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GESY

Discussion Paper No. 189

Can't Buy Me Rights! The Contractual Structure of Asymmetrical Inter-firm Collaborations

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December 2006

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Financial support from the Deutsche Forschungsgemeinschaft through SFB/TR 15 is gratefully acknowledged.

CAN'T BUY ME RIGHTS! —THE CONTRACTUAL STRUCTURE OF ASYMMETRICAL INTER-FIRM COLLABORATIONS

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ABSTRACT

The efficient allocation of control rights in inter-firm collaborations is a widely emphasized issue. In this paper, I empirically identify control rights and the allocation of these rights using a unique survey data set on collaborations between biotechnology and pharmaceutical firms. Fifteen control rights are identified to make up the structure of deals with five rights being the items of contention in deal making (ownership of patents, production, further development of the technology, the right to manage the collaboration, and the right to market universally). I find that the assignment of control rights is related to the bargaining position of firms and incentive issues. Hence, goliaths –pharmaceutical incumbents – subrogate critical rights to the new ventures when the final outcome of the project is depending on the venture's effort.

KEYWORDS: contracts, performance, inter-firm collaboration, biotechnology

JEL CLASSIFICATION: D23, L24, G30, M13, O32

Acknowledgements: I am indebted to John Hagedoorn, Dietmar Harhoff, Joachim Henkel, Jan Kirsten, Karen Wagner, and seminar participants at EGOS Conference 2005, Ludwig-Maximilian University of Munich, and Stanford University for valuable comments and discussions. I would especially like to thank my interviewees, the ODEON Center for Entrepreneurship, and Jörn Densing and Guido Schenk from VContarget (provider of the service portal of the Technologie-Beteiligungs-Gesellschaft mbH) for their support in building the data base. Financial support from the Deutsche Forschungsgemeinschaft through SFB/TR 15 is gratefully acknowledged.The usual disclaimer applies.

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1. Introduction and motivation

Novel innovative technology is scarce, complex, and typically expensive to develop. Young technology firms often have promising ideas, but lack financial resources or complementary assets to implement their projects. For many of these firms, a necessary step towards realizing their ideas is to enter into R&D collaboration with an established corporation.

However, such partnerships face three interrelated obstacles: 1) the uncertainty inherent in technology-intensive industries, 2) incomplete contracting problems, and 3) problems occurring through unbalanced bargaining power of the partners (Aghion and Tirole, 1994; Hart, 1995). The first two obstacles refer to the importance of contractually specifying control rights, whereas the last obstacle challenges efficient agreements. The theory of incomplete contracts has generated valuable insights into the assignment of control rights. Grossman and Hart (1986) and Hart and Moore (1988) argue that property rights should be given to the party with the greatest marginal ability to impact the final outcome. Extending the Grossman-Hart-Moore—framework, Aghion and Tirole (1994) stress that bargaining power is another important determinant. In addition, they show that cash constraints can prevent the parties from allocating control rights efficiently.

This paper empirically sheds light on the theoretical propositions. Empirical evidence in this field is of outstanding importance. More specifically, the interplay between incentive issues and bargaining power is an empirically underinvestigated topic. In industries where new ventures align with incumbents the press often bemoans the Goliaths – business incumbents – to squeeze out the petite new ventures. Hence, this (public) view presumes that the allocation of control rights is simply led by the bargaining position of the parties. However, this study shows that parties are undergoing a very complex negotiation process carefully considering incentives issues. Unlike other studies being based on secondary data, this paper contributes to the empirical literature in providing an in-depth interview and survey based study on contracting issues in the biopharmaceutical industry.

The biotechnology industry provides an appropriate environment for these research questions. The majority of young biotechnology firms are eager to enter collaborations with large pharmaceutical firms to finance research and development projects and to make up for the lack of resources and know-how (Niosi, 2003; Pisano, 1989; 1991; Powell et al., 1996; Pisano and Mang, 1993; Deeds and Hill, 1996; Danzon et al., 2003). These collaborations are mostly described to be asymmetrical since the partners differ in size and experience.[1] The success of the partnership is very critical for the firm's future.[2] However, developing new technology/drugs is an inherently uncertain and unpredictable endeavor. Negotiating an enforceable contract is a major element in the decision making process of the participating firms. Hence, information on contractual structure and characteristics of the partnership are to a large extent held secret. Using detailed survey data on 30 alliances between biotechnology and pharmaceutical firm in Germany, the contracting structure and its determinants are analyzed. The in-depth interviews show that 15 rights are very carefully considered in contracting with five rights being

of outstanding importance to the parties (ownership of patents generated by the collaboration, the right to control the manufacturing process, the right to further develop the technology/drug without restrictions after the collaboration is terminated, the right to manage the collaboration, and the right to market universally). Providing empirical support for the propositions of Aghion and Tirole (1994), the results reveal that besides the bargaining position, incentive considerations drive the allocation of the most important rights.

The paper is organized as follows. Section 2 describes the theoretical considerations on the allocation of control rights and discusses the hypotheses. Section 3 characterizes the biotechnology industry as an appropriate setting for this kind of study. The research design is presented in section 4. In section 5, the hypotheses are tested. Section 6 concludes the paper and suggests possible further research in this field.

2. Institutional and theoretical considerations on the allocation of control rights

In the theory of the firm, contracts should be designed to maximize expected utility. However, unforeseen contingencies and costs of writing or enforcing contracts lead to incomplete contracts (e.g., Williamson, 1985; Klein et al., 1978; Hart, 1995). Due to the incomplete contracting problem, it is necessary to protect the two parties' specific investment in the collaboration by agreeing upon control rights. Control rights are the rights to make decisions on contractually unspecified issues in an allowed set of decisions, e.g., contract, custom or law (Simon, 1951; Hart, 1989; Jensen and Meckling, 1992; Lerner and Merges, 1998).[3]

Following Grossman and Hart (1986) and Hart and Moore (1988) it is optimal to assign the control rights to the party with the greatest marginal ability to influence the success of the joint project.[4] This party is strongly interested in making optimal decisions if it directly benefits from the surplus that will arise from the project.

Aghion and Tirole (1994) adapt that model to the organization of R&D activity. Their model assumes that a small research unit partners with a customer or financier to develop a new technology. The research unit provides the effort and the partner provides the necessary financial resources. Whereas the financial resources can be contractually specified, the R&D effort of the small firm cannot be specified. R&D projects are ill-defined ex ante because of their uncertain nature. The involved parties cannot contract on the delivery of a specific innovation. According to the model by Aghion and Tirole (1994), the allocation of control rights is dependent on 1) the parties relative marginal ability to impact the success of the project, and 2) the ex ante bargaining power of the partners.[5]

The authors show that efficient as well as inefficient outcomes are possible. If the research unit has the ex ante bargaining power and its marginal ability to impact success is higher than that of the partner, the control rights are assigned to the research firm, resulting in an efficient allocation. If the small research unit has a weak bargaining position but its marginal ability to impact success is higher than

that of the partner, an efficient allocation occurs only if the research unit has a necessary amount of cash to compensate the other party for a transfer of rights. In the case of a cash constraint research unit, the parties may not agree on an efficient allocation of control rights.[6]

From the above arguments a triad of hypotheses concerning the allocation of control rights can be derived:

H1: The greater the marginal ability of the new venture to impact project success, the more control rights are allocated to the new venture.

H2: The higher the bargaining power of the new venture, the more control rights are allocated to the new venture.

H3: The larger the amount of capital raised of the new venture, the more control rights are allocated to the new venture.

Some empirical studies exist on the assignment of control rights.[7] Valuable insights on the design of developing and licensing contracts are provided in Pisano and Mang (1993). They find that contracts are multifaceted and depend on the character and objective of the collaboration. Lerner with co-authors presents some studies on the allocation of control rights by using secondary data. The study of Lerner and Merges (1998) analyzes the contracts of 200 biotechnology partnerships (SEC filings of US firms from 1980 to 1995). They find a positive relation between the small firms' financial resources and the number of control rights that are assigned to that firm. Contrary to theoretical propositions, they report that when the technology is in an early stage, the larger firm receives more rights. Hence, incentive issues seem not to be considered in deal structure. Using the same dataset, Lerner et al. (2003) show that shifts in financing availability influence the assignment of control rights. In times where little external financing is available the small firm retains less control rights and the cooperation performs less successfully. While these studies are based on a relative large dataset, the drawback of using secondary data is often in rough measures. For example, bargaining power in Lerner and Merges (1998) and Lerner et al. (2003) is measured by the availability of outside capital in the biopharmaceutical industry lacking for examples variables that make up for the interest of the incumbent in the product of the venture. In their study of 106 internet portal alliances, Elfenbein and Lerner (2001) incorporate product market strength as another determinant of bargaining power reporting that financing and product market strength influence the distribution of ownership between contracting parties.

3. Characteristics of inter-firm collaboration in biotechnology

The path-breaking discoveries – most notably recombinant DNA and hybridoma (cell fusion for monoclonal antibodies) – sparked off a new promising industry, the biotechnology industry. In order to be serious market participants the firms must be at the "forefront of knowledge-seeking and tech-

nology development" (Powell, 1998, 232). This applies to biotechnology firms as the early adopters and innovating actors that operate in the field, and in an equal manner to pharmaceutical firms as the established firms that had to rearrange their R&D techniques to the radical innovation (Audretsch, 2001; Audretsch and Feldman, 2003). The following characteristics make the biotechnology industry an appropriate setting to study contractual structure and success patterns of inter-firm collaboration.

- Uncertainty and complexity: The R&D process, by its very nature, is highly uncertain and complex. On average, it takes 10 to 15 years to proceed from drug discovery to the market launch of a drug. Only 500 out of 10,000 screened compounds enter preclinical testing, 5 enter clinical testing, and only 1 completes the long and winding road to regulatory approval (PhRMA, 2003). Furthermore, only 3 out of 10 marketed drugs produce revenues that match or exceed the costs of producing them (PhRMA, 2003; DiMasi et al., 2003).
- Asymmetrical collaborations: The biotechnology industry is characterized by a relatively high number of asymmetrical partnerships usually between an entrepreneurial biotechnology firm and a large pharmaceutical firm. Both type of firms offer comparative advantages in bringing new technology to the market. The entrepreneurial biotechnology firms pioneer drug discovery based on the outstanding innovations and provide new drug candidates and innovative technology to feed the decreasing drug pipelines of the pharmaceutical firms. The pharmaceutical firms have experience in navigating the drug through the strictly regulated steps of the clinical trials to the approval process, and in marketing the drugs.
- Critical effort: The characteristic of the drug discovery process demands very critical effort from the biotechnology firm to be successful.[8] A collaboration contract referring to an early stage of technology/drug development should be designed to encourage the biotechnology firm's effort.
- Bargaining position: In general, pharmaceutical firms have a better bargaining position in negotiating the collaboration contract than biotechnology firms. Numerous biotechnology firms make desperate efforts to attract the attention of the lower number of pharmaceutical firms. Biotechnology firms often rely on collaborations with pharmaceutical firms to finance their research and development projects (Pisano and Mang, 1993; Nicholson et al., 2002).[9] Nicholson et al. (2002) find that in 1998, three times as much financing is raised from partnerships with pharmaceutical firms than from the private and public equity market together.

In the course of this study numerous interviews with deal making experts have been undertaken to learn about the nature of the negotiations and the determinants of their contractual structure. The interviews reveal how careful these deals are structured. First, it is found that the prospect of the collaboration – e.g. the technology/drug that is contracted upon – is anything but a guarantee for a successful partnership. All interviewees emphasized that at the time the contract is signed it is too early to be able to predict the success of a biotechnology-pharmaceutical project. These projects are inherently risky.

When a collaboration project is singed, this means not a "homerun" for one of the partner's but the start of a straining and winding road to jointly master the development of a technology. Second, because of the uncertainty and complexity a fair deal must be found to motivate the partners. Thereby, the motivation and the incentives for all partners are superficial. The interviews also revealed that trying to find a fair deal for all partners is the result of a learning process the industry had to undergo. Two managers of business development departments of large pharmaceutical firms admitted that it was not long ago when they got a premium for each single closed deal with attractive deal terms that brought the prospect of a new product into the pharmaceutical firm's development pipeline. The motto among the deal makers was trying to find a potential collaboration or in-licensing technology and drive a hard bargain. With many joint projects failing and displeased partners, deal making today is more the attempt to find a "win-win-situation" with the consequence of relative long negotiation periods. Johnson & Johnson (2003, 10) explicitly points out in its report that the "… business-development specialists avoid standardized deals and focus on the success of the products and the long-term goals of both partners". W. Stoiber from JSB partners who was involved in the legendary Bayer-Millenium deal adds "… for the pharmaceutical firm it is not enough that there is a promising product. They want to bring a drug to the market. Therefore they try to find a fair deal" (Interview on January 10, 2003). Similarly, S. Moroney from Morphosys AG claims that "from our perspective the most successful collaborations are the ones that are a fair deal and motivate" (Interview on April 17, 2003) as well as S. Schreiner from Roche Diagnostics AG "… both partners must be committed… and trust plays a major role" (Feb 10, 2003). Putting the incentive aspects in the spot light, Peter Buckel from Xantos AG reports "… independently from the project, there is a welcomed trend that pharmaceutical firms consider more and more incentive reasons. This is rational as the success of a project depends on the collaborative behaviour" (April 15, 2003).

4. Research design

4.1. Data source and sample

This study is based on a unique survey data set of biotechnology firms in Germany collected in the second half of 2003.[10] Prior to the survey, I interviewed 18 biotechnology experts (managers of pharmaceutical firms and biotechnology firms, venture capitalists, consultants, etc.) to learn about contracting and identify important control rights that are included in the biotechnology-pharmaceutical contracts.[11] The questionnaire has 3 parts. A general part on the characteristics of the surveyed biotechnology firms (including future development scenarios), a part on the most important collaboration of the firms with another biotechnology firm, and a part on the most important collaboration with a pharmaceutical firm, if they had entered one. This study is based on the last part of the survey. Hence only biotechnology firms that entered a contract with a pharmaceutical firm answered this part of the survey.

The questionnaire was made available to participants in a variety of forms. Firstly, all 178 biotechnology firms that received capital support through the German government-owned bank "Technologie-Beteiligungs-Gesellschaft mbH" (tbg) were requested to fill out the online survey about collaborative activities. The tbg co-financed the vast majority of venture capital financed biotechnology firms.[12] The majority of firms financed by the tbg report their financial data on a monthly basis via an internet portal provided by VC on target GmbH. VC on target provides web-based solutions for inter-operational information exchange. Each firm uses its own "account" in which its reporting status is listed and, in addition, in which tasks can be posted. The cooperation with VC on target GmbH and the tbg allowed me to post a notification with an introduction to the study and a link to the online survey. Ninety-four firms filled out the online survey. However, only 76 surveys were filled out completely. I received the anonymous data from VC on target in electronic form.

Secondly, 25 managers of biotechnology firms were asked to fill out a paper-based questionnaire. I called the managers requesting their participation and informing them about the goal, background, and process of the study. The managers were able to choose the mode of receiving the questionnaire—by mail or as an e-mail attachment. Fifteen managers filled out the questionnaire. The paper-based responses were manually entered into the same database. Finally, a total of 109 surveys were returned. Thirty of those who responded gave detailed information on their collaboration with a pharmaceutical firm. These data are used for the present study.[13]

The biotechnology industry in Germany started with a lag of about 15 years to the USA (Lehrer, 2000). The BioRegio contest in 1995 was a major catalyst in the development and growth of the German biotechnology industry. The German Federal Ministry of Education and Research launched this competition to encourage the commercialization of biotechnological research from universities and other academic research institutes. The number of biotechnology firms that were founded since the BioRegio contest is impressive; however, the industry is still in its infancy. The situation of the German biotechnology firms is well suited to the model by Aghion and Tirole (1994). The firms are relatively young and their technology/drug is often in an early development stage in which the effort of the young firm is crucial. The 30 analyzed partnerships are R&D collaborations. The firms are on average 5.4 years old. Partnerships with pharmaceutical firms were entered on average 2.5 years ago.

4.2. Variables

In the following, the variables used to address the research questions will be introduced. First, the control rights that are identified in German collaboration contracts and the construction of the variable will be presented. Then I introduce the additional variables. All measures were pre-tested in a series of personal interviews with managers of biotechnology firms.

4.2.1 Control rights in inter-firm collaboration contracts

The relevant control rights were identified by interviews with industry experts and an in-depth analysis of the literature on collaboration contracts between biotechnology and pharmaceutical firms. Fifteen important control rights can be identified and are included in the majority of deals.

Column (1) of table 1 lists these rights, column (2) shows the percentage with which these rights appear in the sample, and column (3) shows how often the right is assigned to the biotechnology firm. In each case, I coded the variable as 1 if the biotechnology firm owns this right, 0.5 if there was joint ownership and 0 if the pharmaceutical firm retains the right. The proportion of rights of the biotechnology firms is smaller than the proportion of the pharmaceutical firms. The rights can be classified in three groups: Ownership and technology rights, control rights concerning the collaboration (i.e., managing, expanding collaboration), and marketing rights (brand name, territories).

[Insert Table I about here]

In the following, I will shortly introduce the control rights. The first set of control rights displayed in table 1 addresses ownership and technology rights. The ownership of the relevant patents generated by the collaboration (**no. 1**) is being contested in deal making. Patenting activity in the biotechnology sector is extremely high. Patents are necessary to appropriate rents from innovations. Often patents are important for future developments or technology improvements. In the biotechnology and pharmaceutical sector, a strong patent position is a positive signal to other market actors (e.g., customers, financiers). In addition, the parties are eager to control the patent litigation process (**no. 2**) to defend and secure the patent. The right to publish (**no. 3**) addresses a trade-off between academic objectives and economic behavior. On the one hand, scientists are eager to promptly publish discoveries because they are evaluated by their publication track record. On the other hand, publishing early may endanger obtaining the patent right.[14] The owner of the right to control the production of the technology/drug (**no. 4**) can produce the technology/drug himself or choose an external producer. The right should be carefully allocated to a partner, because the European Medicines Evaluation Agency (EMEA) for the European Union and the Federal Drug Administration (FDA) for the US market give their approval only to a producer who is reviewed in the extensive approval process. Later changes are costly and time-consuming. Right **no. 5** allows its owner to further develop the technology/drug without restrictions after the collaboration is terminated. The core competencies of biotechnology firms are often based on a specific technology. The firm's success is at risk if the firm does not have the right to improve the technology or perform further development on it. The pharmaceutical firm's investment in the technology is jeopardized if the biotechnology firm has this right and brings an "upgrade" on the market. Similarly, right **no. 6** gives its owner the possibility to use the jointly developed technology after the collaboration is terminated.

The second set of rights covers the control of the collaboration. The right to manage the collaboration (**no. 7**) is assumed to have a strong impact on project success. The owner of this right leads and redi-

rects the collaboration, if necessary. Right **no. 8** applies to the clinical trials, which are the most expensive drug development phases.[15] The pharmaceutical firms often own this right, because they typically have a comparative advantage in this stage. Right **no. 9** allows the partner to interrupt or shelve the collaboration project. The partner firms are often working on several projects simultaneously. It may happen that a particular project needs specific attention, which may result in other projects being temporarily kept on hold. The following two rights relate to the scope of the collaboration. The right to enlarge the cooperation (**no. 10**) allows the possibility to work on additional projects within the partnership, i.e., a new drug or technology version or a new indication area. Similarly, right **no. 11** allows the prolongation of the collaboration.

The final set of control rights is related to marketing rights. A firm's brand publicity increases when it markets a technology/drug under its own name. Generally, both partners are eager to market under their brand (**no. 12**). Typically the pharmaceutical firms are better known than the younger biotechnology firms, which make the marketing of the technology/drug easier. In the prescription and over-the-counter market, a well-known brand name may continue to give some exclusiveness after generic products enter the market. Nevertheless, ambitious biotechnology firms want to establish their own brand to become a fully integrated biotechnology company and are therefore not willing to give this right up easily. The owner of right **no. 13** has an exclusive right to market the technology/drug worldwide. The profit from the technology/drug is in the hands of the marketing machinery of the pharmaceutical firm if it retains the right. If a novel technology/drug has potential applications in different sectors, it can be attractive for a firm to get the right to market in specific indications (**no. 14**). Right **no. 15** allows a firm to sub-license. In a global agreement it can be efficient if, e.g., the pharmaceutical firm is allowed to sub-license in markets where it has no direct presence.

In the literature, the nature of control rights in collaborations between biotechnology and pharmaceutical firms is a little-explored issue.[16] In this paper, I use two sets of control rights to construct the variable which are both used in the tests of the hypotheses. First, I create the number of control rights to the biotechnology firm out of the presented 15 rights (**"number out of 15 rights").** Second, the variable is calculated out of the five most important control rights ("**number out of the most important rights**"). In my interviews I asked the deal makers to indicate which rights are in the focus of negotiations. With this approach five rights are identified being of particular importance for the contracting parties. The following five rights are supposed to be the items of contention in deal making: the ownership of patents generated by the collaboration (no. 1), the right to control the production of the technology/drug (no. 4), the right to further develop the technology/drug without restrictions after the collaboration is terminated (no. 5), the right to manage the collaboration (no. 7), and the right to market universally (no. 13).

The construction of the dependent variable causes primarily two concerns.[17] First, I assume that all control rights are equally important, when I count the number of control rights out of the 15 rights. However, this is unlikely to hold in practice. As I already mentioned some rights are more important

for the parties than others and, in addition, the importance of rights might be dependent on the specific collaboration situation of the partners. To partly address this problem, I test the hypotheses using the number of rights that are assigned to the biotechnology firm out of the 5 most important control rights.[18] Second, some control rights might be assigned in a bundle and are therefore not independent of one another. The small number of observations makes it difficult to identify such rights. In the appendix, I include a table that shows how often two rights appear together in the agreements (table A.2).

4.2.2. Additional variables for analyzing the determinants of control rights

Critical effort:

The following two variables are included to measure the critical effort of the biotechnology firm:

- **Number of employees from the biotechnology firm on the project:** Interviews suggest, that the number of employees of the biotechnology firm who work on the collaboration project is proposed to be an indicator for the critical effort that is needed from the biotechnology firm. The more employees working on the collaboration project, the greater the impact the biotechnology firm has on project success.
- **Early stage:** The development stage of the relevant drug/technology at the time when the contract is signed is another source of information on the critical effort of the biotechnology firm. The core competencies of the young firm are primarily in the early stages of the drug/technology development process. I include a dummy variable that indicates whether the relevant product is in the early stage of the development process when the collaboration is entered. In the case of a product firm, early stage is defined as before the clinical phase. In the case of a technology firm, early stage is defined as the stage before the technology is tested/a prototype is developed. The variable "early stage" is coded 1 if the observation is related to an early stage project, 0 otherwise.

Bargaining power:

Although the literature and the expert interviews emphasize that the bargaining power is typically in the hands of the established pharmaceutical firm, I include two variables that are indicators for the bargaining position of the biotechnology firm.

- **Initiative from the pharmaceutical firm:** In general, the biotechnology firm is the one that initiates the collaboration with the pharmaceutical firm. However, with decreasing product pipelines and expiring patents, pharmaceutical firms show increasing interest in entering partnerships with promising biotechnology firms. I propose that when the pharmaceutical firm starts the initiative to collaborate, the bargaining situation of the technology firm is better than those cases in which the biotechnology firm undertakes the initiative. The variable "initiative

from pharmaceutical firm" is coded 1 if the pharmaceutical firm started the initiative to partner with the biotechnology firm, 0 otherwise.

- **Patent of biotech firm:** In the biotechnology industry patenting activity is high. The profit for the first mover who wins a patent race is often substantial (Deeds and Hill, 1996). Hence, the bargaining position of the biotechnology firm increases when the relevant technology/drug is patented or a patent is applied for. The variable "patent of biotech firm" is coded 1 if the biotechnology firm has received or applied for a patent for the relevant technology/product at the time the collaboration is signed, 0 otherwise.

Financial situation:

Two dummy variables are constructed to measure the amount of raised capital from external sources at the time the cooperation contract is signed. The variable "finance_500,000_1mio" is coded 1 if the biotechnology firm raised € 500,000 or more but less than € 1 million, 0 otherwise. The variable "finance_more1mio" is coded 1 if the biotechnology firm raised more than € 1 million, 0 otherwise. These critical amounts are chosen because seed financing is often up to € 500,000 and the first financing round is mostly more than € 1 million.

Control variable:

I added the variable "academic spin-off" as a control variable, which is expected to affect the allocation of control rights but is not included in the discussion of the hypotheses. I assume that biotechnology firms that are spin-offs of academic research institutions have a different organizational structure and negotiation behavior with external partners than non-academic startup firms. The variable "academic spin-off" is coded 1 if the observation relates to an academic spin off, 0 otherwise.

5. Empirical tests and results

5.1. Determinants of the allocation of control rights

5.1.1. Descriptive statistics

Table 2 shows summary statistics for the data used to shed light on the determinants of the allocation of control rights. I present two alternatives of the dependent variable. In the first alternative, the dependent variable is the number of control rights that is assigned to the biotechnology firm out of 15 rights. The average biotechnology firm owns only 3.6 rights. In the second alternative, only the five most important rights are considered. The average biotechnology firm holds 1.7 rights out of the five most important ones. I shortly comment on the independent variables. On average 5.8 employees of the biotechnology firm work on the collaboration project. 60% of the collaboration projects were in an early stage when the collaboration contract was signed. This is likely to reflect the early development

stage of the German biotechnology firms. In 33% of the cases, the pharmaceutical firm started the initiative to enter a partnership with the biotechnology firm. This shows that pharmaceutical firms are—even to a lesser degree than biotechnology firms—searching for collaborations to fill their technology/drug pipeline. The majority of 80% did at least apply for a patent for the relevant technology/drug before the collaboration contract was signed. This result points to the high importance of early patenting in this industry. Regarding financing, 20% of firms closed a new financing round within 9 months before the contract with the pharmaceutical firm is signed. Only 30% of the biotechnology firms raised less than € 500,000, 13% rose between € 500,000 and € 1 million, and 57% received more than € 1 million from external resources (e.g., venture capital, government-subsidized capital). The lion's share of firm in the sample (63%) is a spin-off from university or public research institution. This statistics show that research at public institutions pushes the biotechnology industry in Germany.

[Insert Table II about here]

In table 3, I provide an overall view of the bivariate relationships between the independent variables. Most of the correlation coefficients are below 0.25. However, a few relationships are stronger and deserve attention. The variable number of employees of the biotechnology firm on the project has a negative correlation with early stage projects. When the parties contract upon an early stage technology, less people from the biotechnology firms are involved in the further collaboration project. Additionally, a positive correlation of the number of employees on the project with the dummy variable "financing more than € 1 million" (ρ=0.45) and a negative correlation with the dummy variable "financing between € 500,000 and € 1 million" (ρ=-0.28) is detected. Presumably because firms that have a better financial position are larger and are able to assign more employees on a collaboration project.

[Insert Table III about here]

5.1.2. Results

In the following, I present the results of analyzing the determinants of control rights in biotechnology-pharmaceutical collaboration contracts. I use a robust ordinary least square regression.[19] The results of the regression are shown in table 4.[20] Column (1) introduces the independent variables. Column (2) and (3) report the results if the dependent variable considers all 15 control rights. Respectively column (4) and (5) contain the results if the five most important rights are considered. In column (3) and (5) the reduced models are reported. Here variables are excluded which are alone and jointly insignificant in the respective full model with all variables. A Wald test statistic is used to check for joint significance.[21]

[Insert table IV about here]

The results differ somewhat, depending on the alternative of the dependent variable that is used. However, in all models, the variable "number of employees of biotechnology firm on project" is robustly significantly positive at the 0.01 level. I use this variable as a proxy for the critical effort of the biotechnology firm in the inter-firm collaboration. Corresponding with the hypothesis, the more employees of the biotechnology firm are working on the project, the more control rights are allocated to the firm. The other proxy for the level of critical effort indicates whether the relevant technology is in an early stage. The results show that a biotechnology firm that collaborates on an early stage project with a pharmaceutical firm receives more control rights than if it collaborates on a later stage project. The argument is that an early stage project demands more critical effort from the biotechnology firm which leads to more control rights allocated to this firm compared to the case of a later stage project. However, significance of coefficients differs. The coefficient is significant on the 10% level if I calculate the number of control rights out of the five most important rights, but not significant if I calculate it out of the fifteen rights. According to Aghion and Tirole (1994) early stage projects are typically exposed to severe problems of contractual incompleteness. Therefore, more rights should be given to the biotechnology firm, which is the critical partner in these stages, in order to maximize output.

The dummy variables "initiative from pharmaceutical firm" and "patent of technology/product" are included to measure the bargaining power of the biotechnology firm. The impact of the "initiative from the pharmaceutical firm" is significantly positively related to the number of control rights. Thus, the biotechnology firm's bargaining position is enhanced and it receives more control rights if the pharmaceutical firm takes the first step to enter the partnership. The variable "patent of technology/product" is positively related to the number of control rights that are assigned to the biotechnology firm. However, the coefficients are only significant in the case of the five most important rights. Thus, if the biotechnology firm has not received patent protection for the relevant technology at the time the contract is signed, it retains less of the most important rights in the negotiation process.

I hypothesized that the financial position of the biotechnology firm affects the allocation of control rights. However, no significant effect can be reported. These results are somewhat at odds with those obtained in a study by Lerner and Merges (1998) who found a significantly positive relation between the financial position of the biotechnology firm and the number of control rights it retains, and by Lerner, Shane and Tsai (2003) who show that financing cycles affect the allocation of control rights. To further elaborate on this finding I also included a variable that measures whether the biotechnology closed a financing round the last 9 months prior to the pharmaceutical contract. The variable shows a relatively high but not significant correlation with the number of control rights associated (ρ=0.27 for all 15 rights resp. 0.25 for five most important rights). Additionally, the variable shows no significance if included in the regression model.

The control variable "academic spin-off" is negatively related to the number out of 15 control rights and positively to the five most important rights. Thus, spin-offs from academic institutions receive less

control rights but more important rights than other biotechnology firms. However, the coefficient is not significant.

Regarding the goodness-of-fit, the models in which the dependent variable is calculated by the number of control rights out of the five most important rights show the highest pseudo-R-squared. I explore the robustness of these results in several unreported regressions, e.g., different classification of the financing variable, adding variable on patent situation of the pharmaceutical firm regarding the collaboration technology, adding variable on biotechnology firm age. All of these changes have not worth mentioning influence on the results reported above.

Summing up, the results indicate that the allocation of control rights is significantly driven by the level of critical effort from the biotechnology firm[22] and by determinants regarding the relative bargaining position[23] of the firms. These results are consistent with the model of Aghion and Tirole (1994) that predicts that incentive issues and the bargaining position drive the allocation of control rights. However, contrary to Aghion and Tirole (1994), the results suggest that the financial situation of the biotechnology firm does not affect the distribution of control rights. Hence, with better financial resources, the biotechnology firms cannot "buy" more control rights. Interestingly, the impact of the independent variables depends on the way the dependent variable is constructed. The models in which the number of control rights considers only the five most important rights (column (4) and (5)) are the ones in which most coefficients show a significant influence. In this model all variables regarding critical effort and bargaining position have significant coefficients. Corresponding to the interviews, the results show that most hypotheses on contracting apply on the distribution of the five most important rights.

6 Conclusion and further research

This paper empirically identifies control rights and analyzes their allocation in inter-firm collaborations between biotechnology companies and pharmaceutical firms. The biotechnology setting is attractive for studying these research questions (1) because technology/drug development is a very risky and uncertain process, resulting in incomplete contracting problems and (2) because of the extraordinary importance of the success of partnering projects for the biotechnology firms' future. To my knowledge, this is the first study, which addresses the contractual structure by in-depth interviews as well as by using a unique survey dataset. The lack of studies might be explained by the obstacles faced to obtain the required confidential data on contractual information and information about the relationship between the partners.

This study identifies fifteen control rights to make up the structure of biotechnology-pharmaceutical deals with five rights being the items of contention in deal making (ownership of patents, production, further development of the technology, the right to manage the collaboration, and the right to market

universally). Regarding the distribution of control rights between partners, the Aghion and Tirole (1994)-framework suggests that incentive issues, the bargaining power of partners and the financial situation of the research unit drive the deal contract. Consistent with this framework, the overall results show that the critical impact of the biotechnology firm on the project and its bargaining position are related to the number of control rights the firm retains. Hence, even in asymmetrical partnerships between new ventures and incumbents, incentive issues induce the 'goliath' to subrogate critical rights. Interestingly, the impact of these determinants varies regarding the set of control rights considered. In the case of the five most important control rights, all included measures for incentive issues and bargaining power show significant coefficients. This indicates that the contracting parties carefully relate incentive and bargaining issues to the type of rights.

In contrast to my presumptions, I find no evidence that the distribution of control rights is affected by the financial situation of the biotechnology firm. A better financial situation does not enable the research firm to "buy" or retain more rights. These results are somewhat contradictory to the results of Lerner and Merges (1998) and Lerner et al. (2003), who found a relationship between financing situation and the number of control rights the research firm retains. The findings may be due to country-specific differences between the USA and Germany. Some interviewees also reported a change in negotiation behavior to more joint value maximization to provide the best starting point to a successful partnership as compared to single value maximization. An analysis that investigates country-based specifics and changes in inter-firm contracting over time would be a very promising field for future research.

While the overall results are encouraging, the current study has limitations providing avenues for future research. First, the empirical analysis is based on a small number of observations. There is room for improving these estimates with a more comprehensive database. A larger database would also allow examining the various types of R&D collaborations (e.g., how much effort and what kind of effort are demanded from the partners). Second, a more comprehensive dataset would allow elaborating on the complexity of deals. For example, how are the two drivers of contracting bargaining power and incentive issues related to each other? Which rights are of specific importance for the new venture and which for the pharmaceutical firm?

Tables

Table I

Allocation of control rights in the sample

	% included in contract	% assigned to biotechnology firm
I. Ownership and technology rights		
No. 1: Ownership of patents generated by the collaboration	86.7	38.5
No.2: Right to manage patent litigation	60.0	41.7
No.3: Right to publish	80.0	35.4
No.4: Right to control the production of the technology/product	86.7	36.5
No.5: Right to further develop technology after the collaboration is terminated without restriction	86.7	57.7
No. 6: Right to exclusively use technology after collaboration is terminated	83.3	46.0
II. Control rights concerning the collaboration		
No. 7: Right to manage collaboration	83.3	44.0
No. 8: Right to manage clinical tests	53.3	15.6
No. 9: Right to delay/shelve the collaboration project	60.0	36.1
No. 10: Right to enlarge collaboration	66.7	20.0
No. 11: Right to prolong collaboration	76.7	32.6

III. Marketing rights		
No. 12: Right to market under own brand	70.0	14.3
No. 13: Right to market universally	76.7	15.2
No. 14: Right to market in specific territories (indications)	73.3	20.5
No. 15: Right to sub-license	60.0	16.7

Table II

Descriptive statistics (n=30)

Variable	Mean	S.D.	Min.	Max.
Dependent variables				
Number out of all 15 rights allocated to biotechnology firm	3.63[24]	2.86	0	12..5
Number out of five most important rights	1.65[25]	1.20	0	4
Independent variables				
Number of employees of biotechnology firm on project	5.8	4.12	2	20
Early stage	0.6	-	0	1
Initiative from pharma firm	0.33	-	0	1
Patent of biotech firm	0.80	-	0	1
Finance_500,000_1mio	0.13	-	0	1
Finance_more1mio	0.57	-	0	1
Academic spin-off	0.63	-	0	1

Table III

Correlation matrix for the independent variables

	(1)	(2)	(3)	(4)	(6)	(7)
(1) Number of employees of biotech on project	1.00					
(2) Early stage	-0.26♦	1.00				
(3) Initiative from pharma firm	-0.05♦	0.14	1.00			
(4) Patent of biotech firm	-0.11♦	0.10	-0.18	1.00		
(5) Finance_500,000_1mio	-0.28♦	-0.08	0.14	-0.05	1.00	
(6) Finance_more1mio	0.45♦	-0.03	-0.10	0.07	-0.45	1.00
(7) Academic spin-off	0.17♦	-0.20	0.10	-0.21	0.10	0.03

Note: N=30. ♦ Point biserial coefficient, others: Cramers'V.

Table IV

Ordinary Least Square Regression

(1)	(2)	(3)	(4)	(5)
	Number out of 15 CR		**Number out of 5 CR**	
	Full model	Reduced model	Full model	Reduced model
Number of employees of biotech on project	0.379***	0.285***	0.186***	0.148***
	(0.086)	(0.084)	(0.044)	(0.031)
Early stage	1.122		0.560*	0.609*
	(0.836)		(0.330)	(0.353)
Initiative from pharma firm	3.082**	3.303***	1.054**	1.077**
	(1.121)	(1.037)	(0.425)	(0.432)
Patent of biotech firm	1.454		0.759**	0.654**
	(1.071)		(0.343)	(0.309)
Finance_500,000_1mio	0.403		0.094	
	(1.060)		(0.535)	
Finance_more1mio	-0.528		-0.627	
	(1.051)		(0.480)	
Academic spin off	-0.037		0.009	
	(0.819)		(0.352)	
Constant	0.218	0.877	-0.426	-0.498
	(1.213)	(0.701)	(0.511)	(0.329)
Observations	30	30	30	30
F-test	5.63(7,22)	7.89(2,27)	5.98(7,22)	11.19(4,25)
Pseudo R-squared	0.53	0.44	0.54	0.48

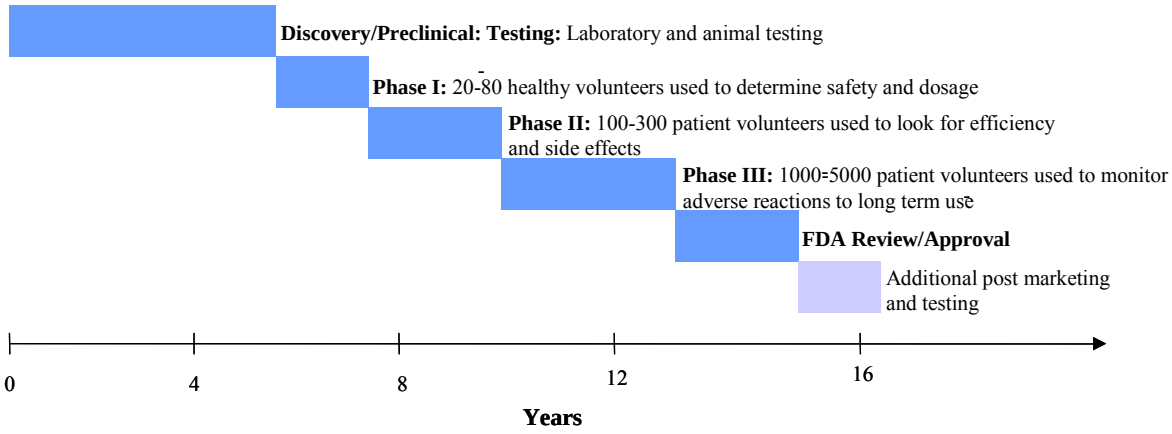
Robust standard errors in parentheses.

* significant at 10%; ** significant at 5%; *** significant at 1%

Appendix

A.1: Figure 1[26]

Drug development time and stages



A.2: Co-allocation patterns of control rights

If this control right is allocated to the pharmaceutical firm	…how often is that control right allocated to the pharmaceutical firm														
	a)	**b)**	**c)**	**d)**	**e)**	**f)**	**g)**	**h)**	**i)**	**j)**	**k)**	**l)**	**m)**	**n)**	**o)**
a) Right to produce technology	100%	79	91	85	79	97	97	85	67	79	73	85	79	97	61
b) Right to market in specific territories	68	100%	89	89	63	89	84	84	63	47	68	79	79	79	58
c) Right to market universally	71	81	100%	81	67	95	86	76	57	57	71	76	76	86	67
d) Right to market under own brand	74	89	89	100%	68	89	89	74	58	58	74	74	68	79	53
e) Right to sublicence	81	75	88	81	100%	100	94	75	56	56	63	69	63	88	69
f) Right to manage collaboration	70	74	87	78	70	100%	87	74	57	52	65	74	74	83	61
g) Ownership of patents	70	70	78	74	65	87	100%	78	61	52	57	65	70	83	57
h) Right to use technology after cooperation is terminated	70	80	80	70	60	85	90	100%	65	45	50	70	80	80	50
i) Right to further develop technology after termination without restrictions	73	80	80	73	60	87	93	87	100%	67	60	87	87	87	53
j) Right to manage patent litigation	93	64	86	79	64	86	86	64	71	100%	79	86	79	100	64
k) Right to delay/shelve project	67	72	83	78	56	83	72	56	50	61	100%	89	83	78	56
l) Right to enlarge collaboration	70	75	80	70	55	85	75	70	65	60	80	100%	95	85	60
m) Right to prolongate collaboration	62	71	76	67	48	81	76	76	62	52	71	90	100%	86	57
n) Right to publish	73	68	82	73	64	86	86	73	59	64	64	77	82	100%	64
o) Right to manage clinical tests	71	79	100	79	79	100	93	71	57	64	71	86	86	100	100%

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Notes

[1] In this paper an asymmetrical inter-firm collaboration is defined as a partnership between two partners that differ in size and experience. Several researchers emphasize the relationship between partner asymmetry and the unbalanced bargaining power of the partners (i.e., Kesteloot and Veugelers, 1997; Harrigan, 1988).

[2] For example, the German based firm Micromet AG had to realign operations and lay-off more than 1/3 of its full time employees after the R&D partnership with Novuspharma SpA was cancelled in February 2004 (Micromet AG – Press release of January 28, 2004).

[3] Several researchers emphasize the close relationship between equity ownership and control rights (see Pisano, 1989; Allen and Phillips, 2000). However, Grossman and Hart (1986) and Aghion and Tirole (1994) point out that residual income rights alone do not solve the incentive problem that results from incomplete contracting issues. Control rights on how assets are used must be considered. In this paper, the ownership of patents is treated as a control right. The right does not only allow capitalizing on the patented technology but includes the right to make decisions on usage.

[4] See also Hayek (1945, 524) who argues that "decision must be left to the people who are familiar with these circumstances". He emphasizes that markets assign the decision rights to the party with the relevant knowledge.

[5] In addition to the models by Grossman and Hart (1986) and Hart and Moore (1988), in their model Aghion and Tirole (1994) suggest that the distribution of bargaining power between the partners is assumed to be another important determinant for the contractual structure.

[6] Aghion and Tirole (1994) show that in the case of a cash constraint research unit it is optimal when the research unit finds a co-investor (venture capitalist or bank) to compensate the financing firm for getting more control rights.

[7] Another strand of studies is drawing on financial contracting literature. Building on the model of Aghion and Bolton (1992) and Dewatripont and Tirole (1994), these studies explore the allocation of control rights between entrepreneurs and investors (e.g., Gertner et al., 1994; Berglöf, 1994; Dessein, 2005).

[8] In general, the value chain to develop a drug can be split in two phases: the drug discovery and the drug development stage. These phases demand quite different firm capabilities and resources. Whereas drug discovery can be characterized as a diffuse process to identify new promising drug candidates, the drug development stage proceeds in a strictly regulated mode to navigate the drug through the clinical stages, through approval to the market (Henderson and Cockburn, 1996). In the appendix A.1 I include a figure that shows the stages of the drug development process.

[9] The average cost to develop a new drug grew from $138 million in 1975 to $802 million in 2000 (PhRMA, 2003; DiMasi et al., 2003).

[10] A detailed descriptive analysis of the survey and the data can be found on the author's web site.

[11] Lerner and Merges (1998) and Lerner et al. (2003) analyzed the allocation of control rights on the basis of SEC filings and the Recombinant Capital database. This approach was not possible, because the contracts be-

tween biotechnology firms and pharmaceutical firms in Germany are mostly held strictly confidential. In several cases the firms are contractually not allowed to give information to third parties. The only possibility to assess the terms of the contracts is by an anonymous survey. Additionally, the selected approach allows exploring relationship specific behavior patterns.

[12] Lead investor was in most cases a venture capital firm. There are certain requirements for receiving funding by the tbg, e.g., the number of employees must be below 50, the firm must have less than € 5 million on its balance sheet. For further information see http://www.kfw-mittelstandsbank.de/mportal/tbg/Finanzierung/Finanzierung.jsp.

[13] Twenty-two of the 30 questionnaires were filled out online, thus, provided through VC on target. I checked for differences between the questionnaires provided by VC on target and self collected questionnaires. I employed a probit model and found that whether a questionnaire is provided by VC on target or not is not depending on the control rights allocated to the firm (coefficient = -0.214; standard error = 0.210) and the perceived success of the collaboration (coefficient = 0.007; standard error = 0.009). Hence, the results suggest no indication for systemic differences between questionnaires provided through VC on target and self collected questionnaires.

[14] Patents in Europe are granted based on "first to file" instead of "first to invent" as in the USA.

[15] In these stages the firm starts with human trials if it received an IND certificate for the USA or the European equivalent (CTX in the UK).

[16] Exceptions are the articles of Lerner and Merges (1998) and Lerner et al. (2003).

[17] See Lerner and Merges (1998) for a detailed description of this approach.

[18] Industry experts and dealmakers emphasize that the overall allocation of control rights is important and not the analysis of single control rights. No single control right stands out as so critical that a consideration of the other control rights would be obsolete.

[19] At this point I want to note that there might be concerns regarding the continuous character of the dependent variable. To take a possible ordinal character of the dependent variables into account I also performed ordered probit models. The results are very similar. The signs of the coefficients are in the same direction as well as the level of significance of all coefficients with the exception of "early stage" which shows significance at the 5% level when the five most important control rights are regarded as dependent variable. I did not report them in this paper since ordered probit model is based on Maximum Likelihood estimation which is sensitive to the number of observations, hence, difficult to apply with small sample size. The results of the oprobit model can be obtained from the author upon request.

[20] The paper is limited by its small sample size. See Goldberger (1991) for a discussion on the problem of "micronumerosity" and multicollinearity.

[21] Result of the Wald-test to check for joint insignificance of insignificant variables regarding column (2): $F(5,22)=0.88$; $Prob>F=0.51$; column (4): $F(5,22)=0.99$; $Prob>F=0.42$.

[22] The critical effort of the biotechnology firm is indicated by the number of biotechnology firm employees on the project and whether the collaboration project is in an early stage.

[23] The bargaining position is indicated by the firm that initiates the partnership and the patent position of the biotechnology firm regarding the specific technology/substance.

[24] Median = 3 rights. Skewed distribution.

[25] Median = 1.5 rights.

[26] Following PhRMA (2003, 3).