RWI : Discussion Papers

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The Birth of German Biotechnology Industry

Did Venture Capital run the show?

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Claire Champenois, Dirk Engel and Oliver Heneric*

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

Abstract

We answer the questions, how many firms acting in the modern German biotechnology industry are funded by venture capital companies (VCC) as well as equity funded by corporate investors. The theory suggests a high relevance of VCC as venturing partner of high-tech projects. In addition we argue that corporate investors are a venturing partner of firms with high-risk projects to a lower extent. Incumbents, however, are confronted with some opportunities in the low-risk area of the biotechnology industry to secure an optimal supply for the current product pipeline. Our empirical results emphasize a crucial importance of venture capital as financial resource for high-risk projects: whereas 42 percent of all healthcare developer in the early stage are venture-backed firms, only a small share of low-risk projects received venture capital. The results for corporate investors are reversible. Fewer high-tech projects and more low-risk projects compared to VCC are equity financed by corporate investors. The econometric analysis suggests that the observed pattern is mainly driven by the level of project risk and hence, supports all our hypotheses.

JEL-Classification: G32, L21, C25

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

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Executive Summary

The literature emphasizes the crucial importance of venture capital to reduce the funding gap of young high-tech firms carrying out a lot of R&D activities. In analogy, the development process of a new high-tech industry, i.e. the modern biotechnology industry, depends on the sufficient access to this financial resource. Our paper answers the question, how many firms of the German biotechnology industry are equity funded by venture capital companies (VCC) as well as how many firms have been successfully acquired corporate investors as venturing partners. Biotechnology offers an example of a recent booming high-technology industry, in which Germany gradually caught up with the leading countries in Europe.

Beside the expected high relevance of VCC, theoretical arguments suggest that corporate investors avoid to be a venturing partner of firms with high-risk projects. Reasons for that are the higher risk-adversity of corporate investors, the higher attractiveness of alternative strategies such as collaborations, and the preferences of the biotechnology firms for VCC. On the contrary, incumbents are confronted with some opportunities in the low-risk area of the biotechnology industry to secure an optimal supply for the current product pipeline. We emphasize the OECD-definition of biotechnological industry to consider the wide range of technological and entrepreneurial opportunities within the sector and hence, to test our hypotheses. The empirical analysis is based on 378 biotechnology firms, founded between 1995 and 1999, in the ZEW-Foundation Panels.

Our results emphasize a crucial importance of the access to venture capital provided by venture capital companies: VCC are venturing partner of 42 percent of healthcare developer in their early stage. Opposite to that but in accordance with our expectations, corporate investors are marginally involved as venturing partner of high-risk projects. Our multivariate analysis further suggest that the observed pattern is mainly driven by the level of project risk and hence, support all our hypotheses. Product and service firms in the healthcare sector have a significant higher probability to receive venture capital than suppliers, whereas specialized suppliers in all biotechnology fields (red, green and gray) are significantly more favored by corporate investors.

1. Introduction

Venture capital seems to be best instrument suited to reduce the funding gap of young high-tech firms (Amit et al. 1998; Carpenter, Petersen 2002). Access to equity partners may have considerable economic benefits, measured by the number of new patent applications and firm performance (e.g. Powell et al. 1999; Kortum, Lerner 2000; Engel, Keilbach 2002). Policy makers and scientific

scholars expect that the availability of venture capital is a driving force in the creation process of a new industry and they undertake considerable efforts to secure best conditions for venture capital investments. Against this background, this paper analyzes the frequency of the equity funding of firms in the German biotechnology industry and investigates the determinants of the observed pattern.

Existing studies highlight the role of VCC measured by the number and the amount of investments or analyze a specific segment of biotechnology firms (Ernst & Young 2002). To our knowledge, a comprehensive study about the relevance of different venturing partners, however, is missing.[1] Further, we expect that the importance of VCC and corporate investors as venturing partner differs according to the project risk and targeted markets of biotechnology firm. Besides the usual focus on high relevance of VCC for equity funding of high-risk projects, theoretical arguments suggest that corporate investors avoid to be a venturing partner of firms with high-risk projects. Opposite to that, incumbents are confronted with some opportunities in the low-risk area of the biotechnology industry to secure an optimal supply for the current product pipeline.

We emphasize the OECD-definition[2] of biotechnological industry to consider the wide range of technological and entrepreneurial opportunities within the sector. Germany's biotechnology industry has evolved rapidly since 1995 and has reached the top position in Europe concerning the number of biotechnology firms in 2000. A substantial increase in firm creation activities is typical for new industries, offering enormous technological and entrepreneurial opportunities (Klepper 1996). The value chain within the biotechnology industry contains high-risk projects (e.g. the development of new drugs and technology intensive services) as well as low-risk projects (e.g. traditional services, biotechnology equipment). Platform technologies such as the Polymerase Chain Reaction (PCR) technique are well known examples for the importance of technology intensive services that accelerate the development process.

Our descriptive analysis shows that VCC are very often venturing partner for firms developing new drugs or platform technologies. They are of little importance to finance low-risk projects. The respective results for corporate investors emphasize that this type of investors avoid equity ventures in high-innovative biotech firms. The observed pattern also holds in a multivariate analysis which controls for some core variables as determinants of funding.

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1 Best anecdotal evidence 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 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".

The paper is organized as follows: In section 2 we highlight the motives and instruments of VCC and corporate investors concerning their activities in the biotechnology industry. Further, we formulate the hypotheses for empirical investigation. The short description of the database in section 3 is followed by a descriptive analysis of the share of venture-backed firms and the share of firms receiving equity from corporate investors. The analysis sheds light on the preferences, i.e. the favored product strategy and targeted market, from venture capitalists and corporate investors. Based on a multivariate analysis in section 4 we check for a pseudo correlation of the observed pattern. The paper ends with the discussion of the main results and some concluding remarks in section 5.

2. Conceptual Framework

Newly created high-tech biotech firms carrying out research and development projects require considerable financial resources. Development costs for a new drug – from biological target identification to authorization to commercialization – amount to $ 500 million on average (Ollig 2001: 24). Furthermore, these financial resources are required over a long period of time. Therefore, internal finance appears to be an insufficient instrument for high-tech biotechnology firms. Significant sales are absent and the entrepreneur's personal funds are usually too small, as confirmed for example by an empirical study carried out by Champenois[3]. Government R&D-subsidies[4] as additional internal resource are very limited regarding the amount and intended purpose, too. In addition, young high-tech firms have limited access to loans. The reasons are information asymmetries, lack of sufficient collateral value and that loans are unsuitable to pre-finance R&D-projects (Carpenter, Petersen 2002). The same is true for public loans. Their allocation depends on the readiness of a financial institutions (private commercial banks, saving banks "Sparkassen" and credit co-operatives "Genossenschaftsbanken") to take over fully or partly the default risk. According to Myers' (1984, 1986) pecking order theory, firms escape to external equity, the last financial resource, to reduce the remarkable funding gap for high-tech projects.

Equity investors can be divided into two categories: (i) a classical informal one, comprising private investors well-known as "business angels" as well as "corporate investors" and (ii) a recent formal one, consisting of newly created VCC whose strategy is to buy and sell equity stakes of young firms. Business

[3] A (still unpublished) empirical investigation by Champenois 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.

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

angels face the same market imperfections as banks regarding information asymmetries. Furthermore, the finance amount required in biotechnology often exceeds their own capabilities.[5] On the contrary, corporate investors and VCC have greater financial capabilities than business angels.

The number and activities of VCC 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. VCC seems to be best suited to deal with information asymmetries that typically exist for high-tech projects. Risk-pooling, risk-diversification and specialization are the most popular arguments to derive advantages of VCC over single investors (Chan 1983; Amit et al. 1998). VCC syndicate a lot of investments to overcome the limitations in fund raising, to achieve sufficient diversification and to increase the quality of screening procedure (e.g. Bygrave 1987; Brander et al. 1999 for details). VCC act as intermediaries between outside investors and young innovative firms: They provide funds as well as considerable management support and advice. Most of them pursue a purely financial goal, which is maximizing their returns on investments.[6] 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.[7]

In the biotechnology industry, the healthcare – especially human medicine – branch is the largest market for biotechnology firms 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 market share, since their success rate in clinical trials is ahead of conventional chemical compounds (Gambardella et al. 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 market of $ 200 billion (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

5 Business angels select best proposals and invest on average 125,000 to 500,000 € in a firm; Nathusius, 2001.

6 The German venture capital market is characterized by different groups of venture capitalists: Independent VC's, private owned as well as public bank-owned VC's (Engel 2004). Companies from the last group tend to require lower minimum internal rates of return than the others. Corporate VCC are mostly members of VCC' associations. Based on their origin and strategy we count them to the group of corporate investors.

7 For an extensive discussion of VC investment criteria see, among others, Tyebjee, Bruno 1984 and MacMillan et al. 1987.

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 ("gray" biotech) is viewed as being economically insignificant compared to the two previous ones.

A successful technological innovation is one of the key factors 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 of the industry or make activities currently carried out by the industry significantly easier or cheaper. The 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. In conclusion, we derive our hypothesis 1:

H1: Firms developing new healthcare applications and new technology platforms to develop these applications offer most attractive equity investment opportunities for VCC within the biotechnology industry.

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. Two types of corporate investors can be differentiated. A first group identifies biotechnology as a new market niche offering attractive opportunities for horizontal or vertical enlargement of incumbent's business activities to secure an optimal supply for the current product pipeline. Suppliers like machine manufacturers may be a good example of such incumbents and hence, corporate investors. 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.

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, Depret

2001; Buse 2000). Technologies like genomics, proteomics, high-throughput screening, bioinformatics, for example, have established themselves as industry standards for R&D activities and development of new therapeutics, diagnostic kits, plant crops, etc[8]. Furthermore, dependence over new biotechnology technologies and products is particularly important in the healthcare sector, 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.[9] 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[10].

To address this challenge and to use the window of opportunity, pharmaceutical corporations can choose between two instruments: alliances or equity investments. Large corporations are, however, relatively risk-adverse, since they specialize their investments in a few technologies and markets (which represent a strong strategic impact), i.e. that they can seldom diversify their risks. The high volatility of corporate venture capital activities (i.e. corporation-owned VCC 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 corporate venture capital (CVC) activities was observed only after independent VCC showed signs of success (Gompers, Lerner 1998; Gompers 2002)[11]. 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 CVC' activities started in 2000[12], 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.

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8 Following Hamdouch and Depret (2001: 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.

9 Price Waterhouse Coopers (1998: 4) 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.

10 Between the end of the 90's and 2006, 100 therapeutics representing revenues of $ 37 billion are going to lose patent protection; Ollig 2001: 64.

11 An above-average, dramatical decrease of CVC investments in the US market is evident in 2001 compared with the year before; Chesbrough 2002.

12 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.

Alliances with innovative biotechnology firms, 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[13]. However, the a priori predefinition of payments can lead to problems if market acceptance of a new product is by corporate investors. A high preference for collaboration without equity investment is evidenced by aggregated data[14] as well as Champenois' empirical research.[15] Incumbent's risk-adversity, advantages of collaborations to meet their strategic goals and strategic opportunities in the low-risk area of biotechnology industry leads to our second hypothesis:

H2: Corporate investors namely pharmaceutical and chemical corporations avoid equity funding of high-tech biotechnology firms in order to finance the development of new products. On the contrary to that opportunities in the low-risk area of biotechnology industry are more frequently used from incumbents via equity investment.

In sum, three arguments seem to be crucial for the comparison of VCC and corporate investors' activities. First, from corporate investors' point of view equity funding of high-risk projects in the early stage is not the first best solution to use the window on opportunity. Second, VCC enjoy significant advantages over single private equity investors, including corporate investors, when high information asymmetries exist. Third and finally, R&D performing biotech firms may have higher bargaining power in periods of easier access to equity issues and hence, they prefer VCC as equity partner (Lerner et. al. 1999 for detailed discussion). To sum up, we derive our third hypothesis as follows:

H3: VCC finance more high-tech firms via equity investments than corporate investors.

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13 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.

14 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 pharmaceutical industries accounted for 77 percent of total financing for biotechnology firms in 1998 in the USA, compared to 13 percent in 1991; Nicholson 2002.

15 The previously mentioned qualitative empirical research revealed that out of 10 newly created biotechnology firms 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.

3. Database and Descriptive Results

Database and Identification of Equity Funding

We test our three hypotheses for the creation process of Germany's modern biotechnology industry in the middle of the 90's, at the same time as the VC-investment activities went up rapidly. 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 targeted markets, patents and addresses of 1,205 biotechnology firms based in Germany. However, the BIOCOM Database does not provide information on the presence and type of equity investors. 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 firms of BIOCOM Database in the ZEW-Foundation Panel.[16]

For a majority of biotech firms, the information in the ZEW-Foundation Panel was delivered between 1998 and 2000 for the first time. Analysis about the role of 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 very old firms the probability for an exit of a venturing partner increases rapidly. Hence, we focus on biotechnology firms founded between 1995 and 1999. Finally, we exclude derivative foundations (= existing business units within a firm turned into a legally independent entity) as we ignore firms with more than 250 employees at the time of the foundation, resulting in sample of 378 firms.

We have identified the VCC based on a computer assisted search for members of associations and for companies with obvious venture capital activities (Engel 2004 for detailed information).[17] The remaining companies holding a venture on biotechnology firms count to the group of corporate investors. We checked each record of venture by hand and re-coded some of them to ignore liability based affiliations.[18] CVC-units of incumbents are mostly member of VC-associations and have to be re-classified to the group of corporate investors. Remarkable, we could not detect any venture of well-known CVC-unit in the middle of the 90's. That's not really surprising as we remember the irrele-

16 Identification based on a computer-assisted search for names and address of biotechnology firms in ZEW-Foundation Panel (state: June 2002, means practically that most of ventures until the middle of 2001 are identified) which is widely used in other studies.

17 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.

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

vance of formal CVC-units in the middle of 90's. As a result, we can differentiate between four states of funding and hence, detect for alternatives for biotech companies:

- equity funding exclusively by VCC ("Venture capital"),
- equity funding exclusively by corporate investors ("Corporate investor"),
- equity funding jointly by VCC and corporate investors ("Venture capital & corporate investor"),
- equity funding is not detected ("Independent company").

Equity Funding of Biotechnology Firms: Descriptive Results
Before we analyze empirically the role of VCC and corporate investors as venturing partners, we first aim at describing the methodology to classify different business models[19] of biotechnology firms, namely according to the level of project risk and targeted markets.

Based on BIOCOM database we can distinguish between three different cardinal points in the value chain of biotechnology industry and classify firms accordingly into three categories:

1. Product firm – high level of project risk on average
2. Service firm – medium level of project risk on average
3. Supplier firm – low level of project risk on average.

Product firms engage in the R&D of primarily cell-based technologies in order to develop new healthcare, agriculture or environment products. They are confronted with a high level of risk and uncertainty about the success of product development. 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 firms support and try to foster the R&D process of biotechnology firms as well as chemical or pharmaceutical firms. Most of the so-called platform technology firms are to be found in this group. They provide Protein or DNA sequencing, screening, target validation, assay development services or molecular biology analysis. Based on differences in the national institutional framework, Germany is more focused on the use of this kind of technology compared to the UK biotechnology industry (Casper, Kettler 2001). 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

[19] A description of business model includes in general the components of the business, the functions of the business, and the revenues and expenses that the business generates. On the contrary to that we focus on specific characteristics.

Table 1

Differences in measures for risk-chance profile of biotechnology firms

Product strategy	Annual average employment growth rate			Patent (yes/no)	
	Mean, in %	Median, in %	stand. dev., in %	mean	stand. dev.
Product firm	37,3	25,2	49,9	0,556	0,503
Service firm	29,9	24,4	37,8	0,444	0,499
Supplier firm	16,2	2,7	34,0	0,297	0,459

Remark: Significant differences between risk measures for product or service firms on the one hand and supplier firms on the other hand are detected for the median of employment growth and mean of patent. See table 2 for aggregation procedure.

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not differentiate between firms developing platform technologies and firms offering traditional services. The supplier firms are responsible for the needs of the modern laboratory. They provide pipette products, calibration services, biotechnology equipment or production facilities. They have the lowest level of risk on average, meaning that a few projects can be very risky, but the majority is confronted with a low level of risk.

We test empirically our classification in three categories based on descriptive statistics, test and simple regressions. Typically, high-risk projects are characterized by above-average innovativeness and a high standard deviation of growth. The descriptive statistics for our proxy variables annual employment growth rate and patent according the product strategy, presented in , and tests confirm our classification. Median of employment growth rate and mean of patent significantly differs between the groups. Further, results are hold as we take into account some more determinants for growth and innovativeness in an unreported multivariate analysis.

In our empirical analysis, complexity arose through the fact that a given firm could be registered in our database under several product strategies such as product *and* service firm. Seven different combinations of product strategies are possible and are taken into account in the multivariate analysis.[20] To receive a better accuracy of discrimination, we restricted the number of combinations to three in the descriptive analysis. The first category, product firms, contain firms which only develop new products. The second one, service firms, encompasses firms that either offer services only or services and new products. The last group, supplier firms, contain the remaining firms (Table 2). Table 3 emphasizes that the majority of firms targets the medicine, healthcare market. About the half of all biotech firms are classified as suppliers, the category of low level of risk on average.

[20] Product development has a different meaning in the context of drug development compared to the context of an supplier firm and hence, emphasize the disaggregation and classification as above mentioned.

Table 2

Aggregation of firm's product strategy to three classes for the descriptive analysis

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

Source: ZEW-Foundation Panels, BIOCOM Database 2000.

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Table 3

Product strategy and targeted markets of biotechnology firms in Germany
Founded between 1995 and 1999

	Red	Green	Gray	Unknown	# obs.
Product firm	45	7	2	1	55
Service firm	116	10	7	6	139
Supplier firm	142	11	10	21	184
Number of firms	303	28	19	28	378

Source: ZEW-Foundation Panels, BIOCOM Database 2000. – Remark: "Red" indicates market for health care, "Green" indicates the agricultural and food market and "Gray" indicates the market for environmental applications.

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A significant share of biotechnology firms count to the group of venture-backed firms (Table 4): 15.6 percent of all biotechnology firms founded between 1995 and 1999 exclusively received venture capital, 10 percent were equity funded by corporate investors and 2.6 percent were jointly equity financed by VCC and corporate investors.

More interesting, Table 4 indicates major differences according the three classes of risk. The scopes of product firms are deeply in the focus of venture capital companies: 30.9 percent of them received equity from venture capitalists exclusively and 3.6 per cent are mixed funded by VCC and corporate investors. Corporate investors funding is of little importance. In addition to syndicated funding with VCC, they started a stand alone early stage venture on 3.6 percent of all product developers. A remarkable share of product firms use only financial resources which has nothing to do with venture capital or equity funding by corporate investors. The clear orientation of VCC on product developer in red biotechnology is empirically suggested, too. About 42 percent of the product firms in red biotechnology received venture capital exclusively from VCC or in cooperation of VCC with corporate investor. From VCC' point of view a remarkable high share of interesting projects with potential for

Table 4

Venturing partner according to product strategy
in percent of column sum

	Product (high-risk)	Service (medium-risk)	Supplier (low-risk)	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 firms	55	139	184	378

Source: ZEW-Foundation Panels, BIOCOM Database 2000.

high value creation is located in the segment of services. 26.5 percent of all service firms are venture-backed firms. Suppliers are financed by VCC only in few cases.

To sum up, VCC favor high-risk projects in the field of healthcare applications which are even more attractive than investments in other fields. Further, 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. The descriptive analysis confirms our hypothesis 3, VCC undertake more equity investments in high-tech firms than corporate investors. In contrast, a high rate of participation by corporate investors in the supplying industry, compared to the product developer, is evident.

4. Econometric Analysis

Econometric Approach
A considerable limitation of the descriptive analysis is that we can only describe the role of VCC and corporate investors as equity partners differentiated by the level of project. The differences in the presence of equity partners in high and low-risk projects can potentially be affected by differences in other variables e.g. founder's knowledge. The empirical test of hypothesis 1 and 2 needs to control for effects resulting from differences in other variables. An appropriate method for doing that is the multinomial logit model (MNL) (e.g. Greene 1997: 915f.). Typically, MNL's starting point is the choice between alternatives conditioned on a vector of exogenous variables (e.g. level of risk, founder's knowledge).[21] We differentiate between three alternatives instead of four, now. Reasoned by insufficient number of cases for choice "Venture capital & corporate investor" we added jointly financing to the choice "VC-company" and alternatively to the choice "Corporate Investor".

An assumption of the econometric model is that the error terms are 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 test suggested by Hausman and McFadden (1984). We checked the independence of alternatives "Corporate investor" and "Independent" from the presence of venture capital as we exclude alternative "Venture capital" from the model. In similar manner we ignore alternative "Corporate investor" to check the changes in the ratios of the probabilities "Venture capital" and "Independent". The test statistic, however, is undefined because the variance-covariance matrix of the estimators does not satisfy the asymptotic properties of the test. Therefore we derive the simultaneous distribution of estimators (command suest in STATA 8.0). According Hausman and McFadden (1984) we now test whether parameter estimates of each two-alternative model is equal to estimates of the full model. The unreported results suggest that IIA could not be rejected in our model. Thus, we can conclude that the disturbances in our model are independent.

Estimation Results

Table 5 contains the descriptive statistics for considered variables, Table 6 and Table 7 show the results of MNL-Estimation. We present coefficient estimates as well as marginal effects. Marginal effects allow a statement about the magnitude of the relation between each exogenous variable and the probability to acquire a specific venturing partner. They indicate probability changes in percentage points if the value of an indicator variable changes from zero to one. Variables of main interest are listed in the first rows. Control variables are listed under the heading "Other Firm Characteristics".

The results based on the differentiation of firms according product strategy and targeted markets are related to the reference group. The reference group contains firms which only deal with supplying activities. Further we count firms to the reference group which deal with supplying activities and offering services because earlier regressions emphasize that point estimates do not differ from reference group. Firms which develop new products or firms which offer services seem to be best suited to receive venture capital compared to the reference group. The marginal effects emphasize a remarkable difference in probabilities. For instance, firms which only develop new products achieve a 37 percent points higher probability to be funded via VC compared to firms in the reference group. Further, firm's orientation on the healthcare sector offer best chances to acquire a VCC as equity partner compared to firms with activi-

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

Table 5

Descriptive statistics of exogenous variables

Exogenous variables	Mean	Standard deviation
Product strategy and targeted markets[1]		
Developing new products	0.139	0.346
Offering services	0.189	0.392
Supplying activities and developing new products	0.088	0.284
Offering services and developing new products	0.181	0.386
Supplying activities, offering services and developing new products	0.088	0.284
Targeted markets: red biotechnology	0.800	0.401
Other firm characteristics[2]		
Doctor/Professor	0.616	0.487
Team foundation	0.451	0.498
Founded in	0.165	0.372
1996		
1997	0.205	0.404
1998	0.229	0.421
1999	0.256	0.437
Number of observations	375	

Remark: [1]BIOCOM database. – [2]ZEW-Foundation Panel. Three observations are excluded because of missing data in "other firm characteristics". RWI ESSEN

ties in the field of green or gray biotechnology. An alternative specification considers the interaction between both variables. The coefficient estimates are significant higher when we take an interaction term, product and service firms in the red biotechnology area, into account. The results confirm clearly our hypothesis 1, VCC are strongly oriented in financing high-risk projects in large sized markets with best opportunities for growth.

Contrary to that, product and service firms have a significant lower probability to acquire corporate investors as venturing partner than supplier firms. The marginal effects quantify the extent of lower probability between minus 5.5 and minus 8.7 percent points. Strikingly, firms' targeted market doesn't matter to gain a corporate investors more successfully. Corporate investors avoid equity financing of high-risk projects and use opportunities in the low-risk area to secure an optimal supply for current product pipeline. Both empirical results confirm our hypothesis 2.

The results are very similar as we count the syndicated investments by VCC and corporate investor to the group of corporate investors, alternatively (Table 7). Now, a significant lower probability of firms in the category "Offering Services" 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 VCC and corporate investors within the area of high-tech projects. Corporate investors are more willing to undertake equity

Table 6

Determinants of the probability to be firm's venturing partner
Base category: No venturing partner (# 270)

Exogenous variables	VC-company[1] (67 obs.)		Corporate investor (38 obs.)	
	coeff.	dy/dx	coeff.	dy/dx
Product strategy and targeted markets				
Developing new products	2.319*** (0.725)	0,367** (0,144)	–1,54** (0,782)	–0,079*** (0,022)
Offering services	2.121*** (0.685)	0,299** (0,12)	–0,675 (0,551)	–0,055** (0,023)
New products and supplying activities	1.768** (0.776)	0,264* (0,148)	–1,27* (0,758)	–0,065*** (0,021)
New products and offering services	1.469** (0.697)	0,189* (0,105)	–1,783** (0,748)	–0,087*** (0,022)
Supplying activities, services, new products	1.203 (0.789)	0,159 (0,126)	–2,158** (1,052)	–0,08*** (0,021)
Targeted markets: red bio-technology	1.483*** (0.55)	0,088*** (0,027)	–0,445 (0,416)	–0,043 (0,038)
Other firm characteristics				
Doctor/Professor	1.698*** (0.58)	0,125*** (0,041)	–0,174 (0,465)	–0,022 (0,034)
Team	0.546 (0.343)	0,042 (0,029)	0,434 (0,392)	0,027 (0,029)
Founded in				
1996	0.925 (0.735)	0,085 (0,091)	0,812 (0,593)	0,058 (0,059)
1997	1.603** (0.707)	0,175 (0,107)	0,915 (0,592)	0,054 (0,056)
1998	1.26* (0.695)	0,133 (0,092)	0,265 (0,615)	0,007 (0,043)
1999	0.82 (0.765)	0,088 (0,087)	–1,422* (0,786)	–0,08*** (0,031)
Intercept	-6.96*** (1.03)		–1,21* (0,663)	
Number of all observation	375			
Log-Likelihood	–232.14			
Pseudo R^2 (Likelihood Ratio Index)	0.2025			

Source: ZEW-Foundation Panels, BIOCOM Database 2000. – *Significant on the 10%-level; **Significant on the 5%-level; ***Significant on the 1%-level. – [1]Syndicated investments between VC-company and corporate investor are included. Reference group: Firm with supplying activities exclusively or supplying activities and offering services, in green or gray business field, no Ph.D or professor within founder's team, founded in 1995. dy/dx indicates the marginal effect. Heteroscedastic robust standard errors in parantheses.

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investment in high-risk projects if financial intermediaries like VCC are involved in project evaluation. The results confirm empirically that syndication helps to reduce the risk of selecting a bad project if high information asymmetries exist (Locket, Wright 2001).

The remaining variables are discussed briefly. The presence of founders with high affinity to science measured with the title "Ph. D." and "Professor" (in ac-

Table 7

Determinants of the probability to be firm's venturing partner
Base category: No venturing partner (# 270)

Exogenous variables	VC-company (57 obs.)		Corporate investor[1] (48 obs.)	
	coeff.	dy/dx	coeff.	dy/dx
Product strategy and targeted markets				
Developing new products	2.516*** (0.84)	0.355** (0.162)	–0.868 (0.598)	–0.08*** (0.027)
Offering services	2.028** (0.802)	0.229* (0.12)	–0.09 (0.453)	–0.03 (0.032)
New products and supplying activities	2.189** (0.875)	0.311* (0.165)	–1.282* (0.749)	–0.088*** (0.026)
New products and offering services	1.848** (0.805)	0.218* (0.12)	–1.913*** (0.739)	–0.118*** (0.025)
Supplying activities, services, new products	1.564* (0.889)	0.193 (0.142)	–2.216** (1.032)	–0.106*** (0.024)
Targeted markets: red biotechnology	1.095** (0.56)	0.054** (0.025)	–0.045 (0.417)	–0.01 (0.039)
Other firm characteristics				
Doctor/Professor	2.147*** (0.707)	0.125*** (0.04)	–0.108 (0.427)	–0.023 (0.038)
Team	0.459 (0.348)	0.026 (0.023)	0.484 (0.368)	0.04 (0.035)
Founded in				
1996	0.799 (0.734)	0.055 (0.068)	0.75 (0.579)	0.071 (0.07)
1997	1.324* (0.721)	0.101 (0.079)	1.104** (0.559)	0.105 (0.075)
1998	1.053 (0.701)	0.081 (0.069)	0.457 (0.58)	0.033 (0.059)
1999	0.765 (0.785)	0.066 (0.071)	–1.126 (0.721)	–0.086** (0.041)
Intercept	–7.148*** (1.158)		–1.631** (0.694)	
Number of all observation	375			
Log-Likelihood	–238.91			
Pseudo R^2 (Likelihood Ratio Index)	0.1895			

Source: ZEW-Foundation Panels, BIOCOM Database 2000. - *Significant on the 10%-level; **Significant on the 5%-level; ***Significant on the 1%-level. – [1]Syndicated investments between VC-company and corporate investor are included. Reference group: Firm with supplying activities exclusively or supplying activities and offering services, in green or gray business field, no Ph.D or professor within founder's team, founded in 1995. Heteroscedastic robust standard errors in parantheses.

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cordance to Audretsch, Stephan 1996) increase firm's probability to receive venture capital. 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, 2002). Biotechnology start-ups founded in 1997 and 1998 have a higher probability to receive venture capital than those founded in 1995 (the reference group). The pattern is mostly reasoned by the expectations of

higher return on investments in the end of the ninetees of the last century compared to earlier years. The possibility to realize high prices for initial public offerings of young firms with high potential of growth affect positively the VCC's rate of return and hence, the willingness of investors to invest money in the funds of VCC (Brav, Gompers 1997; Lerner, Gompers 1998; Jeng, Wells 1998; Engel 2004 for empirical evidence).

Some sensitivity analyses are done to check the robustness of results. As we consider firm size measured with number of employees the sample will be reduced of about 43 observations. We detect a nonlinear inverse U-shaped relationship between size and the probability to be funded by VCC or corporate investor. We further considered variables on the level of counties to measure region's ability to generate most attractive investment opportunities and to support the innovation process of biotechnology firms via co-operations and informal network activities. Coefficients do not significantly differ from zero and hence, we do not focus on this variables. All sensitivity analyses is common that results for variables of main interest will be unchanged.

5. Discussion and 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 analysis emphasize a substantial importance of venture capital finance as funding source for biotech firms developing new products and technologies in the therapeutic and diagnostic fields, known as high-risk biotech firms. 42 percent of them received venture capital in early stage. In contrast, low-risk projects on average namely supplier firm were equity funded by venture capitalists to little extent. Someone could interpret the result for product firms in the opposite direction: Venture capital is not important, because 58 percent do not have it. Two arguments speak 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 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 (Engel 2004). The multivariate analysis emphasize that firm's developing new drugs and platform technologies have a higher probability to be equity funded than supplier firms. The results of descriptive analysis are hold in the multivariate analysis if we consider some more determinants of funding.

Biotechnology firms 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 firms. We believe that risk-adversity, higher attractiveness of alternative strategies such as collaborations, acquisition in later stages and preferences of the biotechnology firms 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. Corporate investors' (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 funding gap. Against this, corporate investors are more involved as venturing partners in low-risk biotech firms based on attractive opportunities for horizontal or vertical enlargement of incumbent's business activities to secure an optimal supply for the current product pipeline. The multivariate analysis confirm once again the result of descriptive analysis.

Venture capital is particularly important for early stage financing of high-risk biotechnology firms. 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 firms are experiencing increasing difficulties in acquiring external equity after the crash of the 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 increased drastically. 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 firms and the financing of new ones. The message for policy makers is clear: creation of new industries, the commercialization of "disruptive" technologies needs best conditions for venture capital investments. Public support (e.g. tax advantages, public equity under private management) can partly help to secure "baseline" investments in years of low amounts of fund raising by VCC.

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