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Academic spin-offs, corporate spin-outs and company internal start-ups as technology transfer approach

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Abstract As a rule, a technology transfer gap exists between research and development and the commercialisation of the results. This article investigates the role of new ventures for technology transfer from universities and research institutions as well as between or within companies to close this gap. Based on case studies in Germany and Switzerland, different examples of this technology transfer approach have been analysed. Academic spin-offs can help to transfer technology from universities and research institutions to industry especially if there is the need for additional funding to further develop the technology. Corporate spin-outs can be used for technology transfer between companies as an alternative to closing operations should these no longer fit into the parent organisation. Internal start-ups were identified as a new approach for company internal technology transfer from research departments to business units focused on commercial operations to overcome innovation barriers within companies.

Keywords Technology transfer · Start-up · Spin-off · Spin-out

JEL Classification O 31 · O 32 · O 34

1 Introduction

Technology transfer is becoming more and more important to close the gap between academic research and the commercialisation of the results to realise industrial applications. The EU and national governments have undertaken a number of initiatives to increase the transfer of research to industry (Wright et al. 2006), as high quality research at universities and research institutions within the EU has not been sufficiently translated into commercial applications. The transfer of technology from universities and research

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institutions to the commercial sector has, in the past, been dominated by licensing arrangements with the industry (Siegel et al. 1999). Within the terms of the agreements, universities and research institutions receive an initial payment and subsequent royalty payments as a fixed share of the company's turnover based on the right to use a technology or, more precisely, to use the correlated intellectual property (IP). Licensing arrangements are only applicable when the assets can be protected by patents and other IP rights (Hearn 1981). But in many cases, the technology is not mature enough to establish strong IP rights making it difficult to commercialise the technology. Another approach for universities and research institutions to commercialise new technologies are academic spin-offs (Franklin et al. 2001; Samson and Gurdon 1993).

The term R&D spin-off stands for a new company based on the findings of members of a research group from academia. A spin-out is when a part (department, business unit division or even a project team) of a company or organisation becomes an independent business (De Cleyn and Braet 2009; Mustar et al. 2006). But the two terms are not always used unambiguously, as sometimes the term corporate spin-off is used for a small company which has been split-off from a larger, parent organisation. The spin-out company takes personnel, assets, IP, technology, and existing products from the parent organisation. In many cases the management team of the new company originates from the same parent organisation. A corporate spin-out may initially face fewer difficulties than an academic spin-off, as parent companies could assist a start-up company better than universities and research institutions (Smilor 1987). Although corporate spin-outs are often created through a reorganisation of ownership among existing shareholders (Bergh and Lim 2008), financing through an external investor, which is usually a venture capital (VC) investor, is likewise frequently used (Rind 1981).

This article investigates the creation of spin-offs and spin-outs as a method for technology transfer, not only from universities and research institutions to companies, but also between companies. The principle of creating new ventures is used for company internal technology transfer: the concept of internal start-ups, which has not yet been described in the scientific literature, was identified during our research. The creation of new ventures as an approach for technology transfer was analysed from the standpoint of the initial technology owner with the intention to commercialise the technology. This paper specifically seeks to address the following research questions.

RQ1 How are academic spin-offs, corporate spin-outs and internal start-ups used for technology transfer?

RQ2 What are the key aspects, to understand academic spin-offs, corporate spin-outs and internal start-ups, used for technology transfer?

The first part of this paper provides in Sect. 2 the theoretical background according to academic spin-offs and corporate spin-outs and in Sect. 3 the methodology to answer the research questions. In the second part of the paper, the results and discussions are described in Sect. 4 and the implications and conclusions in Sect. 5.

2 Theoretical background

2.1 Academic spin-offs

Academic literature shows the importance of the stimulation of technology transfer through the creation of academic spin-outs (Shane 2002; Heirman and Clarysse 2004; Stam

et al. 2009), especially in high-tech areas targeting markets with high growth potentials. In several European countries, there has been a substantial increase in the number of academic spin-outs created (Wright et al. 2004; Moray and Clarysse 2005; Chiaroni et al. 2005; Clarysse et al. 2007). This is accompanied by a change in government policies that encourage universities and research institutions to commercialise their research results. The aims are support of the structural change and the regional or even national development, especially through job creation (Mian 1997). The new role of the university can be considered as another contribution in the creation of an entrepreneurial society (Audretsch 2009).

To facilitate technology transfer from academic research to industrial applications many universities and research institutions have implemented technology transfer offices (TTOs), entrepreneurship centres and incubators (Goldfarb and Henrekson 2003; Bercovitz and Feldmann 2006; Rasmussen et al. 2006). Despite the fact that normally licensing is short-term financially more attractive, most TTOs recognise start-ups as an interesting method of technology transfer and help scientists in their entrepreneurial efforts (Feldman and Feller 2002; Markman et al. 2005; Meyer 2006). In the literature, a high spin-off rate is likely related to having a supportive culture for spin-offs (Franklin et al. 2001), specific research areas (O'Shea et al. 2005), more experienced TTOs (Powers and Mc Dougall 2005), more human resource investment in TTOs (O'Shea et al. 2005), and higher research and development (R&D) expenditures (Lockett and Wright 2005).

Founding a start-up out of a university or research institution is a special challenge for entrepreneurs. Normally, academic researchers neither have the knowledge and expertise nor the experience to commercialise their research results (Litan et al. 2007). Even worse is the resistance of the university environment to commercialise research results due to concerns related to the role of academia in society (Gibbons 1999). Major concerns arise through different incentive and rewarding systems between public and private research. These are related to the trade-off between disclosure and secrecy as well as crowding out effects between public and private R&D expenditures (Dasgupta and David 1994). Some authors see conflicts of commitment and interest (Faria 2002) and a negative impact on the research agenda (Vavakova 1998) when faculty members are involved in commercialising activities.

Lockett et al. (2003) have found that the more successful universities and research institutions have clearer strategies towards the spinning out of companies. In addition, these universities and research institutions were found to possess greater expertise and networks that may be important in fostering spin-off companies. The ownership of equity in spin-offs may increase the potential up-side gain and appear to be an attractive option to universities and research institutions. There is some evidence that taking equity in a spin-out company produces a greater average return in the long run compared to the average return available from the average licensing business (Bray and Lee 2000).

2.2 Corporate spin-outs

There are various reasons for realising a corporate R&D spin-out. In the case of redundant capacities or non-core activities (e.g. after a merger of two companies), a spin-out can be used to reduce capacities and costs as an alternative to closing or selling the unit (Parhankangas and Arenius 2003; Bergh and Lim 2008). Another reason could be the reduction of capital requirements and risk, if corporate R&D projects are not in the strategic focus of a company (Chemmanur and Yan 2004). But spin-outs can also be used as a method to make R&D more flexible for increased effectiveness and efficiency (Krishnaswami and Subramaniam 1999). Today, many areas of the corporate R&D process

chain can be outsourced and covered by external service providers. Highly specialised service providers will play a more important role and integrative part of the processes in corporate R&D. The more flexible structures within the services networks could make R&D more efficient. Contributing to this are spin-outs, which have developed new products and alone, or together with partners from the established pharmaceutical industry, have brought these onto the market (Festel et al. 2011).

There are often innovation hurdles in companies with established structures, like bureaucratic thinking, fear of cannibalism or the well-known not invented here syndrome. R&D spin-outs can overcome these hurdles through their different cultures (Bergh and Lim 2008; Jagersma and van Grop 2003). They can more easily pick up external impulses and serve as a mechanism to explore revolutionary ideas in a setting apart from mainstream business (Jagersma and van Grop 2003; Parhankangas and Arenius 2003). For example, competencies from other companies or top-class scientists from universities and research institutions can be engaged to form excellent teams.

2.3 Internal start-ups

Internal start-ups, which are not yet described in the scientific literature, are founded within corporate R&D organisations with some independency from the parent organisation. Within these internal start-ups, know-how from company internal R&D is transferred to commercial business units. This approach has some decisive advantages over traditional company internal technology transfer approaches, especially to show the market proof-of-concept. It is more flexible and accelerates the dissemination of knowledge throughout companies. As in the case of academic spin-offs and corporate spin-outs an important aspect is to overcome innovation barriers by increased incentives for researchers (Ferrary 2008).

3 Methodology

In order to answer the research questions, we conducted a qualitative study.

3.1 Research scope

It is usual for start-ups to have very different stakeholders, like technology owners (universities and research institutions or companies) or technology users (founders and management teams, investors or companies), with often conflicting views. The analysis and discussion of this paper is from the standpoint of the technology owner who is looking to commercialise their technology and realises that technology transfer is necessary to achieve that. The unit of analysis are those technologies developed by universities, research organisations and companies, which should be commercialised with the help of technology transfer. Of course there are other reasons for creating new ventures other than technology transfer, but we developed and analysed the case studies in the context of using them as a technology transfer approach.

3.2 Research approach and quality

Case study research has been opted for as methodology in this exploratory study. As Flyvberg (2006) describes "the case study produces the type of context dependent knowledge that research on learning shows to be necessary to allow people to develop from

rule-based beginners to virtuoso-experts". The main advantage of case study research remains that a study object is studied within its real life context (Yin 1981). We selected to apply a multiple case study approach, as numerous authors consider results from multiple case studies as more convincing, trustworthy, and robust (Eisenhardt 1989; Yin 2006). The multiple case study method compares cases and highlights resulting insights through similarities and dissimilarities between the cases (Borchardt and Göthlich 2007). The selection of cases was based on an objective of maximum variation. This enabled us to obtain information on the significance of various circumstances for the case studies (Flyvberg 2006).

Our case studies were identified by interviewing academic spin-offs, corporate spin-outs and other involved parties, like universities and research institutions, companies and investors, following a narrative approach (Polkinghorne 1988; Czarniawska 1998; Pentland 1999). The interviewees were asked to describe their involvement with a minimum of interruption by the interviewer, so as to obtain a better understanding of the actual events and to avoid the influence of personal views and theoretical perspectives on the data collection. Semi-structured interviews were used to develop the case studies. Within this research design, different sources of qualitative and quantitative data, like document and literature analysis, interviews and observations, were included (Yin 2006). All the collected information sources were used for reasons of data triangulation to obtain a more holistic view of the case studies (Eisenhardt 1989). By combining the different sources of information and collecting information over a longer period of time, including different rounds of interviews, an in-depth description of the different technology transfer approaches was obtained.

Quality assurance based on the criteria reliability, validity, and objectivity becomes very important, particularly when conducting explorative research applying a multiple case study approach and analysing qualitative data research (Albers et al. 2007; Lamnek 2008; Bortz and Döring 2005; Yin 2006). Since there can be no validity without reliability, a demonstration of the former (validity) is sufficient to establish the latter (reliability), so that reliability is a consequence of the validity in a study (Lincoln and Guba 1985; Patton 2002). There are six factors that ensure credibility in qualitative research according to Corbin and Strauss (2008): (1) prolonged engagement in a field setting with a wide variety of empirical observations, (2) triangulation, (3) clarification of researcher bias, (4) using participants' words for theory development, (5) providing detail, rich data descriptions, and (6) peer reviews by other researchers and by participants. The setup, methods, analyses, and presentation of the study ensure to meet all points, so we believe our investigation fulfils all criteria for ensuring research quality either focusing on validity, reliability, and objectivity or credibility.

3.3 Data collection and analysis

The initial literature research was carried out from 2004 until 2006. It consisted of a literature review regarding academic spin-offs, corporate spin-outs and their application for technology transfer in both academic and practitioner oriented journals as well as the internet. The main result was a database with interesting examples of academic spin-offs and corporate spin-outs including involved parties (e.g. universities and research institutions, companies, founders and management teams and investors) in Germany and Switzerland. Focus was on the two industries chemicals and pharmaceuticals as well as the two technologies biotechnology (medical and industrial biotechnology) and nanotechnology.

Between 2006 and 2008, narrative interviews with 15 academic spin-offs, 12 corporate spin-outs, 16 universities and research institutions as well as 6 TTOs, 25 companies and 23 investors (VCs and corporate VCs) out of the obtained database were conducted. The interview partners were selected by (1) ranking them regarding fit to the research scope and (2) interest in and availability for an interview. Each interview partner was interviewed by a single interviewer in one sitting of approximately 1 h. Given the exploratory nature of the research at this stage and the narrative interview approach, the interviews were conducted in an unstructured, open-end way without any formal questionnaire. Before each interview, the interviewer had gathered in-depth information on the company or institution through various public sources (e.g. databases, website, press releases), enabling an efficient conduct of the interviews.

Based on the narrative interviews, 12 case studies from Germany and Switzerland were identified: 5 case studies each for academic spin-off and corporate spin-outs and 2 for internal start-ups (Table 1 with basic information and Table 2 with more details). The selection of cases was based on (1) an objective of maximum variation to cover the whole range of cases, (2) the potential to obtain appropriate answers for the key aspects and (3) the willingness to further participate in this study.

Between 2008 and 2009, semi-structured interviews were used to develop these 12 case studies. All the interviews took place face to face, were between 1 and 2 h and were conducted by the same single interviewer who had conducted the narrative interviews. A reference set of questions was developed as a guideline for the interview, thereby leaving enough room for spontaneous answers, which gave a semi-structured nature to the interviews. The questions were structured around different topical groups containing (1) basic data (parent institution and technology owner, involved parties), (2) background (reasons for creating a new venture, relevance of technology transfer aspects), (3) realisation (conceptual design, engagement of investors, spin-off/spin-out process) and (4) results (development of the new venture, achievement of technology transfer goals).

The results of these semi-structured interviews as well as the narrative interviews were analysed using the key aspects regarding new ventures for technology transfer. Through that process, the case studies were analysed and compared regarding the following aspects: (1) further development of the technology, (2) additional resources and partners and (3) technology transfer goals and results. The results of this analysis for each case study were structured around key questions for each key aspect. One case study from each group, academic spin-offs, corporate spin-outs and internal start-ups, showing successful technology transfer in the most representative way for all case studies in that group, was selected and is described in detail within the next section. For all the case studies, additional secondary data was collected from the interviewees (e.g. business plans) and through internet research during the interview phase. Final literature research was conducted in the first half of 2011 to identify relevant scientific literature and to update the case studies.

3.4 Limitations

An important limitation of our study relates to the data gathering methodology. In most cases, data have been obtained with a single respondent per case study. Data triangulation then becomes difficult, especially for inside company information. This limitation has, at least partially, been countered by the use of secondary data sources. A major limitation relates to the geographical focus of sample firms in our research. The predominance of German and Swiss interview partners, which is (probably) a distorted sample of the real

Table 1 Basic information regarding the case studies

Type	Case study	Parent institution/ technology owner	Location	Technology area	Year of foundation	Current status
Academic spin-offs	A	University	Germany	Chemicals/materials	1999	Chemical company as majority shareholder
	B	University	Germany	Nanomaterials	2000	Integration into consumer company
	C	University	Germany	Cosmetics	2001	Integration into cosmetrics company
	D	University	Germany	Biofuels	2007	Trade sale to industrial partner
	E	University	Germany	Biocatalysis	2008	Independent company
Corporate spin-outs	F	Pharma company	Switzerland	Liquid crystals	1995	Independent company
	G	Pharma company	Switzerland	Drug development	1998	Integration into former parent company
	H	Pharma company	Switzerland	Pharma services	1999	Independent company
	I	Chemical company	Germany	Drug development	2001	Merger with another company
	J	Pharma company	Germany	Pharma services	2002	Independent company
Internal start-ups	K	Chemical company	Germany	Nanomaterials	2003	Integration into business unit
	L	Chemical company	Germany	Catalysts	2004	Integration into business unit

Table 2 Short characterisation of the case studies

Type	Case study	What was the background and starting point?	Why was a new venture for technology transfer chosen?	What were the most important realisation steps?
Academic spin-offs	A	High throughput experimentation technology with proof-of-concept in the laboratory and potential for chemical companies	Additional financial resources for the development of the technology to a stage interesting for established companies	VC financing (including corporate VC of a chemical company) to further develop the technology with intensive industry co-operations from the beginning
	B	Production technology in laboratory scale for new nanomaterials with potential applications in consumer products	Additional financial and human resources for the development and testing of products for the consumer market	Spin-off supported by a consumer company providing money and management capacity
	C	Specialised and non validated laboratory testing system to develop and study new active ingredients for cosmetics without animal tests	Additional financial and human resources to use the system in a broad set of validated applications in the cosmetics industry	Finding an industry partner from the cosmetics industry to support the spin-off process with money and management capacity
	D	Genetic tools to modify microorganisms for the production of biofuels and biobased chemicals and first laboratory strains for ethanol production	Acquisition of strategic investors for further funding of the technology development (e.g. the development of industrial relevant strains and other molecules)	Further R&D work at the university financed by the investor based on R&D contracts and co-development of a first product together with an industry partner
	E	Molecular biological tools to modify a special microorganism in the laboratory to develop cost effective biocatalysts for new applications	Further development of the biocatalysis technology from laboratory scale to technical scale in a broad range of applications	VC financed development within governmental supported co-operation programmes with industrial partners to show the technical proof-of-concept
Corporate spin-outs	F	Trade sale of a pharma company's liquid crystal business, without the R&D department, to another company	Spin-off of the R&D department to bring in VC investors for further funding of the technology development	Development of the R&D department into an operational, fully integrated company from raw material sourcing to marketing and sales
	G	Desinvestment of a drug development project with a drug candidate which failed the profitability criteria of a pharma company	Possibility for further funding of the drug development and to acquire other drug candidates (especially a cost competitive production route)	Building-up an own pipeline of drug candidates through in-licensing and successful development of this pipeline over 6 years

Table 2 continued

Type	Case study	What was the background and starting point?	Why was a new venture for technology transfer chosen?	What were the most important realisation steps?
	H	Reduction of overcapacities of a broad range of pharma development services after the merger of two pharma companies	Possibility to deliver the partly, very specialised services with high hardware costs to a broader group of customers from the pharma industry	Restructuring of the operations to provide a cost competitive range of services needed by the pharma industry
	I	Strategic decision of a chemical company to divest parts of the non-core pharma operations	Acquisition of VC investors for further funding of the technology development	Restructuring of the operations including trade sale of parts to other companies and development of a pipeline of drug candidates in the core areas
	J	Reduction of the overcapacities within the clinical research operations after the merger of two pharma companies	Possibility to deliver the partly, very specialised clinical research services to a broader group of pharma companies	Focusing of the service offerings to target special niche markets and restructuring of the company's internal resources
Internal start-ups	K	Laboratory scale production technology for nanomaterials for a broad range of applications	Company internal cannabilisation effects with established products	Building-up of an own semi technical production facility to deliver larger quantities of the nanomaterials to customers
	L	Technology to produce very specific catalysts for organic chemical synthesis	Low acceptance of the new catalytic approach within the established R&D organisation of the chemical company	Developing of a broad range of catalysts and building-up of a marketing and sales team

population, might have influenced our findings. In order to fully understand the topic, it might be necessary to interview experts outside of Europe and with a broader technological scope. Given the exploratory nature of this study, this problem should be overcome in follow-up studies on the subject. A last limitation relates to the measurement of perceived relevance based on personal perception rather than on actual importance. Respondents' perceptions might distort actual results, as their lens on the world might lead to a faulty perception of reality. Especially in combination with the first limitation (single respondent), this measurement choice might affect the strength of our conclusions.

4 Results and discussions

The case studies were analysed regarding different key aspects: (1) further development of the technology, (2) additional resources and partners and (3) technology transfer goals and results.

4.1 Further development of the technology

The need for further development of the technology is characteristic for all case studies. The aspects describing the need for further development in the case of corporate spin-outs and internal start-ups are rather similar to academic spin-offs with a case specific mix of the different aspects, i.e. there is no clear difference between the three groups. There is normally proof-of-concept only at the laboratory scale, not only in the case of academic spin-offs. Other aspects are missing upscaling into technical scale or no cost effective production process, so that new products cannot be produced on a cost competitive level. The need for further development is also due to a low relevance for industrial applications or there is insufficient performance. If there is no customer feedback, due to a missing prototype or access to customers, the customer acceptance of the new products is unclear. Further development is necessary, if the new products have no competitive advantage in the eyes of the customers. No validation for commercial use and no fulfilled regulatory hurdles are also reasons for additional development work.

Necessary is the further development of the technology to a stage interesting for established companies looking to offer concrete products or services. Normally, technical proof-of-concept has to be done before investments in production and marketing and sales are made. The kinds of further development are very similar in the three groups of case studies. Equipment development means developing hardware and software for the cost efficient implementation of a new technology in the industry. Of importance is the upscaling of production processes through process development and the development of a cost effective production process. The improvement of performance enables the implementation in the industry. Scientific understanding of key aspects enables improvement of performance and fulfilment of regulatory aspects. Generally, there is the development of industrial applications (e.g. implementation of products and technologies in the industry), the development of special grades or formulations for technical applications, the development of marketable products and complete service offerings.

Similar in the three groups of case studies are also the results of further development work. Equipment for industrial applications and providing of fee-for-service work are major aspects. Cost effective production process for huge volumes enables the entrance into the market. Formulations for customer specific solutions are the basis for customer solutions. Validated systems with certification are in some cases essential for sales and the

performance should be high enough for the industry. In each case there is a case specific mix of three aspects. An example is case study A with its high throughput experimentation technology which had at the university only proof-of-concept in the laboratory scale and high operational costs in industrial applications due to low automatisation of the process. The development of high throughput experimentation equipment enabled the spin-off to provide fee-for-service work for industrial customers and to sell the equipment to these customers. Case study H grew to a worldwide well-known provider of special pharma development services with strong teams consisting of scientists and marketing and sales experts. The spin-out of the operations enabled the further development of selected technologies and correlated services based on scientific expertise. Within case study K, the new nanomaterials from the laboratory were not really relevant for the industry as the particle size and the application properties were not suitable for industrial processes. Further development work of the internal start-up together with the business units of the parent company solved these problems. Another result was the cost effective production process for a broad range of nanomaterials and formulations which could be directly used by the consumer company in their products.

4.2 Additional resources and partners

The need for further development of the technology is directly linked to the need for additional money and other resources to finance the additional R&D work. Here we see clear differences between the three groups, academic spin-offs, corporate spin-outs and internal start-ups. Academic spin-offs need additional money and other resources because there is no academic interest in further R&D, on the basis of insufficient resources or the topics are out of scope (examples are case studies D and E). Financing of additional resources is made by industrial partners, VC (including corporate VC) and private/strategic investors. The reasons for investment are large market potentials attracting strategic and VC investors and the opportunity of a trade sale or IPO. Case study E shows the need for additional resources at universities in areas which are out of scope and not interesting from an academic point of view. The cost intensive further development work to develop industrial relevant biocatalysts could not be financed by the university as technology owner and was financed by VC. Case study D is an example for a technology development within the academic scope of the university but where the necessary resources (scientists and equipment) were not available at the university.

The need for additional resources for corporate spin-outs is based on the divestment of non-core operations in the form of a spin-out as alternative to closing operations. For more and more R&D projects, which are neither to be stopped nor sold, there are not enough company internal resources (capital, management capacity) available. Following a merger or simply complementing a strategic realignment on core areas, spin-outs provide a valuable option to leverage assets of low strategic importance, or under exploited assets in their parent companies. In the case of corporate spin-out J, the parent organisation divested parts of the clinical research department and the spin-off was the alternative to closing down operations. Another possible reason to opt for a spin-out is the isolation of a high-risk core business project, in order to prevent the project from affecting the riskiness of the core company, like in the case of case study G. Here we saw the divestment of a drug development project by the pharma company due to problems during the development process. These developments enable companies to concentrate on own core activities, without having to abandon new products coming from the spin-outs. The additional resources are financed by industrial partners, VC (including corporate VC) and private investors.

Reasons for the investment are realisation of value creation potential, to provide flexible services for the parent company or the opportunity of a trade sale or IPO.

The situation of internal start-ups is different, as they are fully financed by corporate R&D department and corporate innovation budgets. The need for additional resources is due to the fact that there are not enough resources in the business units, the development work is too risky and the market proof-of-concept is not yet shown. In the case of case studies K and L, the relevant business units within the chemical company were not willing to finance the development work due to low success probability. The investment was made because there was the possibility to bring innovative products with over average profitability onto the market to strengthen the existing business. Aim from a corporate point of view was increased innovativeness and the realisation of growth option on part of the parent company.

In this section we would like to focus particularly on investors financing academic spin-offs and corporate spin-outs. The involvement of financial investors brings both advantages and disadvantages. From the beginning, there is a strong business orientation because the investor pushes to realise profitable growth. Additional funding can be invested to meet specific targets and the investor's network can help develop the business. The main advantage is that funding the new venture by financial investors is an "acid test" for the quality of the new venture as it must be able to attract external capital. Experienced VC companies see especially corporate spin-outs as an opportunity to take advantage of existing R&D assets.

There are also disadvantages of engaging additional investors. A part of the value creation potential is abandoned to the capital provider and there is a potential conflict of interest concerning exit options (reintegration, often wanted by the parent company, versus trade sale or IPO, targeted by the financers). Frequently, there is the problem that industrial companies are not willing to provide the required returns to financial investors. Most investors expect annual returns above 20% (Rind 1981), which most often can only be realised after an exit. This exit determines the success or failure of an investment from the investor's viewpoint. The financially most attractive way to achieve an exit is an IPO, as the company value is normally higher compared to other exit options, like trade sales. This exit option is especially favoured by the management team, as they usually keep their positions in the company. An IPO is not always the most favoured exit option for strategic investors, who would like to have access to the technology (Erikson and Sørheim 2005) and an IPO has not always been possible in recent years. For example, spin-off I postponed its IPO in June 2001 due to the tough market environment for IPOs after the end of the "dot-com bubble" in March 2000. The "dot-com bubble" was a speculative overheating-phase on stock markets covering roughly 1995–2000 during which stock markets in Western nations saw their value increase rapidly from growth in the new internet sector and other high-technology areas like biotechnology. If an IPO is not possible, management and investors have to come up with alternatives, like a trade sale to a strategic buyer.

4.3 Technology transfer goals and results

The analysis of the technology transfer goals and results showed some similarities and dissimilarities between the three groups. In the case of academic spin-offs, the goal is the technology transfer from the university and further development to make it valuable for industrial partners. The transfer from the university to an industrial company via a spin-off was successful because of market introductions of new products and, in some cases, the integration into an industrial company. In case study D, there was a joint development of a

new product and the later acquisition of the academic spin-off by the industrial company. This is an example of the transfer of a technology from the university to the industrial partner via purchase of the spin-off company. This enabled the global launch of a new product for ethanol production on to the market. Case study A shows that the technology transfer cannot only be done by the trade sale to a new owner but also by acting as a more or less independent service provider for many customers in the industry.

Corporate spin-outs have the aim to realise technology transfer into a new legal entity to further develop the technology as an alternative to closing the operations. Result is the transfer from the parent company to the new owners via a spin-out (in some cases). That is successful as there are some cases of market introduction of new products and in some cases integration into an industrial company as well as the survival of the divested entities. As in the case of academic spin-offs, the technology transfer can be realised by the trade sale to a new owner and as a service provider for many customers.

Some fundamental issues are to be considered when using a corporate spin-out for technology transfer. A new company with its own legal entity, including logo and name, must be established to demonstrate the independence from the former parent company. The build-up of heavy bureaucratic structures must be avoided and a transfer of all relevant assets (i.e. laboratories, equipment, patents and other IP rights like copyrights and trademarks) as well as key personnel (tacit knowledge) to the spin-out is essential. Managing remaining ties between the spin-out and its parent company is essential to the success of the spin-out. While the parent company could retain limited equity and product rights in the spin-out company, excessive product trumping or management interference from the parent company deters investors and impedes the spin-out entrepreneurial attitude. In order to be fundable, the spin-out must have the complete right to use the transferred IP for its intended field of use, subject to termination only under very limited conditions. The case studies H and J show the transfer of the operations into a new legal entity to complement and further develop the services offerings. Result was an independent company with cost competitive service range especially for the former parent company. The services are widely used by the former parent company as well as other customers from the pharmaceutical industry.

Internal start-ups show the technology transfer from R&D departments into a commercial business unit. Result is the integration of the internal start-up into a business unit of the parent company. Also here, there are some examples of the market introduction of new products. Case studies K and L are examples for the transfer of the technology from the R&D department into a commercial business unit. Result was in both cases the integration of (parts of) the internal start-up into a business unit of the chemical company and the introduction of new products into the market.

5 Implications and conclusions

5.1 Advantages and disadvantages

The analysis of the case studies confirmed that the creation of new ventures is a suitable method for technology transfer, whereby academic spin-offs, corporate spin-outs and internal start-ups have their specific advantages and disadvantages (Table 3).

Academic spin-offs can help to transfer technologies from universities and research institutions to the industry if there is further need for technology development especially in close co-operation with industrial partners. The early engagement of industrial partners

Table 3 Advantages and disadvantages regarding technology transfer

Type	Further development of the technology	Additional resources and partners	Technology transfer goals and results
Academic spin-offs	*Advantages* Early engagement of industrial partners More target-oriented R&D work Additional incentives for researchers *Disadvantages* Financial incentives too dominant Conflict of interest with academic goals	*Advantages* Engagement of financial investors Business oriented partnering opportunities More co-operation possibilities to complement know-how *Disadvantages* Too intensive and subsidised use of academic resources	*Advantages* More targeted technology transfer More motivation of researchers Bridging of the technology transfer gap *Disadvantages* Higher risk of failure and personnel risk of researchers Longer payback horizon for parent organisation
Corporate spin-outs	*Advantages* Alternative to closing operations More entrepreneurial spirit of researchers More focus due to lower bureaucracy *Disadvantages* Less synergies to parent organisation Loss of expertise from parent company	*Advantages* Engagement of financial investors Business oriented partnering opportunities More co-operation possibilities to complement know-how *Disadvantages* Too dominant position of parent organisation	*Advantages* More flexibility and speed due to performance pressure More flexibility regarding commercialisation options *Disadvantages* Higher risk of failure and personnel risk of researchers
Internal start-ups	*Advantages* Market oriented R&D driven by business units Faster time to market Ability to attract high performing employees *Disadvantages* Less synergies to parent organisation Higher complexity of interaction Conflicting interests between R&D and business	*Advantages* Additional support by business units Business oriented partnering opportunities More co-operation possibilities to complement know-how *Disadvantages* Conflicts regarding resource allocation Less top management attention	*Advantages* More flexibility and speed due to performance pressure More flexibility regarding commercialisation options *Disadvantages* Acceptance problems in the parent organisation "Not invented here" syndrome

enables a more targeted R&D work and additional incentives for researchers. Investors can finance additional resources and there are more business oriented partnering opportunities as well as more co-operation possibilities to complement know-how. Therefore, academic spin-offs can bridge the technology transfer gap between academic research and application as academic research results themselves are normally not far enough developed to be of concrete interest for the industry. Of course, there are also disadvantages, like too dominant financial incentives combined with conflicting interests with academic goals and intensive use of academic resources which are subsidised. The academic parent organisations have to expect a longer payback horizon compared to licensing business.

Corporate spin-outs can be used for technology transfer as a good alternative to closing operations if they no longer fit into the parent organisation. More entrepreneurial spirit of the researchers and more focus due to lower bureaucracy can speed up R&D despite lesser

synergies to the parent organisation and the loss of expertise from the parent company. As for academic spin-offs there is the opportunity to acquire additional resources and partners. The performance pressure as small organisation helps to achieve the technology transfer goals and results faster. If the parent organisation is not a too dominant, which is often seen as a disadvantage in realising a spin-out, there is a higher flexibility regarding commercialisation options. Both spin-offs and spin-outs can be integrated into a new parent company or work as service provider as a more or less independent company.

The principle of company internal start-ups for technology transfer within companies can help to improve technology transfer from research labs to the markets as there are normally innovation barriers within companies. The market oriented R&D driven by business units enables faster time to market. This is also due to additional support by the business units, business oriented partnering opportunities and more co-operation possibilities with external institutions to complement the internal know-how. The internal start-up is then integrated into an operational business unit if the technological and market proof-of-concept is shown. The deployment of human resources and capital is based on the same decision criteria that external investors would apply, so there is also increased performance pressure. More flexibility and speed due to performance pressure can achieve a competitive advantage compared to internal structures and competitors. But acceptance problems in the parent organisation and "not invented here" effects can arise which need to be managed.

5.2 Recommendation

There are a few important common aspects between all case studies in the conceptual and execution phase. Academic and corporate researchers neither have the knowledge nor the experience to commercialise their R&D results. The scientist is often absorbed by his daily duties and challenges in R&D and has quite often a biased view on how his R&D output could be used. Besides capital, new technology based companies very often lack business know-how, as the founders are usually highly R&D orientated scientists. An important aspect of designing a R&D spin-out is staffing and incentives for the key people. They must believe implicitly in their science, they must be willing to commit their careers to the exploitation of this science and they must have the entrepreneurial, risk taking drive.

In order to be successful, a new venture, besides enough financial capital, also heavily relies on operational business assistance. An adequate and transparent profit sharing model between parent organisation, management and scientists of the new company as well as financial investors is fundamental. Policy makers should further support the creation of new ventures for technology transfer through providing incentives for business oriented and experienced people to join new ventures and to successfully help realise technology transfer. These incentives could be tax incentives for the new ventures themselves (e.g. preferred depreciation models for R&D expenses), entrepreneurs and investors (e.g. reduced tax rates on exit profits).

5.3 Need for further research

This research evaluated technology transfer through the creation of new ventures, especially in the two countries Germany and Switzerland, and, with a rather narrow focus, regarding industries (chemicals and pharmaceuticals) and technologies (biotechnology and nanotechnology). More fundamental research has to be conducted to better understand and describe this topic on a broader basis.

1. Technology transfer by spin-offs and spin-outs in regions other than Germany and Switzerland as well as other industries or technologies.
2. Identification of internal start-up approaches in industries other than the chemical industry (e.g. the computer industry) and industry specific comparison of this technology transfer approach.
3. Better understanding of the decisions made by the technology owners to select new ventures versus licensing as technology transfer approach.

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