularly high share of **large teams of founders**, i.e. the teams consist of at least four persons. This team size is very rare in non-academic new businesses and also less frequent in competence spin-offs and academic start-ups. This also results in a higher average **number of founders**: 2.25 in the case of transfer spin-offs as compared to 1.20 for non-academic new businesses and 1.8 for academic start-ups (Fig. 46).

This **special characteristic of transfer spin-offs** may, on the one hand, be due to the more complex “production function” of such businesses. Manufacturing products or providing the services requires different types of expertise which are difficult to find in one single person.

Fig. 46: Number of founders in research and knowledge-intensive sectors by business foundation types



Source: ZEW Spin-off Survey 2001, expanded values.

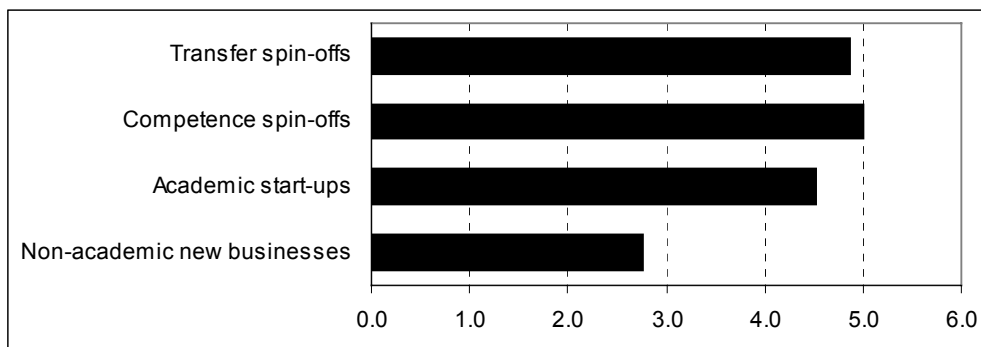
On the other hand, the expected innovation yield that depends on the offer of goods based on new research results or scientific methods – i.e. normally market novelties – can increase

the willingness of potential co-founders to contribute also financially to the new business. However, the large number of founders might also be the result of a strategy of risk-sharing and reducing search costs by combining the information of a larger number of spin-off founders – leading to more security when making decisions in a situation where there is greater uncertainty about market acceptance and the technological feasibility of the business idea.

### The impact of spin-offs on employment

On average, spin-offs are founded with slightly more employees than other businesses in research and knowledge-intensive industries. In their first business year, spin-offs (both exploitation and competence spin-offs) employ just under 5 people (including the founders), academic start-ups employ 4.5 people whereas the number of employees in non-academic new businesses is just under 3 (Fig. 47).

Fig. 47: Number of employees in the first business year



Source: ZEW Spin-off Survey 2001, expanded values.

The **higher initial number of employees** results for a good part from the higher number of founders. But academic new businesses also employ a higher number of staff in addition to the founders in their first business year than non-academic start-ups.

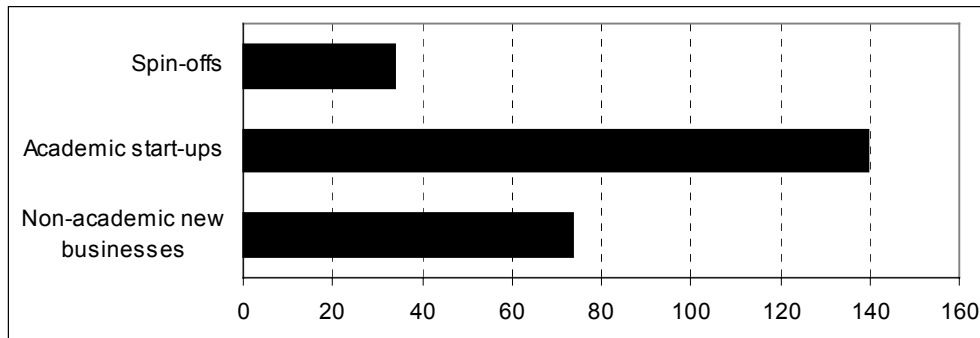
Across all types of new businesses the initial size of the business distinctly differs across **sector groups**. The biggest enterprises are founded in the high-tech manufacturing (on average 5 employees in the first year), whereas the initial business size in the service sector industries is only 3.3 (technology-oriented services) and 4.4 (knowledge-intensive services) respectively. Spin-offs, however, do not fit into this pattern. They have a high initial number of employees even in the area of knowledge-intensive services (above 6).

The **gross contribution** of new spin-offs to employment, i.e. the total number of jobs created in spin-offs, was close to 34,000 full-time jobs per year in the second half of the 1990s, 12,500 of which were working in transfer spin-offs and 21,000 in competence spin-offs. In comparison, despite the smaller average initial size of academic start-ups their contribution to employment is considerably larger because the number of this type of new businesses is much higher. Their gross contribution was 140,000 full-time jobs in the research and knowledge-intensive industries (Fig. 48).

The gross contribution to employment of non-academic foundations in these sectors was just under 74,000 full-time jobs per year. When evaluating these figures it is necessary to deduct

from the gross effects the job losses in those businesses that are crowded out because of the market entry of the new businesses and consequently are closed down. There is no data on these losses but we can assume that their number is relatively small as the research and knowledge-intensive industries are growing overall.

Fig. 48: Gross contribution to employment by business foundation types (in 1,000 full-time jobs in the first business year)



Source: ZEW Spin-off Survey 2001, expanded values.

### Growth of spin-offs

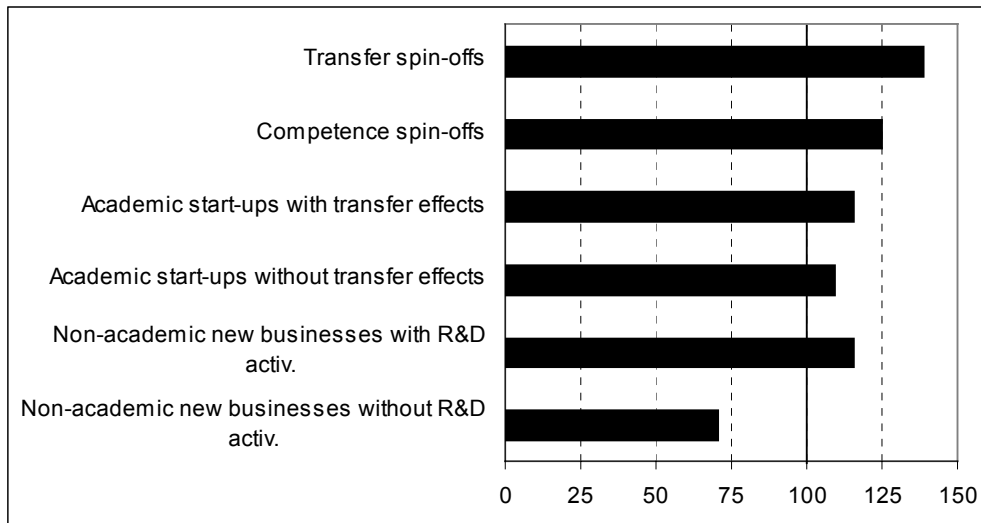
The **growth of the number of employees** is clearly stronger in spin-offs than in other types of new businesses. Of all the spin-offs that were founded between 1996 and 2000 and still existed at the end of 2001, 57% have a positive growth of the number of employees compared to 52% of academic start-ups and 41% of non-academic new businesses. There are two reasons why the positive difference between growing and shrinking enterprises is not surprising: First, it is only possible to observe growth of surviving businesses whereas the number of new businesses founded since 1996 that no longer existed at the end of 2001 and thus have negative growth of the number of employees<sup>13</sup> is not known. And second, we only looked at the research and knowledge-intensive industries in such sectors as saw the strongest macroeconomic growth in the past years.

The number of employees grew strongly in transfer spin-offs in particular. Their average annual growth rate is **40% above the average** found in all new businesses set up in research and knowledge-intensive sectors (Fig. 49). Nevertheless, the growth of all other businesses set up by academic entrepreneurs is above average as well. Breaking down non-academic foundations according to their R&D activities shows more rapid growth for those engaged in R&D while non-academic new businesses without R&D activities are the only new businesses in research and knowledge-intensive industries whose increase in employees is below average. An R&D orientation thus promotes strong growth in terms of employment of young businesses in research and knowledge-intensive industries.

<sup>13</sup> We assumed for the extension of the figures in the individual years when the businesses were set up that there is no significant statistical difference in terms of survivorship probability between the business foundation types examined in this survey. This assumption is corroborated by the structure the new businesses: there are no noticeable differences between exploitation spin-offs, competence spin-offs, academic start-ups and non-academic new businesses with regard to the variables that determined the probability of a business closure to a major extent (cf. Prantl 2000).



Fig. 49: Increase in employees in surviving new businesses in research and knowledge-intensive industries (all new businesses in RKI = 100)



Source: ZEW Spin-off Survey 2001, expanded values.

Due to the strong increase in the number of employees working in the surviving spin-offs and start-ups, we can expect a positive **net employment effect**, i.e. the effect less the job losses in businesses that were closed again soon after their formation and in businesses that were crowded out. For determining the negative employment effects caused by the new businesses crowding out businesses that had been founded earlier, extensive analyses would be required which cannot be carried out under this study. It is reasonable to expect, though, that these effects tend to be of minor importance in industries in which demand is highly dynamic and which therefore experience overall growth. The present survey does not provide figures on the survivorship probability for academic start-ups and new spin-off foundations. But other studies on this suggest that we can assume that at least one out of two new businesses survives for the first five years.<sup>14</sup> Given an average annual increase in employees of approximately 20% in the surviving academic new businesses this means that after five year the **balance of the contribution** of academic new businesses to **employment** (i.e. less the jobs in start-ups that have been closed up to then) is approximately 215,000 full-time jobs (in the research and knowledge-intensive industries) and thus exceeds the immediate effect on employment of 175,000. The job losses caused by academic new businesses disappearing from the market are thus more than set off by the growing number of employees in surviving academic start-ups.

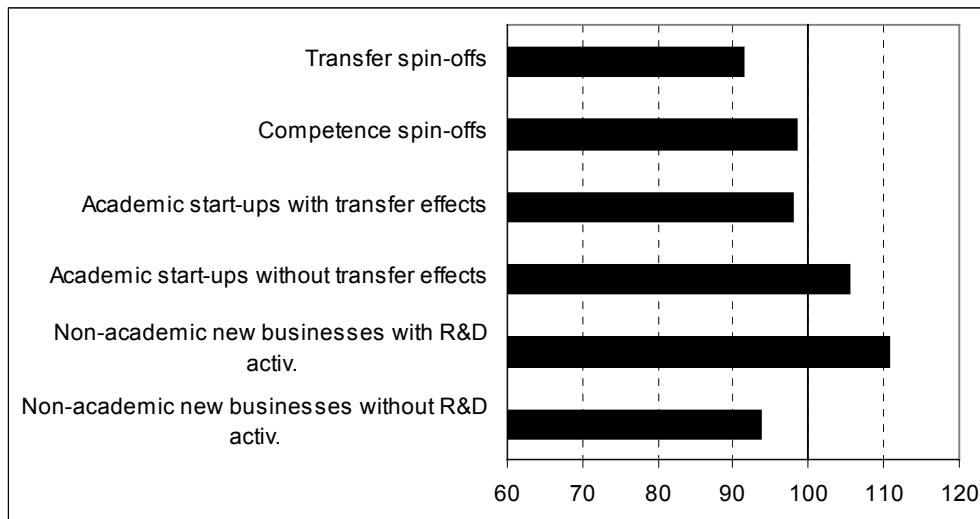
### Employee turnover ratio and credit rating

The strong increase in the number of employees of spin-offs has a repercussion on the **economic performance criteria** applied to these businesses. The **employee turnover ratio**, i.e. the ratio of turnover to the number of employees is noticeably lower in transfer spin-offs than in other new businesses, but also in competence spin-offs and academic start-

<sup>14</sup> Cf. Woywode (1997) and Almus and Nerlinger (1998) for their discussion of the manufacturing industry based on the ZEW Foundation Panel or Weißhuhn and Wichmann (2000) based on the Establishment Panel from the IAB.

ups with transfer effects it is below the average found in the research and knowledge-intensive industries (Fig. 50). Non-academic new businesses engaged in R&D show the highest ratio of turnover to employees.

Fig. 50: The employee turnover ratio of new businesses in research and knowledge-intensive industries (all new businesses in RKI = 100)



Source: ZEW Spin-off Survey 2001, expanded values.

The differences between the different business foundation types are less pronounced than the differences with regard to the increase in employees. This was to be expected: first, there are only minor differences in the sector composition between the business foundation types, and differences in productivity that are typical of sectors do not have an effect. Second, in competitive markets one cannot expect major differences in productivity within one industry as businesses with a low productivity will disappear from the market quickly due to insufficient profitability whereas high employee turnover ratios indicate temporary market imbalances that induce businesses to enter the market and probably lead to a fall of average productivity.

**Multivariate analyses** of the determinants of the employee turnover ratio show that the low employee turnover ratio of spin-offs can mainly be attributed to the high share of **persons still employed in academia** in the team of founders.<sup>15</sup> An explanation to account for this negative effect is that spin-off founders who are still working in academia see the new business venture as an attempt to market a new product or process but at the same time use their work in academia as a personal source of income. This „insurance“ provided by continued employment in a scientific institution can, however, reduce the pressure for an efficient, profit-driven management of the business and give the aim of further technological improvement of the product priority over the aim of a rapid increase in turnover. The lower employee turnover ratio of these spin-offs that are especially closely linked to academia can also be due to the fact that the minimum efficiency size of research-based spin-offs is considerably higher. At first, this requires a rapid increase in employees which the company

cannot keep up with, not least because it is not possible to expand or tap the market for the innovations with the same growth rate that can be achieved for expanding the staff.

The low employee turnover ratio of spin-offs is accompanied by a poor **credit rating**, i.e. an unfavourable evaluation of creditworthiness by an external credit reference agency. As a result, the **recommended maximum credit line** which serves as a guideline to banks for their lending business is pushed downwards. This becomes particularly evident when looking at the maximum credit line per person employed: it reflects the expectations of the credit reference agencies – who tend to be risk-averse – with regard to present and (discounted) future revenues of a business normalised to its size. In general, the indicator represents the situation as at the end of 2000.

Transfer spin-offs clearly do worst while non-academic start-ups without R&D activities enjoy the highest credit line (Fig. 51). On average, the maximum credit line per employee available for transfer spin-offs is more than Euro 0.5 million below that of all new businesses in research and knowledge-intensive industries.

Multivariate analyses show that there are three groups of determinants that have a considerable influence on credit rating:

- the **human capital** in an enterprise, in this study measured as the share of academics – has a strong, **positive effect** on credit rating. The participation of scientists and/or professors in the business has no additional positive influence.
- Continuous **R&D** activities slightly **improve** the credit rating.
- If the **exploitation of new research results** from science is an indispensable or at least important basis for the formation of the business, it receives a distinctly lower credit rating.

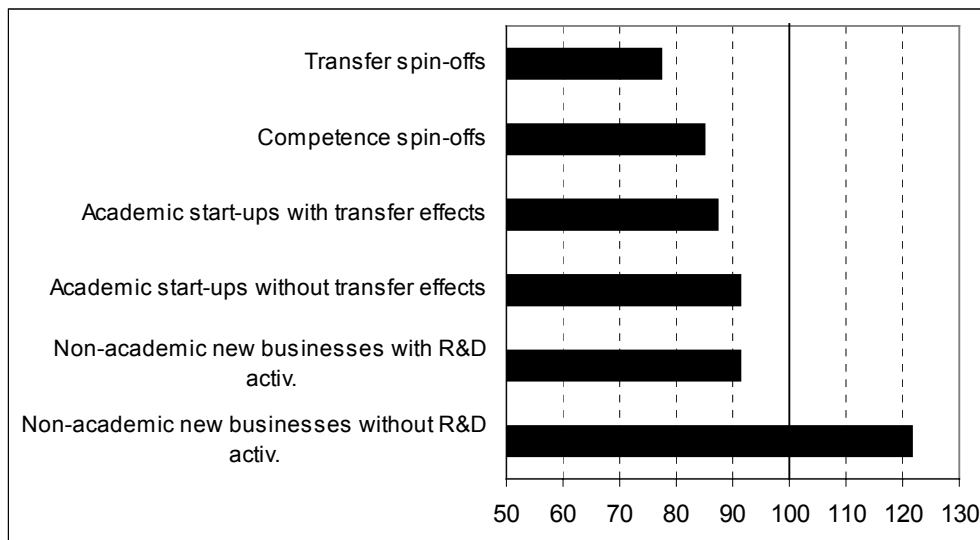
**Transfer spin-offs** thus have a **lower credit rating** as their business activities tend to entail higher risk, which impairs their creditworthiness from the perspective of risk averse investors. This negative effect is so strong that it more than compensates the positive effects of the high level of human capital and of the R&D activities (which are considered as an indicator of growth).

The poor performance with regard to these success indicators implies both an internal and an external **financing constraint** for spin-offs: the low productivity limits the cashflow, i.e. equity financing, as the debt market offers them credit conditions that are more unfavourable than those offered to other new businesses in the research and knowledge-intensive industries.

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<sup>15</sup> For calculating the employee turnover ratio we used employment at full-time equivalents, i.e. founders or employees working only part-time in the business are accounted for on a pro-rata basis.

Fig. 51: Recommended maximum credit line per employee of new businesses in research and knowledge-intensive sectors, evaluation by an external credit reference agency (all new businesses in RKI = 100)



Source: ZEW Foundation Panels, ZEW Spin-off Survey 2001, expanded values.

### Success factor knowledge

In research and knowledge-intensive industries the **knowledge orientation** of young spin-offs proves to be the **most important success factor**. Businesses who are engaged in R&D activities of their own and through official contacts use academia as a cooperation partner grow more rapidly, have greater productivity and enjoy better external credit ratings. The human capital available to them (share of academics), by contrast, is not a success factor *within* the knowledge-intensive segment of the economy. The use of recent scientific research results – the main characteristic of transfer spin-offs – has a negative impact on external credit rating. The uncertainty accompanying the commercial exploitation of R&D leads to credit rationing in the traditional capital market (bank lending) because the costs that would be incurred by banks in the event of a failure of the spin-off are high (credit loss) while the revenues remain limited to interest income even if the spin-off is very successful.

**Transfer spin-offs** thus are characterised by a specific pattern of success factors: their initial number of employees is higher and it increases considerably faster in the first years than in other new businesses. However, turnover cannot cope with this growth which results in a lower employee turnover ratio. This, together with the uncertainty inherent to the exploitation of new research results, leads to a poor credit rating. The **priority of the increase in employees** observed in transfer spin-offs is due to the following factors:

- on the one hand, the necessity to combine to an especially large degree different capabilities (technological, scientific, economic) that are difficult to bundle in one or a few persons;
- on the other hand, it is more difficult for them than for other new businesses to achieve economies of standardisation or scale as they tend to be specialised on customised and development-intensive products and services. An expansion of production consequently also implies an expansion of headcount.

- In addition, the strategy used by spin-offs to counter the higher business risk is to share the risk with a larger number of founders.

One can assume, however, that this growth pattern is valid for the first years only and will be reversed later – when the new product or service has been accepted by the market –, i.e. turnover will then grow more rapidly than employment. This is also suggested by the increase in employees of older transfer spin-offs which typically slows down to be only slightly above average.

## 12. Brief summary of the most important results

- 1) The **number of spin-off formations** in Germany had reached the level of approximately 6,800 businesses per year by the end of the 1990s, approx. 2,600 of which are transfer spin-offs that convert new research results from scientific establishments directly into marketable products and services. However, their effect on overall spin-off activities is relatively limited when considering that in all of Germany approximately 250,000 new businesses are founded per year, 65,000 of which are in the research and knowledge-intensive industries. Spin-off foundations account for three percent of all new businesses and approximately 11% of the new businesses founded in research and knowledge-intensive industries.
- 2) The key importance of spin-off formations is their contribution to the **transfer of knowledge and technology**. They serve as a transfer channel, completing other forms of knowledge exchange between academia and the economy such as R&D cooperations, staff mobility, distribution of new insights via publications and patents or informal talks between scientists and companies.
- 3) **New businesses founded by academics** are very important for the **structural change** towards a knowledge-based economy. The just under 38,000 academic new businesses account for 60% of all new businesses in research and knowledge-intensive industries and are responsible for the increase in new businesses that has taken place in these sectors since 1999.
- 4) Today, the research and knowledge-intensive industries are the sectors of the economy that enjoy the highest employment growth rates. Concentrating on these industries, academic start-ups follow this industry trend and experience strong growth as well. The 38,000 new businesses set up by academics every year create approx. 175,000 full-time **jobs** in their first business year already, i.e. nearly two thirds of all new jobs created in research and knowledge-intensive industries in Germany every year.
- 5) The contribution of transfer spin-offs to employment is 12,500 jobs per year, that of competence spin-offs amounts to 21,000 jobs per year. The growth rates for **employment** are even above the trend level in the research and knowledge-intensive industries. On the other hand, the strong increase in employees observed in transfer spin-offs is contrasted by a relatively low turnover per employee. To achieve the efficient minimum business size, new spin-offs at first strive for a rapid increase in employees. **Turnover** cannot keep up with this development, however, but follows the typical pattern of the industry. This has a negative effect on the employee turnover ratio.

- 6) For the overwhelming majority of spin-off formations, higher education institutions serve as incubator facilities. Among the group of higher education establishments (general) universities are the most important **incubator facility** in absolute terms. Nearly one in two spin-offs depends on knowledge or capabilities coming from this institution. External research institutions play a minor role for the formation of spin-offs. Spin-off intensities – based on scientists – are highest at technical colleges and universities.
- 7) Overall, **scientists** account for more than one third of all the founders of transfer spin-offs. They also account for 17% of the founders of competence spin-offs and 12% of the founders of academic start-ups. 12% of the founders of transfer spin-offs are professors at higher education institutions. When looking at all business formations in the research and knowledge-intensive industries, 3% of them involved a professor, i.e. in absolute terms, more than 2,000 business formations per year involve professors.
- 8) The largest number of spin-off founders – just as is the case for founders of academic start-ups – are graduates from higher education institutions. They account for more than 60% of all founders in the research and knowledge-intensive industries while their share in transfer spin-offs is somewhat smaller with just under 50%. In the second half of the 1990s, approximately 47,000 graduates were participating as founders in the formation of new businesses in research and knowledge-intensive industries, nearly a fifth of which were spin-offs.
- 9) In the second half of the 1990s, 1.25% of the scientists departed from public research institutions every year in order to create a business. When adding those scientists who worked in dependent employment in the time between departure from academia and business formation as well as those who continue to work in academia it appears that for every 100 scientists working in public research in Germany there are more than 3 scientists per year who are involved in a business formation.
- 10) A substantial part of spin-offs are founded only some **considerable time** after the founders' departure from academia. Less than 50% of transfer spin-offs and only one in four competence spin-offs are created immediately either in academia or after higher education. For 30% of all transfer spin-offs and one in two competence spin-offs more than five years elapse between the founders' scientific activities or higher education and the formation of the business. Apparently, these spin-offs combine scientific know-how with the market experience and client contacts they have after having been employed for some time.
- 11) Two in three spin-offs are founded in proximity to the incubator facility although one in four spin-offs is located at a distance of more than 100 km from the incubator. The **locational** pattern of spin-offs corresponds to a large extent to that of other business formations in the research and knowledge-intensive industries. The overwhelming majority of businesses are set up in the heart of a conurbation or in urban areas which attract new businesses because of the proximity to customers, good transport connections, high-quality infrastructure and extensive human capital.
- 12) The **linkage** of spin-offs to academia is an important aspect: in 30% of transfer spin-offs, 20% of competence spin-offs and 19% of academic start-ups, one of the founders was still active as a scientist or in higher education at the time of the business formation. In



more than one out of five transfer spin-offs at least one founder still is a scientist, often a professor who is co-founder. These partial spin-offs have several advantages: they benefit from close contacts with academia, which enables them to continue to use these resources of knowledge and reduces the employment and/or income risk in the event of a failure of the spin-off.

- 13) In research and knowledge-intensive industries the **knowledge orientation** of young spin-offs proves to be the **most important success factor**. Businesses who are engaged in R&D activities of their own and through official contacts use academia as a cooperation partner grow more rapidly and have greater productivity. Nearly 60% of all transfer spin-offs are engaged in R&D activities of their own, and of these 60% three thirds continuously pursue R&D. The share of businesses engaged in R&D is 40% in the group of competence spin-offs, for academic start-ups it is 30%, and for non-academic start-ups it is less than 20%.
- 14) Having one's **own knowledge stock** is a very important prerequisite for contacts to academia for both spin-offs and academic/non-academic start-ups. For instance, 57% of the new businesses who conduct R&D projects on a regular basis maintain ongoing contacts with scientific institutions – for businesses without R&D activities this figure is only 27%. And 65% of all academic start-ups whose founders included scientists have contacts to academia as compared to as little as 40% of the businesses founded exclusively by graduates or students.
- 15) Taking one's own decisions and working independently is an important **motivation** for almost every spin-off founder. For around two thirds of spin-offs the aim of improving the individual income prospects is the main reason for setting up one's own business. This holds true for business formations by graduates and students in particular. For as much as one in two spin-offs, specific corporate demand for the products or services offered by the enterprise is another motivation for founding a business.
- 16) According to the enterprises questioned, a weak capital base is the most important **barrier to setting up a business**. More than 40% of exploitation and competence spin-offs feel affected by financing constraints. The lack of qualified personnel constitutes the second largest barrier and slows down the process according to nearly a third of the new businesses. The main barriers include permit procedures and legislation which are restrictions that hinder the start phase of transfer spin-offs to an even larger extent (just under 35%) than the start of competence spin-offs (29 %).

## 13. Conclusion

- 1) The study results provide different points of departure for a **spin-off oriented innovation policy**.
  - Firstly, the question of funding the market entry and the first years of growth of transfer spin-offs. Apart from a weak capital base and lack of equity financing they are faced with credit rationing at the traditional debt market. This suggests the use of venture capital as a funding alternative.



- Secondly, in view of the uncertainties which are basically always part of the commercialisation of new research findings, a smoother transfer of scientific activities into new businesses might facilitate the market entry.
  - Thirdly, founders often encounter difficulties only when dealing with operational business. In such cases they need individual support tailored to their specific situation. It remains to be seen whether scientific institutions are the best option when seeking solutions to such problems. Higher education and research institutions, however, are indeed very important as partners in knowledge acquisition and when it comes to providing substantive and scientific advice.
  - Fourthly and lastly, one should not neglect the role of academia as a partner for all research and knowledge-oriented enterprises. Contacts with academia increase the probability of entrepreneurial success. For this reason favourable conditions should be created also at public research institutions – unless they already exist – to promote cooperation between small, young enterprises and academia, regardless of whether these are spin-offs or other new ventures.
- 2) Commercial exploitation of research findings from academia via new business foundations will **avoid potential problems related to knowledge and technology transfer** when using other transfer channels – e.g. when selling findings to existing companies. Well-established companies sometimes hesitate to take up new research findings from academia (“not invented here” phenomenon) and do not pursue them further, e.g. because they lack specific scientific knowledge. If a company purchases a new technology developed in public research facilities, it might even ward off further commercialisation of this technology, if it wants to avoid competition with its own technologies, or wants to prevent competitors from using the new technology.
- 3) Spin-offs, however, are used as a transfer channel when individuals intend to reap the fruits of publicly funded research findings. The commercialisation of new research results via business foundations might clash with the diffusion of scientific insights in publications and thus the free access to this information. Focusing too much on spin-offs as transfer channels might lead academia to neglect some of its other important functions (education, basic research) and other transfer channels (cooperation, staff mobility).
- 4) Promoting spin-offs should be one component of a **broad** political concept which should provide an impetus for knowledge and technology transfers from public research. As is the case for all other types of knowledge and technology transfer, the usefulness and **demand orientation** of knowledge produced by academia is the precondition for spin-off formations.

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00-09	Wolfgang Franz, Martin Gutzeit, Jan Lessner, Walter A. Oechsler, Friedhelm Pfeiffer, Lars Reichmann, Volker Rieble, Jochen Roll	Flexibilisierung der Arbeitsentgelte und Beschäftigungseffekte. Ergebnisse einer Unternehmensbefragung.
00-10	Norbert Janz	Quellen für Innovationen: Analyse der ZEW-Innovationserhebungen 1999 im Verarbeitenden Gewerbe und im Dienstleistungssektor.
00-11	Matthias Krey, Sigurd Weinreich	Internalisierung externer Klimakosten im Pkw-Verkehr in Deutschland.
00-12	Karl Ludwig Brockmann Christoph Böhringer Marcus Stronzik	Flexible Instrumente in der deutschen Klimapolitik – Chancen und Risiken.
00-13	Marcus Stronzik, Birgit Dette, Anke Herold	„Early Crediting“ als klimapolitisches Instrument. Eine ökonomische und rechtliche Analyse.
00-14	Dirk Czarnitzki, Christian Rammer Alfred Spielkamp	Interaktion zwischen Wissenschaft und Wirtschaft in Deutschland. Ergebnisse einer Umfrage bei Hochschulen und öffentlichen Forschungseinrichtungen.
00-15	Dirk Czarnitzki, Jürgen Egel Thomas Eckert, Christina Elschner	Internetangebote zum Wissens- und Technologietransfer in Deutschland. Bestandsaufnahme, Funktionalität und Alternativen.
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01-02	Charlotte Lauer	Educational Attainment: A French-German Comparison.
01-03	Martin Gutzeit Hermann Reichold Volker Rieble	Entgeltflexibilisierung aus juristischer Sicht. Juristische Beiträge des interdisziplinären Symposiums „Flexibilisierung des Arbeitsentgelts aus ökonomischer und juristischer Sicht“ am 25. und 26. Januar 2001 in Mannheim.
02-01	Dirk Engel, Helmut Fryges	Aufbereitung und Angebot der ZEW Gründungsindikatoren.
02-02	Marian Beise, Thomas Cleff, Oliver Heneric, Christian Rammer	Lead Markt Deutschland. Zur Position Deutschlands als führender Absatzmarkt für Innovationen. Thematische Schwerpunktstudie im Rahmen der Berichterstattung zur Technologischen Leistungsfähigkeit im Auftrag des bmb+f (Endbericht).
02-03	Sandra Gottschalk, Norbert Janz, Bettina Peters, Christian Rammer, Tobias Schmidt	Innovationsverhalten der deutschen Wirtschaft: Hintergrundbericht zur Innovationserhebung 2001.
03-01	Otto H. Jacobs, Ulrich Schreiber, Christoph Spengel, Gerd Gutekunst Lothar Lammersen	Stellungnahme zum Steuervergünstigungsabbaugesetz und zu weiteren steuerlichen Maßnahmen.
03-02	Jürgen Egel, Sandra Gottschalk, Christian Rammer, Alfred Spielkamp	Spinoff-Gründungen aus der öffentlichen Forschung in Deutschland.
03-03	Jürgen Egel, Thomas Eckert Heinz Griesbach, Christoph Heine Ulrich Heublein, Christian Kerst, Michael Leszczensky, Elke Middendorf, Karl-Heinz Minks, Brigitta Weitz	Indikatoren zur Ausbildung im Hochschulbereich. Studie zum Innovationssystem Deutschlands.
03-04	Jürgen Egel, Sandra Gottschalk, Christian Rammer, Alfred Spielkamp	Public Research Spin-offs in Germany.