Discussion Paper No. 04-09

The Birth of German Biotechnology Industry: Did Venture Capital run the Show?

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Non-technical Summary

Biotechnology offers an example of a recent booming high-technology industry, in which Germany gradually caught up with the leading countries in Europe. Based on technologies derived from the latest results in molecular biology, genetics, biochemistry, informatics or physics, the development of new therapeutics or diagnostics ("red" biotechnology), new products or services for the agricultural and food markets ("green" biotechnology) or for environmental activities ("grey" biotechnology) require substantial financial resources over a long period of time.

From a theoretical point of view, newly created biotechnology firms carrying out such R&D activities face a restriction of both internal finance (mainly due to limited sales) and external finance in the form of loans from credit institutions. As a result, private equity investors – especially venture-capital companies ("VC-companies") and corporate investors (i.e. established firms investing in young innovative firms) – seem to be the most appropriate financing partners for new biotechnology companies. In regard to their advantages (risk pooling, risk diversification etc.) to deal with information asymmetries compared to private equity investors, VC-companies are expected to invest in the riskiest biotechnology projects, namely in firms developing new healthcare applications and technology platforms in the healthcare field. Corporate investors, wishing to diversify their activities, should invest more than VC-companies in supplier firms. Due to their dependence on technological innovations which have been developed by biotechnology companies, pharmaceutical and chemical industries could also be expected to actively fund innovative health care firms. The importance of equity investors in the emergence of the biotechnology industry in Germany has never been empirically studied. Based on data of 378 companies (derived from a combination of two databases) founded between 1995 and 1999, this paper investigates the role of VC-companies and corporate investors in funding newly created biotechnology firms in Germany. A descriptive and a multivariate analysis – that allows to eliminate pseudo-correlation effects - were carried out. Both provide empirical evidence for the significant role that VC-companies did, in fact, play in the creation of these innovative firms: more than 15% of them received venture capital between 1995 and 1999, which lies far ahead of the average participation of venture capital in other industries. This therefore supports the fact that VC-investments play a critical role in the early stages of risky biotechnology companies.

Differentiating between three business models for biotechnology firms (product, service and supplier companies) highlights the clear preference of VC-companies for product developers (31% of them were venture-backed), especially from the healthcare sector. Strikingly, established industries like the pharmaceutical or the chemistry, invested only

marginally in biotechnology firms that develop innovative therapeutics or diagnostics (only 2% of these firms received an equity investment from an industrial corporation). This surprising reluctance from industrial corporations can be explained by a strong focus on in-house R&D and their preference for strategic alliances (without equity investment) with innovative firms, which allows them to secure access to innovations but also to minimize their risks. Multivariate analyses confirm these conclusions: product and service companies in the healthcare field are most likely to receive venture capital, whereas specialized suppliers in all biotechnology fields (red, green and grey) are favored by equity investors.

The Birth of German Biotechnology Industry: Did Venture Capital run the show?*

by

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Abstract: The goal of this paper is to point out the role played by private equity investors (venture-capital companies and corporate investors) in the emergence of a new biotechnology industry in Germany in the second half of the 90's. This analysis takes into account the different business models and business fields to be found in the biotechnology industry. Based on theoretical arguments, a great relevance of VC-companies in financing young innovative biotechnology firms developing health care applications and technology platforms is expected, whereas corporate investors like pharmaceutical and chemical industries should play a more important role in financing supplier companies. Corporate investors are also expected to be significantly present in the equity financing of health care biotechnology companies. Empirical results from descriptive and multivariate analyses confirm all hypotheses but one: surprisingly, corporate investors invested only marginally in the equity funding of biotechnology firms developing new health care products or services.

Keywords: Start-ups, Biotechnology, Venture Capital, Discrete Choice,

JEL Classification: G32,L21, L6

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1 Introduction

Germany's biotechnology industry has evolved rapidly since 1995 and has reached the top position in Europe regarding the number of biotechnology companies in 2000 (Ernst & Young, 2002). A substantial increase in firm creation activities is typical for new industries, offering enormous technological and entrepreneurial opportunities (Klepper, 1996). Last mentioned opportunities exist for firms not only developing new drugs ("red sector") but also solving environmental ("grey sector") as well as agricultural problems ("green sector"). The value chain within the biotechnology industry contains further services and supplying activities. Both activities also offer attractive entrepreneurial and technological opportunities within the value chain of the application development process. Platform technologies such as the Polymerase Chain Reaction (PCR) technique are well known examples for the important services which accelerate the development process. Based on differences in national institutional framework, Germany is more focused on the use of this kind of technology compared to the UK biotechnology industry (Casper and Kettler, 2001).

This paper seeks to analyze the role of venture capital (VC) companies and corporate investors in financing German biotechnology companies. Access to equity partners may have considerable economic benefits, measured by the number of new applications and firm performance (e.g. Powell et al., 1999; Engel and Keilbach, 2002). Venture capital is currently best suited to reduce the funding gap of young high-tech companies (Amit et al., 1998; Carpenter and Petersen, 2002). Already existing studies highlight the role of VC-companies measured by the number and the amount of investments or analyze a specific segment of biotechnology companies (Ernst & Young, 2002). However, a comprehensive study about the relevance of

different private equity investors is missing.[1] We emphasize a wide definition of biotechnology industry in accordance with the OECD-definition[2] to consider the wide range of technological and entrepreneurial opportunities.

We expect that the importance of equity partners differs according to the product strategy of the biotechnology company. Venture capital companies focus on equity financing of high-tech projects with uncertain returns. Corporate investors avoid equity financing of these projects. They are suitable partners to pay for a successful development process in order to get the control rights. Furthermore, opportunities in the supplier industry are mostly attractive for incumbents with similar activities. Our empirical results confirm that: VC-companies are most important for firms developing new drugs or platform technologies. They are of little importance to suppliers. The results for corporate investors are confirmed. They tend to avoid equity ventures in high-innovative biotech firms.

The paper first considers the need and emergence of external finance for young biotechnology companies from a theoretical point of view in chapter two. The discussion highlights the motives of VC-companies and corporate investors, in regards to finance as well as being present in the biotechnology industry. Following a description of the database in chapter three, we analyze the financing structure of German biotechnology industry in chapter four. We start with a descriptive analysis in chapter four to get an insight for preferences, i.e. the favored product strategy and targeted market, as venture capitalists and corporate investors. Based on a multivariate analysis in chapter five we check for a pseudo correlation of the observed pattern. The paper ends with the presentation of the main results and a discussion of some implications in chapter six.

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[1] Some evidence exists for other new industries. Best example in our point of view is the study of Burg and Kenney (2000) who highlight the role of venture capitalists during the creation process of Local Area Networking (LAN) industry.

2 Conceptual Framework

A Need for Private Equity

Newly created biotech firms carrying out research and development projects face financial problems that are typical for young innovative companies[3]. One specificity of the biotechnology sector is the high level of financing that is required over a long period of time to carry out R&D projects. As a matter of fact, development costs for a new drug – from biological target identification to authorization to commercialization - amount to 500 million US-dollars (Ollig, 2001, p.24).

According to Myers' (1984, 1986) pecking order theory, empirically tested and supported in the small business environment by Norton (1991), Holmes and Kent (1994), entrepreneurs or managers tend to first resort to internal finance. External finance comes only as a second choice and when it is required, firms issue the safest security first, such as loan. External equity financing comes only as a last resort. This ranking is especially true for low-innovative firms. In the case of high-innovative firms experiencing long periods of time without significant sales, a loan is only attractive if repayment starts some years after taking it out. Other studies such as Watson (2002), Jordan et al (1998) and Howorth (1999) all point out that a companies choice for financing their activities will be conformable with the pecking order theory.

Internal finance is very restricted for young, innovative biotechnology firms developing new technologies or products. Significant sales are absent and the

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[2] OECD Definition of Biotechnology: 'The application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services'

[3] In our understanding, innovations comprise technologically new products (goods or services) or processes and significant technological improvements in products and processes, according to the OECD definition (OECD, 1997).

entrepreneur's personal funds are insufficient as confirmed for example by an empirical study carried out by Champenois[4]. Government R&D-subsidies can be acquired to increase the internal finance resources.[5] However, subsidies are very limited regarding the amount and intended purpose.

The second preferred option (loans) is usually of very limited access to innovative biotechnology companies as a result of imperfections in the credit market and suitability of this kind of instrument. Credit institutions know the risk of insolvency for all firms but they face a high uncertainty level (in the sense of Knight 1921, concerning the inability to forecast, as opposed to risk) regarding the individual project quality. Furthermore, credit institutions are less experienced in evaluating most innovative business ideas. As a result, information asymmetries are to be found, characterized by differences between loaner and entrepreneur regarding the assessment of project quality. Similarly to the situation on the market for "lemons" (Akerlof, 1970), information asymmetries lead to adverse selection: projects of lesser quality than expected are financed. To prevent that risk and attract good projects, credit institutions offer lower interest rates. However, this results in a credit rationing effect, since the demand for loans exceeds the supply for the offered interest rate (Stiglitz and Weiss, 1981). One more reason for credit limitation comes from the little suitability of loans. Exorbitant high interest rates are necessary to compensate the high default risk, the low probability for financial success of R&D projects investments. However, entrepreneurs in early business stages can only pay limited interest rates. Furthermore, high-tech investments are intangible and hence, often have a limited collateral value for loan security (for a more detailed discussion see Carpenter and Petersen, 2002). Public loans are no suitable instruments to reduce

[4] An empirical qualitative investigation that took place in 2003-2003 as a part of Champenois' Ph.D research work (not published yet) showed that out of 18 interviewed high-innovative German biotechnology firms, 50 percent had received founders' funding (on top of common capital stock), with a maximal value of 250,000 euro in a single case.

the financial gap: their allocation depends on the readiness of the person or company giving the loan to take over fully or partly the default risk, and this readiness is very restricted in case of high information asymmetries. As a result, in consideration of the pecking order theory one can expect that an external finance alternative (equity finance) to be of great relevance for innovative biotechnology companies and of little importance for suppliers with standardized, well-known production process .

Different Types of Private Equity Investors

Equity investors can be divided into two categories: a classical informal one, comprising private investors "business angels" and corporate investors, i.e. enterprises that have traditionally invested sporadically in innovative firms, and a recent formal one, consisting of newly created venture capital companies "VC-companies" whose activity is precisely to buy equity stakes of young firms. "Business angels" face the same market imperfections as banks regarding information asymmetries. Furthermore, the finance amount required in biotechnology often exceeds their own capabilities.[6] On the contrary, corporate investors and "VC-companies" have greater financial capabilities than "business angels". Therefore, they represent likelier financing partners for young innovative companies.

VC-companies are a new category: their number and activities have substantially increased in Germany, like in the rest of Europe, since the establishment and acceptance of new stock markets in the mid-90's (see Engel, 2003). VC-companies act as intermediaries between outside investors and young innovative firms. They do not only provide their ventures with funds but also with management support and

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[5] The first institutional subsidy was given in 1975 by a private foundation. In 1985 the German Government presented their first program to foster biology and biotechnology. The most important program was arranged in 1995 with the BioRegio competiton.

[6] Business angels invest on average 125,000 to 500,000 euro in a company. (Source: Interview with German Business Angel Club; Nathusius, 2001)

advice. Most of them pursue a purely financial goal, which is maximizing their return on investments.[7] VC-companies enjoy significant advantages over single private equity investors, including corporate investors, when high information asymmetries exist. Above all, through their specialization in equity investments in innovative firms, VC-companies gain experience over time. Learning effects occur, which enable them to reduce information asymmetries to a bigger extent than non-specialized actors. In addition, risk pooling represents a major resource for them to address information asymmetries (Amit et al., 1998). As a matter of fact, investing in many different companies increases the probability that, ex post considered, a few successful projects were financed, which allow to compensate the losses from unsuccessful projects.[8] VC companies can also pursue a purposeful portfolio strategy aiming at reducing risks: they can diversify their investments throughout different firm development stages as well as different technologies and products (biotechnology, medical devices, information/communication technologies etc.).

In the venture capitalists' view, the expectation of high financial returns is mainly correlated with the size and growth of markets targeted by the young innovative firm.[9] In the biotechnology industry, the health care - especially human medicine – branch is the largest market for biotechnology companies and it is expected to grow most significantly in the next years. Mainly due to population aging, the pharmaceutical market is expected to rise worldwide from $ 300 billion in 1998 to $ 980 billion in 2015 (Ollig, 2001). Biotechnology therapeutic products (like recombinant proteins or monoclonal antibodies) are expected to gain an increasing

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[7] The German venture capital market is characterized by different groups of venture capitalists: Independent companies, private companies as well as public bank-owned companies (Engel, 2003). Companies from the last group tend to require lower minimum internal rates of return than the others.

[8] Gebhardt and Schmidt (2002, p. 241) point out that 20 to 30 percent of the overall VC-financed projects end up in a failure; 60-70 percent survive at a low level; and 10 percent are „high flyers".

[9] For an extensive discussion of VC investment criteria see Tyebjee and Bruno (1981, 1984), Virtanen (1996).

market share, since their success rate in clinical trials is ahead of conventional chemical compounds (Gambardella, 2000): at the end of the 90's, biopharmaceuticals represented 10 percent of the pharmaceutical market and 6 out of 10 newly approved drugs had been developed using biotechnology methods; by 2015, the share of biopharmaceuticals should jump to 25 percent, representing a $ 200 billion market (Ollig, 2001). In the diagnostic market, biotechnology innovations are also expected to gain market shares. As opposed to the situation in the "red" biotechnology sector, the agricultural and food market ("green" biotech) offers much less growth perspectives in Europe, due to a low level of acceptance from users (farmers, consumers) as well as difficulties experienced in the technology development, regulatory approval and adoption from the users processes. The market for environmental applications ("grey" biotech) is economically insignificant compared to the two previous ones.

A successful technological innovation is very often the key factor in gaining a significant share of the targeted market. Venture capitalists particularly seek "disruptive technologies" that offer a radically new solution to unsolved technical problems from the industry or make activities currently carried out by the industry significantly easier or cheaper (comparative advantage over existing methods) and, therefore, enjoy a high probability of taking over a full market. The Polymerase Chain Reaction (PCR) technique is an example of a disruptive technology. Before the discovery of this technology in 1985, scientists wishing to copy DNA strands had to go through a laborious (days- or weeks-long) procedure of inserting the DNA sequences into bacterial DNA, growing large cultures of the sequence-carrying cells and, finally, harvesting the desired DNA. PCR allowed them to produce in a few hours more than a million copies from DNA samples in order to diagnose genetic disorders or infectious diseases with a sample of genetic material that would have been much too small earlier (The Scientist, 1989). In conclusion, *companies developing new healthcare applications and new technology platforms to develop*

these applications offer most attractive equity investment opportunities for VC-companies within the biotechnology industry (hypothesis 1).

As far as incumbents are concerned, pharmaceutical or chemical corporations, biotechnology firms and suppliers (manufacturers of laboratory equipment or consumable material, for example) may all be willing to invest in a biotechnology start-up. This can be differentiated between two types of corporate investors. A first group identifies biotechnology as a new market niche offering attractive opportunities for their existing products and decides to implement a diversification strategy through an equity investment in a young biotechnology company. Suppliers like machine manufacturers may be a good example of corporate investors from this group. Occupying a strategic market is characterized by low risk of failure, because the demand for goods and services is well-known when the new activity takes place in early stages of the economic value chain process. Hence, *corporate investors comparatively are more related to finance companies in supplying industry via equity than VC-companies (hypothesis 2).*

A second group seeks new products or new technologies in order to make their own production process more efficient, to be present in new markets or to remain present in existing markets (Schween, 1996; McNally, 1997). These are objectives especially pursued by pharmaceutical and chemical industries. These corporations face a situation of dependence regarding innovations that have been developed by biotechnology firms and that became key to new product developments and their own R&D activities (Hamdouch and Depret, 2001; Buse, 2000): technologies like genomics, proteomics, high-throughput screening, bioinformatics have established themselves as industry standards for R&D activities and development of new therapeutics, diagnostic kits, plant crops, etc[10]. Furthermore, dependence over new

[10] For Hamdouch and Depret (2001, p.88), biotechnology represents the new innovation paradigm for the pharmaceutical industry, replacing the old chemical paradigm that lead to a bottleneck in the discovery of therapeutic innovations.

biotechnology technologies and products is particularly important in the healthcare sector ("red" biotechnology), characterized by a high "innovation pressure": for several years, pharmaceutical corporations have continuously proved unable to discover innovative compounds (new chemical or molecular entities) to meet their strategic objectives in terms of revenues.[11]. There is a high pressure to innovate since numerous patents on blockbuster drugs - the few ones generating the main revenues - are going to expire in the coming years, meaning a loss of exclusivity on sales, hence a drastic decrease in revenues for the pharmaceutical industry[12]. To address this challenge, pharmaceutical corporations may choose to make equity investments in strategically relevant biotechnology firms.

However, one can expect equity investments from established corporations to be limited, for three reasons. First, pharmaceutical corporations invest a large amount in internal R&D genetic engineering inclusively. The leading German firms in this sector invested 2,76 Mrd. Euros in R&D in the year 1998 and each fourth active agent in pre-clinical stage based on genetic engineering (VFA, 2003, p. 22-24). Second, large corporations are relatively risk-adverse, since they specialize their investments in a few technologies and markets (which represent a strong strategic impact), i.c. that they can seldom diversify their risks. The high volatility of corporate venture capital activities (i.e. corporation-owned VC-companies to make equity investments in innovative firms) can be used as an empirical evidence of the risk-adversity of corporate investors: a significant increase in industry's corporate venture capital (CVC) activities was observed only after independent VC companies

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[11] Price Waterhouse Coopers (1998) point out: at the end of 1996, 41 large pharmaceutical companies had 350 active compounds (new molecular entities) in clinical trials (Phase II or III), which translates into 167 new drugs until 2001, i.e. 0.81 drug per year per company. This lies far behind their strategic goals, which are above 2 new drugs a year (quoted by Ollig, 2001, p.63). A similar conclusion is noted by Spaethe (2001), p. 216, referring to an article from the Economist (1998).

[12] Between the end of the 90's and 2006, 100 therapeutics representing revenues of 37 Mrd $ are going to lose patent protection (Ollig, 2001, p. 64).

showed signs of success (Gompers and Lerner, 1998; Gompers, 2002)[13]. That is to say: CVC units are second to move in during the boom stages of the venture capital cycle and first to remove themselves in recession stages. Similar observations can be made in Germany: most of CVC activities started there in 2000[14], three years later after the first substantial increase in fundraising and investments on the VC market. Risk adversity varies with the corporation's size: the smaller incumbents are, the greater their risk-adversity.

Third, other forms of alliances with innovative biotechnology companies, namely in-licensing and/or co-development collaborations, acquisition of successful firms allow corporate investors to meet their strategic goals and to minimize their risks. In the first mentioned type of partnerships, incumbents couple financial payments with success (milestones payments made by incumbents at achievement of technological objectives; royalty payments – i.e. a given percentage of revenues paid to the biotechnology firm when sales occur – coupled with market success). Therefore, they can minimize the amount of their investment in case of a project failure. Moreover, in-licensing/co-development collaborations allow them to invest in later stages of the highly risky drug development process, hence to mitigate their risks[15]. However, the a priori predefinition of payments can lead to trouble if market acceptance of new product is misjudged by corporate investors.

A high preference for collaboration without equity investment is evidenced by aggregated data[16] as well as Champenois' empirical research.[17] Incumbent's risk-

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[13] An above-average, dramatical decrease of CVC investments in the US market is evident in 2001 compared with the year before (Chesbrough, 2002).

[14] BVK (1998) statistics counted four CVC companies as members focusing on early stage activities in 1998 for the first time. The working group „CVC" with 15 members have been established in February of 2002 (BVK, 2002a).

[15] Risks of failure along the drug development process are very high: out of 10,000 identified biological targets, only one will lead to a new drug on the market.

[16] The number of biotechnology alliances for the 20 largest pharmaceutical companies has soared from 85 between 1990 and 1998 to 226 in the 1997-1998 period, and alliances with

adversity and the advantages of collaborations to meet their strategic goals leads to hypothesis 3, *corporate investors are less active in early stage equity funding of biotechnology firms developing health care applications ("red" biotechnology)*.

Differences between corporate investors and VC-companies regarding their objectives and strategy when engaging in equity investment in innovative biotechnology firms are summarized in Table 1.

< insert Table 1 around here >

3 Database

The BIOCOM Database 2000 is the starting point for our empirical analysis. It contains information about firm characteristics like business models defined via product strategy and business field, patents and addresses of 1,205 biotechnology companies based in Germany. However, a lack of information about the presence of equity investors – and of which types - is obvious. We have generated this information by using firm-specific data from the ZEW Foundation Panel. This data has been provided by the largest German credit rating agency "Creditreform" (see Almus et al. 2000 for further explanations). We identified 89 percent of biotech companies of BIOCOM Database in the ZEW-Foundation Panel.[18]

For a majority of biotech companies, the information in the ZEW-Foundation Panel was delivered between 1998 and 2000 for the first time. Analysis about the role of

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pharmaceutical industries accounted for 77 percent of total financing for biotechnology companies in 1998 in the USA, compared to 13 percent in 1991 (Nicholson, 2002).

[17] The previously mentioned qualitative empirical research revealed that out of 10 newly created biotechnology companies in Germany having signed strategic collaborations (i.e. involving licensing and/or product co-development) with incumbents, only two have received equity funding from their industrial partner.

[18] Identification based on a computer-assisted search for names and address of biotechnology companies in ZEW-Foundation Panel (state: June 2002) which is widely used in other studies.

equity investors at the foundation date only makes sense, if firms are young at the time of data delivery. Here we can easily assume that shareholders at foundation date are still active as a venturing partner. For older firms the probability for an exit of a venturing partner increases rapidly. Hence, we focus on the financing structure for biotech companies founded between 1995 and 1999. The strong increase of start-up as well as VC-activities in the mid-1990s is a second motivation for the limitation of the sample. Our sample contains 378 companies founded between 1995 and 1999. To exclude derivative foundations (= existing business units within a firm turned into a legally independent entity) we ignore companies with more than 250 employees at the time of the foundation. We have identified the VC-companies based on a computer assisted search for members of associations and for companies with obvious VC-activities (see Engel, 2003 for detailed information).[19] The remaining companies with links to biotechnology companies are included in the group of corporate investors. We checked each record of venture by hand and re-coded ventures of the companies.[20] As a result, we can differentiate between independent companies (no private equity investor has been identified), venture-backed companies (involvement of one or more VC-companies), corporate venture-backed companies (involvement of one or more corporate investors) and companies which have received capital from VC-companies *and* from corporate investors.

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[19] Silent partnerships cannot be identified with this kind of procedure. They concern the relationship between two or more partners inside a firm, are not recorded in the trade register and difficult to observe by Creditreform. Fortunately, exclusively silent partnerships don't play an important role in early stage financing of venture capital companies (BVK, 2002b: 24, 31, 45).

[20] Remember the following case: A management company is the owner of the biotechnology company to save the tangable and intangable assets in case of bankruptcy.

4 Descriptive Results

In this section we first aim at describing the methodology to classify different business models[21] of biotechnology firms. Secondly, we analyze the types of financing structure (venture capital, industry investment or a combination of both) according to business models and business fields.

As far as business models are concerned, we can distinguish between three different cardinal points in the value chain of biotechnology and classify firms accordingly in three categories:

1. Product company
2. Service company
3. Supplier company

Product companies engage in the R&D of primarily cell-based technologies in order to develop new health care, agriculture or environment products. The products can be therapeutics against major diseases (like Alzheimer's, Cancer, High Cholesterol, HIV or Parkinson's), diagnostic kits, vaccine, tissue engineering systems, in the red sector, or genetically modified seeds, in the green sector.

Service companies support and try to foster the R&D process of biotechnology companies as well as chemical or pharmaceutical firms. Most of the so-called platform technology companies are to be found in this group. They started to increasingly pursue a product strategy mainly at the turn of the century. They provide. Protein or DNA sequencing, screening, target validation, assay development services or molecular biology analysis. A second group are the “traditional” technical services or non-technical services such as consulting activities e.g. regulatory support in the course of product development or administration of

external documents and monitoring of proceedings. Unfortunately, the BIOCOM database does not differentiate between firms developing platform technologies and firms offering traditional services.

The Supplier companies are responsible for the needs of the modern laboratory. They provide Pipette Products, Calibration Services, biotechnology equipment or production facilities.

In our empirical analysis, complexity arose through the fact that a given company could be registered in our database under several business model types such as product *and* service company. Seven different combinations of business models were possible. To receive a better accuracy of discrimination, we restricted the number of combinations to three in the descriptive analysis. The first category, Product companies, contain firms which only develop new products. The second one, Service companies, encompasses firms that either offer services only or services and new products. The last group, Supplier companies, contain the remaining firms (see Table 3). However, each of the seven combinations will be taken into account in the multivariate analysis.

First, we would like to give an overview of the relevance of the different business models and business fields for entrants (Table 4). The biotechnology industry in Germany has grown rapidly over the last eight years (Ernst & Young, 2003). The majority of companies are closely related to red biotechnology. This gives clear evidence that in this sector there are more opportunities and probably a higher chance to realize a revenue stream sooner than in other business fields. Green biotechnology comes second and according to the figures in Table 4 the grey biotechnology is barely considered by entrepreneurs. The suppliers still have a significant occurrence in each business field which is related with less risky

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[21] A description of the operations of a business including the components of the business, the functions of the business, and the revenues and expenses that the business generates . Here, we

circumstances and the possibility to acquire customers in the whole life science industry.

< insert Table 4 around here >

In addition to venturous entrepreneurs and the new technologies, venture capital is an important component of the biotechnology business as evidenced by Table 5 that presents the different types of venturing partners according to business models: 15.6 percent of all biotechnology firms exclusively received Venture Capital between 1995 and 1999. Other financing patterns like Corporate Venture Capital, investments by larger companies or co-venturing are unincisive. Exclusive investments by established companies such as from the Chemistry or Pharmaceutical industry have at least a share of 10 percent between 1995 and 1999. That is to say big companies from related industries have a certain but limited interest in financing start-ups in the early stages via private equity. One possible reason for this is that big pharmaceutical firms prefer strategic alliances over private equity investments. To receive a better understanding of these numbers, Table 2 gives an overview of Venture Capital involvement in other industries. In particular, it appears that VC-companies are closely connected to the High-Tech sector but even this close connection leads just into a share of 2% Venture Backed firms related to the potential demand for VC. Other industries like Manufacturing (1%) or Trade (0.6%) are not even close to 2%. The data suggests a relatively low importance of venture capital in other industries compared with the biotechnology industry.

<insert Table 5 around here>

The figures in Table 5 indicate major differences in financing the three different parts of the biotechnology value chain. The scopes of product companies are deeply in the focus of venture capital companies as we assumed in hypothesis 1: 30.9

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focus on the product strategy of biotechnology companies.

percent of them received equity only from venture capitalists. Additionally, 3.6 percent of biotechnology product companies receiving a combination of industry investments and venture capital add up to just 3.6 percent in the sample. Stand alone investments of corporate investors are detected for only 3.6 percent of product companies. The rest of the Product companies, almost 62 percent track a different financing model which has nothing to do with venture capital or equity funding by established firms.

A closer look on the repartition of venturing partner types according to business sectors emphasizes a clear orientation on red biotechnology (Table 6).

<insert Table 6 around here>

This picture is more distinct if we concentrate our analysis on product companies (Table 7). Almost 38 percent of the product companies in red biotechnology received VC whereas product companies from the green and gray sectors did not attract any. That is to say, VC-companies favor product companies focusing on health care applications which are even more attractive than investments in green or gray biotechnology.

<insert Table 7 around here>

Nevertheless, some companies are financed by a combination of corporate venture capital and venture capital (4.4 percent). Investments by corporate investors like chemical or pharmaceutical firms only represent 2.2 percent of all product companies from the healthcare ("red") sector, which is quite low compared with venture capitalists.

To sum up, we detect a low importance of equity funding by corporate investors within the high-tech biotechnology industry. The share of funded firms is much lower compared with venture capitalists (hypothesis 3). In contrast, a low rate of venturing by venture capitalists as well as a high rate of participation by corporate

investors in the supplying industry is evident. Some established firms identify biotechnology as a new market niche offering attractive opportunities for their existing products, which is clearly in accordance with our expectations (hypothesis 2).

5 Econometric Analysis

Econometric Approach

The presence of a private equity partner is not only affected by the business model. Many other factors can potentially determine the financing structure. Hence, the different use of private equity by product, service and supplier companies can potentially be affected by differences in other variables. Our goal is to find out whether the business model is really related to the probability of receiving venture capital as well as capital by incumbent firms. An appropriate empirical method to estimate the probability for different types of financing structure is the multinomial logit model (MNL). Typically, MNL's starting point is the choice between alternatives.[22] The MNL describes the relation between determinants and different types of corporate financing structure as follows:

$$P(Y = g \mid x_i) = \frac{\exp(x_i' \beta_g)}{\sum_{g=1}^{r} \exp(x_i' \beta_g)} \quad \text{for } g = 1,...,r \quad i = 1,...,N. \qquad (1)$$

The parameter vector β varies between the types of finance g, indicating how an exogenous variable x_i affects the probability P for a company i to receive venture capital, to gain a corporate investor or to be independent. In the descriptives we had an additional fourth alternative: syndicated investment of VC-company and

[22] Choice has to be interpreted as realized alternative, resulting from the supply and demand for private equity. We consider an one stage game, because asking for equity yes or not is unobservable.

corporate investor. However, reasoned by insufficient number of cases (N=10) we included this alternative in one specification to the alternative "VC-company" in another specification to the alternative "Corporate Investor".

An assumption of the econometric model is that the error terms ε_i is independent and identically type I extreme value distributed. This implies a severe restriction for our empirical model, which is known as the independence of irrelevant alternatives (IIA). According to the IIA, the ratios of the probabilities of any two choices do not depend on the presence of other choices in the choice set. The IIA assumption is tested using the well known test suggested by Hausman and McFadden (1984) (see e.g. Greene, 1997, p.920f.). First, we checked whether the realized financing structure "Involvement of incumbent firm" is independent of the realized alternative "Independent", if we exclude alternative "Receiving venture capital". Secondly, we tested the independence of last mentioned alternative from the status of financing structure "Independent". Test statistics for the first test ($\chi^2(16) = 0.51$; [Prob>$\chi^2(16)$] = 1.00) as well as the second test ($\chi^2(16) = 0.72$; [Prob>$\chi^2(16)$] = 1.00) clearly show that the IIA hypothesis does not have to be rejected in our model. Thus, we can conclude that the disturbances in our model are independent and homoscedastic and hence, model estimates are unbiased, efficient and consistent.

Estimation Results

Table 8 contains the descriptive statistics for considered variables, Table 9 shows the results of MNL-Estimation. Presentation and interpretation of results in MNL-models are usually based on the coefficient estimates (see Greene, 1997, p. 916). Variables of main interest are listed in the first rows. Control variables are listed under the heading "Other Firm Characteristics" and "Firm's Environment".

Product and service companies have a higher probability to receive venture capital compared to the group of suppliers on the one hand. On the other hand, companies

that are active in the red sector have a higher probability to be venture capital-backed than companies from the green or grey business fields. An alternative specification considers the interaction between both variables. The coefficient estimates are significant higher when we take an interaction term, product and service companies in the red business area, into account. The results confirm clearly our hypothesis 1, VC-companies are strongly oriented in financing high-risk projects. High market volume and expected high growth of a market for health care lead to high attention on the red sector by venture capitalists.

Product and service companies have a significant lower probability to gain an external corporate investor as venturing partner than supplier companies. Strikingly, companies in red biotechnology have no significant higher probability to acquire corporate investors as equity investors than companies in other business fields. Corporate investors avoid equity financing of high risk projects as we expected in hypothesis 3. Other instruments seem to be more important for established firms to use the window on technology in this area. Besides the development of new research tools, the high market potential of pharmaceutical products make this sector attractive for investments in the supplying industry by incumbents.

The results are partly sensitive as we count the syndicated investments by VC-companies and established firms to the group of corporate investors alternatively. Now, a significant lower probability of firms in the category “Developing new products” to achieve equity funding by corporate investors can not be observed. The results give some evidence for the crucial contribution of common project evaluation by VC-companies and corporate investors within the area of high-tech projects. Product companies can easier acquire equity funding when financial intermediaries as well as potential customers are involved in project evaluation. Syndication helps to reduce the risk of selecting a bad project (Locket and Wright, 2001), which has a particular importance for the evaluation of high-tech investments.

Furthermore, other firm characteristics affect the probability to receive venture capital. A high science based background or affinity to science is assumed for founders with the title of Ph. D. or Professor. Firms with this type of founders have a higher probability to receive VC. The reason is that they have access to more tacit knowledge and can perform better in sense of innovation activities and firm growth (Zucker et al., 1998; Zucker et al., 2002). This is especially important for venture capitalists' expectations about venture's revenue. The availability of patents has also a certain impact on gathering venture capital. Patents are our second measure for firms' innovation level. Compared with the first indicator, patents signalize the success of the innovation process and/or the importance to protect new innovative ideas. Both is directly related with expectations of high revenues. Similar 63 percent of venture capital-backed biotechnology firms have one or more patents.

Biotechnology start-ups founded in 1997 and 1998 have a higher probability to receive venture capital than those founded in 1995 (the reference group). In the boom of the VC-market, the role of government supported activities as well as the supply of more attractive business ideas from the VC' point of view are the main reasons for this empirical fact. Larger biotechnology companies are more amenable to receive venture capital. The negative correlation between start-up size and survival rate as well as the expectation that large firms are more able and efficient to organize the innovation process motivate VC's to invest in large-scaled companies.

The final version contains one variable to measure the ability of the region to support the innovation process of biotechnology firms via co-operations and informal network activities. Start-ups in regions with a high level of R&D employees in industry have a higher probability to receive a VC-company as a venturing partner. In these regions we can expect some more corporate spin-offs from incumbents. These spin-offs are most attractive for VC-companies (for empirical evidence see Mackewicz & Partner, 2002). Alternatively, we consider the number of patents of science in counties and a dummy variable indicating the location in a region which took part at the BioRegio contest of the German Federal

Ministry of Education and Research (BMBF) in 1995. Both variables are insignificant, detecting no better equity supply conditions in BioRegio counties compared with the other ones. The three mentioned variables are highly correlated which hinders a common consideration.

< insert Table 9 around here >

6 Conclusion

The paper has focused on a comparison between activities of venture capital companies and those of non-financial external companies to finance German biotech start-ups founded between 1995 and 1999 in early stages. The descriptive and multivariate analysis emphasize a substantial importance of venture capital finance as funding source for biotech companies developing new products and technologies in the therapeutic and diagnostic fields, known as high-risk biotech companies. 42 percent of them received venture capital in early stage. On the contrary, only few low-risk supplier companies are equity funded by venture capitalists. The market potential for their products is limited and offers few chances for added value creation. Venture capital is particularly critical for early stages financing of high-risk biotechnology companies. Someone could interpret the result for product companies in the opposite direction: Venture capital is not important, because 58 percent do not have it. We hold two arguments against this interpretation. First, only a small share of all asking firms receive venture capital reasoned by a sophisticated selection procedure of venture capitalists. Second, the share is conspicuously higher compared with high-tech industries in general. The share of venture-backed firms related to all young firms is about two percent in high-tech industries.

Biotechnology companies developing new research technologies or products (diagnostic kits, therapeutic compounds – from target identification to pre-clinical and clinical testing) are of special interest for incumbents in pharmaceutical and

chemical industry. However, our empirical results suggest that they are rarely active as venturing partners for these high-risk biotech companies. We think that higher attractiveness of alternative strategies such as collaborations, acquisition in later stages and high amount of internal R&D are the main reason for this observation.

Their strategy can be characterized as a “wait-and-see” attitude or option model to be present in case of a successful innovation process. This (direct) contribution to reduce the financing gap at the time of foundation is comparably low. However, their activities are an important signal for venture capitalists to evaluate the market potential of business ideas and hence, indirectly affect the probability of closing the financing gap. On the contrary, incumbents are more involved as venturing partners in low-risk biotech companies, e.g. suppliers for biotech companies which deal with target and technology development process. Occupying strategic market with well-known demand seems to be particular attractive for incumbents with similar activities.

The result applies for a boom stage in the venture capital cycle and the formative stage of the modern German biotechnology industry. A lower importance of venture capital can be expected for biotechnology firms founded after the year 2000. Nowadays, young and new biotechnology companies are experiencing increasing difficulties in acquiring external equity after the crash of stock-markets. Venture capital companies tend to invest more in later stages and focus on follow-up investments. Furthermore, the quality of their selection procedure has drastically increased. Due to the significant role of venture capital investments in the birth of the biotechnology industry, an ongoing restraint from venture capitalist seems to be problematic for the further development of existing biotech companies and the financing of new ones.

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Appendix

Table 1: Investment Strategy of Corporate Investors and Venture Capital Companies

	VC	Industry	
		Large enterprises	Small-medium enterprises
Goal	Financial goal	Primarily strategic goal	
Investment duration	3-5 years	5-10 years (possibly longer)	
Type of Investment	Private equity	Private equity, milestone/royalty payments for successful innovation process	
Investment focus	Broad investment range	Market Niches or new technologies (defined by strategic relevance)	
Risk-adversity and their components			
Risk adversity	Low	Medium	High
Risk pooling	High	High	Low
Risk diversification	High	Low	Low
Risk specialization	High	High	High

Table 2: Share of Venture-Backed Firms Related to the Potential Demand for VC

Hightech-Manufacturing	Other Manufacturing	Hightech-Services	Consul-ting	Other Services	Trade	Construc-tion	All
2.18 %	1.03 %	2.22 %	0.93 %	0.45 %	0.62 %	0.17 %	0.85 %

Remark: Share is equal the quotient from Start-ups between 1996 and 1999 receiving venture capital until the end of 2001 divided by the potential demand for VC. Potential demand for VC: Start-ups founded between 1996 and 1999, legal form of limited liability, business activities in five-digit NACE-Codes in which one or more venture-backed firms are active. Hightech-Manufacturing and Hightech-Services according the average R&D as well as innovation intensity in five-digit NACE-Codes (Engel and Fryges 2002).

Table 3: Aggregation of Firm's Business Models to three classes for the descriptive analysis

Developing new products	Offering services	Supplier activities	Class	#
1	0	0	Product company	55
0	1	0	Service company	71
1	1	0	Service company	68
0	0	1	Supplier company	82
0	1	1	Supplier company	36
1	0	1	Supplier company	33
1	1	1	Supplier company	33

Table 4: Business Model and Business Fields of German Companies in Biotechnology Industry (Founded Between 1995 and 1999)

	Red	Green	Gray	Unknown
Product company	45	7	2	1
Service company	116	10	7	6
Supplier company	142	11	10	21
Number of companies	303	28	19	28

Table 5: Venturing Partner Types According to Business Models (in Percent of Column Sum)

	Product	Service	Supplier	All
Venture Capital	30.9	21.5	6.5	15.6
Venture Capital & Corporate investor	3.6	5.0	0.5	2.6
Corporate investor	3.6	7.9	13.5	10.0
None	61.8	65.4	79.3	71.6
Total	100.0	100.0	100.0	100.0
Number of companies	55	139	184	378

Table 6: Venturing Partner Types According to Business Field (in Percent of the Column Sum)

	Red	Green	Gray	All companies
Venture Capital	18.2	7.1	0	16.3
Venture Capital & Corporate investor	3.3	0	0	2.9
Corporate investor	8.9	10.7	26.3	10.0
None	69.6	82.1	73.7	70.9
Total	100.0	100.0	100.0	100.0
Number of companies	303	28	19	350

Table 7: Venturing Partner Types According to Business Field – only Product Companies - (in Percent of the Column Sum)

	Red	Green	Gray	All product companies
Venture Capital	37.7	0.0	0.0	31.4
Venture Capital & Corporate investor	4.4	0.0	0.0	3.7
Corporate investor	2.2	14.2	0.0	3.7
None	55.5	85.7	100.0	61.1
Total	100.0	100.0	100.0	100.0
Number of companies	45	7	2	54

Table 8: Descriptive Statistics of Exogenous Variables

Exogenous Variables	Mean	Standard deviation
Business model and Business field [1)]		
Developing new products	0.150	0.358
Offering services	0.195	0.397
Supplying activities and developing new products	0.078	0.269
Offering services and developing new products	0.198	0.399
Supplying activities, offering services and developing new products	0.093	0.291
Supplying activities and offering services	0.090	0.287
Business Field: Red Biotechnology	0.802	0.399
Other Firm Characteristics [2)]		
Doctor/Professor	0.685	0.465
Patent	0.378	0.486
Start-up Size (number of employment) (ln)	1.465	1.282
Founded in 1996	0.186	0.390
Founded in 1997	0.228	0.420
Founded in 1998	0.252	0.435
Founded in 1999	0.174	0.380
Firm‘s Environment		
Location in Bioregio [3)]	0.553	0.498
R&D employees in county (ln) [4)]	7.000	1.779
Number of patents (Science) in county (ln) [5)]	4.575	1.672

Remark: [1)] BIOCOM database, [2)] ZEW-Foundation Panel, [3)] Own inquiry, [4)] Statistic of Bundesanstalt für Arbeit, [5)] Greif (1998).

Table 9: Determinants of the Probability of Firm's Venturing Partner

Selected Venturing Partner	VC-company[1)]		Corporate investor	
Exogenous Variables	coeff.	st-error	coeff.	st-error
Business model and Business field				
Developing new products	1.991	0.992 **	-1.699	0.757 **
Offering services	2.058	0.963 **	-0.656	0.614
Developing new products and supplying activities	1.679	1.009 *	-1.226	0.808
Developing new products and offering services	1.214	0.959	-1.909	0.786 **
Supplying activities, offering services and developing new products	0.753	0.978	-2.419	1.044 **
Supplying activities and offering services	-0.129	1.398	0.150	0.534
Business Field: Red Biotechnology	1.270	0.559 **	-0.515	0.429
Other Firm Characteristics				
Doctor/Professor	1.819	0.553 ***	-0.168	0.458
Patent	0.913	0.335 ***	0.534	0.455
Start-up Size (ln)	0.320	0.138 **	0.142	0.147
Founded in 1996	0.992	0.690	1.005	0.624
Founded in 1997	1.640	0.650 **	1.070	0.622 *
Founded in 1998	1.300	0.636 **	0.404	0.638
Founded in 1999	1.154	0.732	-0.644	0.782
Firm‘s Environment				
R&D employees in county (ln)	0.169	0.098 *	0.075	0.124
Intercept	-8.551	1.396 ***	-1.956	1.160 *
Number of observation	333			
Log-Likelihood	-218.39			
Pseudo R^2 (Likelihood Ratio Index)	0.206			

*** significant on the 1%-level, ** significant on the 5%-level, * significant on the 10%-level; Base category: independent companies. [1)] Syndicated investments between VC-company and corporate investor are included. Reference group: Firm with supplying activities, in green or gray business field, no Ph.D or professor within founder’s team, no patent, founded in 1995. Results of MNL estimation with heteroscedastic robust standard errors.