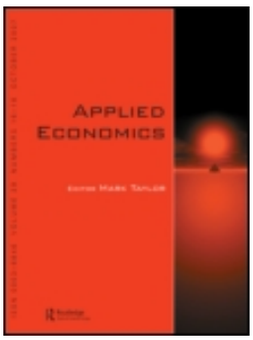

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What kind of German biotechnology start-ups do venture capital companies and corporate investors prefer for equity investments?

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The paper deals with 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. Our 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 venture capital companies (VCC) in financing young innovative biotechnology firms developing health care applications and technology platforms is expected, whereas corporate investors like incumbents in pharmaceutical and chemical industries may play a more important role in financing supplier companies. The empirical analysis is based on 378 biotechnology firms, founded between 1995 and 1999. Descriptive 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, corporate investors are marginally involved as venturing partner of high risk projects. The observed pattern also holds in a multivariate analysis which controls for some core variables as determinants of equity funding. The result for corporate investors differs from observations in the US for collaborative arrangements. Therefore, country specific settings may matter.

I. Introduction

Economies presence in new markets and industries is supposed as key a challenge to realize competitive advantages and hence, economic growth. However, new high tech firms in these industries are characterized by high uncertainty about technological risk and market acceptance of new application.

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Limited internal funds of young high-tech firms and imperfections of capital market suggest that external equity financing is crucially important to reduce the remarkable funding gap for these firms (see Carpenter and 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 and Lerner, 2000).

Surprisingly, to our knowledge a comprehensive study considering the role of venture capital companies (VCC) and corporate investors in formative stages of industries like biotechnology industry is missing.[1] Some authors start from the viewpoint of effective commercialisation strategy of start-ups to understand the role of arrangements between start-ups and incumbents (e.g., Pisano, 1989; Gans and Stern, 2002). Other studies focus on the role of VCC as equity partner of young high-tech firms in general (e.g., Amit *et al.*, 1998; Hellman and Puri, 2000, 2002; Gompers and Lerner, 2001). The studies dealt almost only with the emergence of US biotechnology industry. Hence, it may be fruitful to analyze the role of equity partners against the background of national specific settings.

Related to that, the paper gives first empirical evidence to the role of VCC and corporate investors as equity partners of young German biotech firms. Doing this we present the frequency of equity funding and ask whether firm characteristics and firm environment can explain the observed pattern. We are especially interested in the relevance of project risk. Based on a theoretical discussion we argue that incumbents are less suitable equity partners of R&D-intensive biotechnology firms (high-risk projects). They prefer other instruments to obtain the 'window on technology'. In contrast, VCC may play a fundament role to finance these kinds of projects via equity. We consider a wide range of variables to control for the relevance of other characteristics and by the way, we take into account some German's specificities.

We use a novel dataset to test our hypotheses and emphasize the OECD-definition[2] of biotechnological industry to consider the wide range of technological and entrepreneurial opportunities within the sector. The value chain within the biotechnology industry contains R&D-intensive, 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 investor 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.

The remainder of the paper is organized as follows: In Section II 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 III 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 IV 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 V.

II. Conceptual Framework

Demand for equity

As we mentioned before, biotechnology firms differ in the level of future outcomes and the level of uncertainty to realize the outcomes. 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, p. 24). Furthermore, these financial resources are required over a long period of time. Therefore, internal finance appears to be an

[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''.

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 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, bounded returns and negative effects on firms' default risk (Carpenter and Petersen, 2002). The same is true for public loans. Their allocation depends on the readiness of 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) pecking order theory, firms escape to external equity, the last and most expensive financial resource, to reduce the remarkable funding gap for high-tech projects.

Supply for equity

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 angels face the same market imperfections as banks regarding information asymmetries. Furthermore, the finance amount required in biotechnology often exceeds their own capabilities. Business angels select best proposals and invest on average 125 000 to 500 000€ in a firm. On the contrary, corporate investors and VCC have greater financial capabilities than business angels.

Venture capital companies. Intermediaries like VCC act between outside investors and equity seeking entrepreneurs. VCC raise funds from investors, invest the money in selected projects, give hands-on management to funded firms and realize return on investment via selling their shares to other investors (see Gorman and Sahlman, 1989; Sahlman, 1990 for details). They syndicate a lot of investments to overcome the limitations in fund raising, to achieve sufficient diversification and to increase the quality of screening procedure (see e.g., Bygrave, 1987; Brander *et al*., 2002). From the viewpoint of the economic function of VCC, risk-pooling (Amit *et al*., 1998), risk-diversification (Diamond, 1984; Norton and Tenenbaum, 1993), specialization (Chan, 1983) and better opportunity to syndicate investments (Lerner, 1994) are the most popular arguments to derive advantages of VCC over single investors. These advantages increase with the level of agency costs. On the side of the costs, VCC need sufficient compensation for their efforts and to satisfy outside investors successfully. Accordingly to finance theory, the return on investment correlates positively with the level of risk. To sum up, advantages of VCC over single investors, and the need to realize sufficient returns suggest that VCC seem to best suited to finance high-risk projects.

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, and the radical nature of innovation.[4] Related to the case of biotechnology industry, the health care – 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) and diagnostic products may participate on market growth above on average. As opposed to the situation in the health care (''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 and regulatory approval. The market for environmental applications (''gray'' biotech) is viewed as being economically insignificant compared to the two previous ones.

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 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

[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] For an extensive discussion of VC investment criteria see, among others, Tyebjee and Bruno's (1984) and MacMillan *et al*. (1987).

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.

Incumbents. As far as corporate investors 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. Incumbents seek 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; Gans and Stern, 2002). 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 (Buse, 2000; Hamdouch and Depret, 2001). 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. 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.[5] Further, 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.

To address this challenge and to use the window of opportunity, incumbents can choose in general between alliances/licensing on the one hand and equity participation on the other hand. The choice of instrument depends on several factors, especially the level of uncertainty of project which the corporation wish to control. As we mentioned above, incumbents cannot compete with VCC concerning the funding strategy of high-tech start-ups VCC do have a competitive advantage compared to an equity participation. The empirical fact that corporate venture capital (CVC) units are second to move in during the boom stages of the venture capital cycle and first to remove themselves in recession stages (Gompers and Lerner, 1998; Gompers, 2002) may confirm our argumentation. Similar observations can be made in Germany. Most CVC activities started in 2000,[6] three years later after the first substantial increase in fundraising and investments on the VC market.

In addition, alliances with innovative biotechnology firms, namely in-licensing and/or co-development collaborations allow incumbents to meet their strategic goals and to minimize their cost to handle high level of uncertainty in high-risk projects. For example, in-licensing couples 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). Moreover, in-licensing/co-development collaborations allow the incumbents to invest in later stages of the highly risky drug development process, hence to mitigate their risks.[7] However, the a priori predefinition of payments can lead to problems if market acceptance of a new product is misjudged by corporate investors.

[5] 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).

[6] 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).

[7] 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.

A high preference for collaboration without equity investment for high-tech projects is evidenced by aggregated data[8] as well as Champenois' empirical research.[9]

In the opposite way, incumbents offer advantages over VCC to meet their strategic goals and strategic opportunities in the low-risk area of biotechnology industry via equity participation. Incumbents follow on non-financial goals to higher extent than VCC, and VCC are confronted with disadvantages to realize sufficient compensation for projects with low potential of firm value growth.

To sum up, the set of different instruments to meet the strategic goals and the advantages of VCC to finance high-risk projects leads to our second hypothesis:

H2: Corporate investors' namely pharmaceutical and chemical corporations avoid equity funding of young high-tech biotechnology firms. On the contrary to that, incumbents participate with equity more frequently if low level of uncertainty does exist.

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 may not be 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 (see Lerner *et al*., 2003 for detailed discussion). All this leads to our third hypothesis:

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

III. 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 1205 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.[10]

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 a 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.[11]

[8] 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).

[9] 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.

[10] 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.

[11] 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).

Table 1. Differences in measures for risk-chance profile of biotechnology firms

	Annual average employment growth rate			Patent (yes/no)	
Product strategy	Mean	Median	Stand. dev.	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

Note: 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.

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.[12] CVC-units of incumbents which are mostly member of VC-associations have to be re-classified to the group of corporate investors. Remarkably, 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 irrelevance 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[13] 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 health care, 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, and 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 and Kettler, 2001). A second group is the ''traditional'' technical service 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

[12] Remember the following case: A management company is the owner of the biotechnology firm to save the tangible and intangible assets in case of bankruptcy.
[13] 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.

database does 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 Table 1, and tests confirm our classification. Median of employment growth rate and mean of patent significantly differs between the groups. Further, results are held 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.[14] To receive a better accuracy of discrimination, we restricted the number of combinations to three in the descriptive analysis. The first category, product firms, contains 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, contains the remaining firms (see Table 2). Table 3 emphasizes that the majority of firms targets the medicine, health care market. About the half of all biotech firms are classified as suppliers, the category of low level of risk on average.

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 percent 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

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 (Remark: In analogy to ZEW-Foundation Panel, we do not present a reference).

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 (Remark: In analogy to ZEW-Foundation Panel, we do not present a reference).
Remark: "Red" indicates market for health care, "Green" indicates the agricultural and food market and "Gray" indicates the market for environmental applications.

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 (Remark: In analogy to ZEW-Foundation Panel, we do not present a reference).

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

Table 5. Descriptive statistics of exogenous variables

Exogenous variables	Mean	Standard deviation
Product strategy and targeted markets[a]		
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[b]		
Doctor/Professor	0.616	0.487
Team foundation	0.451	0.498
Founded in 1996	0.165	0.372
Founded in 1997	0.205	0.404
Founded in 1998	0.229	0.421
Founded in 1999	0.256	0.437
Characteristics of firm's region		
BioRegio-winnerregion	0.232	0.423
BioRegio-other participant	0.408	0.492
Business R&D employees/1000	3.997	6.669
Number of observations	375	

Notes: [a] BIOCOM database.
[b] ZEW-Foundation Panel. Three observations are excluded because of missing data in "other firm characteristics".

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 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 health care 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.

IV. 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) (see 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).[15] 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 ε_i are independent and identically type I extreme value distributed. This implies a severe restriction for our empirical model, which is known

[15] 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 6. Determinants of the probability to be firm's venturing partner

	Base category: no venturing partner (#obs. 270)			
	VC-company[a] (#obs. 67)		Corporate investor (#obs. 38)	
Exogenous variables	Coeff.	dy/dx	Coeff.	dy/dx
Product strategy and targeted markets				
Developing new products	2.1***	0.307**	−1.63**	−0.08***
	(0.689)	(0.121)	(0.824)	(0.023)
Offering services	1.86***	0.238**	−0.736	−0.054**
	(0.685)	(0.104)	(0.682)	(0.027)
New products and supplying activities	1.688**	0.236*	−1.303*	−0.066***
	(0.807)	(0.143)	(0.763)	(0.022)
New products and offering services	1.277*	0.15*	−1.771**	−0.086***
	(0.668)	(0.086)	(0.78)	(0.02)
Supplying activities, services, new products	1.176	0.146	−2.161**	−0.08***
	(0.903)	(0.136)	(1.102)	(0.021)
Targeted markets: red biotechnology	1.408***	0.08***	−0.462	−0.044
	(0.479)	(0.024)	(0.392)	(0.037)
Other firm characteristics				
Doctor/Professor	1.694***	0.117***	−0.22	−0.025
	(0.436)	(0.039)	(0.506)	(0.037)
Team	0.565**	0.041*	0.448	0.028
	(0.277)	(0.021)	(0.385)	(0.028)
Founded in 1996	0.785	0.064	0.858	0.066
	(0.652)	(0.072)	(0.675)	(0.071)
Founded in 1997	1.41**	0.139	0.906	0.059
	(0.568)	(0.085)	(0.554)	(0.057)
Founded in 1998	1.045*	0.099	0.271	0.01
	(0.56)	(0.069)	(0.688)	(0.051)
Founded in 1999	0.512	0.051	−1.444*	−0.08***
	(0.741)	(0.073)	(0.827)	(0.029)
Characteristics of firm's region				
BioRegio-winnerregion	0.897*	0.082*	0.187	0.006
	(0.431)	(0.044)	(0.477)	(0.034)
BioRegio-other participant	0.645	0.053	−0.158	−0.015
	(0.483)	(0.04)	(0.417)	(0.028)
Number of Business R&D employees	0.03*	0.002	0.014	0.001
	(0.016)	(0.001)	(0.031)	(0.002)
Intercept	−7.259***		−1.183*	
	(0.873)		(0.712)	
Number of all observation	375			
Pseudo R^2 (Likelihood ratio index)	0.2181			

Notes: *** 1%-level, ** 5%-level, * 10%-level of significance.
[a] Syndicated investments between VC-company and corporate investor are included.
dy/dx indicates the marginal effect.
Heteroscedastic robust standard errors in parantheses.
Multinomial-logit model with standard errors adjusted for cluster on counties.

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). Accordingly Hausman and McFadden (1984) we now test whether parameter estimates of each two-alternative model is equal to estimates of the full model. The results suggest that IIA could not be rejected in our model (Chi-2 statistic with

Table 7. Determinants of the probability to be firm's venturing partner

	Base category: no venturing partner (#obs. 270)			
	VC-company (#obs. 57)		Corporate investor[a] (#obs. 48)	
Exogenous variables	Coeff.	dy/dx	Coeff.	dy/dx
Product strategy and targeted markets				
Developing new products	2.306***	0.305**	−0.996	−0.082***
	(0.796)	(0.132)	(0.646)	(0.028)
Offering services	1.8**	0.188*	−0.261	−0.038
	(0.808)	(0.108)	(0.487)	(0.031)
New products and supplying activities	2.083**	0.282*	−1.344*	−0.088***
	(0.911)	(0.153)	(0.751)	(0.026)
New products and offering services	1.721**	0.192*	−2.013***	−0.121***
	(0.8)	(0.103)	(0.78)	(0.022)
Supplying activities, services, new products	1.548	0.184	−2.267**	−0.107***
	(0.979)	(0.149)	(1.074)	(0.023)
Targeted markets: red biotechnology	1.005**	0.049**	−0.099	−0.014
	(0.506)	(0.022)	(0.386)	(0.037)
Other firm characteristics				
Doctor/Professor	2.121***	0.119***	−0.153	−0.026
	(0.658)	(0.041)	(0.459)	(0.041)
Team	0.475	0.026	0.518	0.044
	(0.319)	(0.02)	(0.354)	(0.034)
Founded in 1996	0.715	0.045	0.769	0.075
	(0.662)	(0.058)	(0.714)	(0.088)
Founded in 1997	1.136	0.078	1.094*	0.109
	(0.735)	(0.079)	(0.582)	(0.084)
Founded in 1998	0.896	0.064	0.41	0.031
	(0.58)	(0.057)	(0.583)	(0.058)
Founded in 1999	0.538	0.045	−1.175	−0.087**
	(0.743)	(0.062)	(0.766)	(0.04)
Characteristics of firm's region				
BioRegio-winnerregion	0.833	0.059	0.313	0.022
	(0.453)	(0.037)	(0.457)	(0.044)
BioRegio-other participant	0.373	0.023	0.155	0.011
	(0.471)	(0.03)	(0.386)	(0.034)
Number of Business R&D employees	0.023	0.001	0.031**	0.003**
	(0.015)	(0.001)	(0.015)	(0.001)
Intercept	−7.293***		−1.739**	
	(1.096)		(0.73)	
Number of all observation	375			
Pseudo R^2 (Likelihood ratio index)	0.2021			

Notes: ***1%-level, **5%-level, *10%-level of significance.
[a] Syndicated investments between VC-company and corporate investor are included.
dy/dx indicates the marginal effect.
Heteroscedastic robust standard errors in parantheses.
Multinomial-logit model with standard errors adjusted for cluster on counties.

30 degrees of freedom is 19.46, p-value = 0.9299). Thus, we can conclude that the disturbances in our model are independent.

Estimation results

Table 5 contains the descriptive statistics for considered variables, Tables 6 and 7 show the results of MNL-Estimation. We present coefficient estimates as well as marginal effects for final specification. Insignificant variables are excluded if regression fit is not affected. 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 31 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 activities in the field of green or gray biotechnology. An alternative specification considers the interaction between both variables. The coefficient estimates are significantly 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 8.0 and minus 5.4 percent points. Strikingly, firms' targeted market doesn't matter to gain corporate investors more successfully. Corporate investors avoid equity financing of high risk projects and use opportunities in the low-risk area via equity. 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 (see 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 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 (see Bygrave, 1987; Brander *et al*., 2002; Locket and Wright, 2001).

The remaining variables are discussed briefly. We start with one German specificity: the role of BioRegio-contest (BRC). The German Federal Ministry for Education and Research (BMBF) launched the BioRegio-contest in 1995 to stimulate the commercialization of biotechnology research in Germany. Actors in regions are invited to develop integrated concepts for commercialization process. Seventeen regions participated and three winner regions were selected by a jury of experts. BioRegio-winner regions achieve a 8 per cent points higher probability to raise funds from VCC than firms outside these regions. The result reflects advantages of BRC-winning regions to offer interesting investments opportunities for VCC. These advantages may result from unobservable abilities of regions on the one hand and spillovers based on participation and winning the BRC on the other hand. Participation stimulates the interaction among entrepreneurs, industry, financing sector, universities and public administration and hence, reduces the agency costs to select interesting projects. In addition, the label of winner and exclusive financial support by government for winning regions gives some opportunities more to reduce agency costs. We further try to measure regional differences with respect to technological capacity and knowledge capital. Only the number of R&D employees significantly differs from zero and shows a positive coefficient.

The presence of founders with high affinity to science (measured with the title ''PhD'' and ''Professor'') increases the firm's probability to receive equity by a VCC. 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).[16] Our results is contrary to findings for bank loan access. Grilli's (2005) analysis for internet start-ups suggests that bank loan decision is not driven by founders' skills and competencies.[17]

Some sensitivity analyses are done to check the robustness of results. As we consider firm size

[16] Empirical evidence of Bruederl and Preisendoerfer (2000) and Almus (2002) support the positive relationship between the human capital endowment and the propensity to become a fast growing firm.

[17] In contrast, founders' skills and abilities matter for start-ups in established industries with well-known risk of failure. The estimation results of Storey (1994) showed that banks are more likely to lend to those individuals with any educational qualification.

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. All sensitivity analyses is common that results for variables of main interest will be unchanged.

V. 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. Forty two 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 are against this interpretation. First, only a small share of all asking firms receives 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. The multivariate analysis emphasizes 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. The result differs from observations in the US for collaborative arrangements. Study of Pisano (1989) shows a significant higher probability to use equity forms when biotechnology firms are R&D-intensive. The results cannot compared really one-to-one. However, the analysis of the German case contributes to the discussion that country specific settings matters.

Corporate investors' (direct) contribution to reduce the financing gap at the time of foundation is comparably low for young German biotech's. 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 confirms 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.

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