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CONTRACTUAL COMPLEXITY OF R&D ALLIANCES –

A two-dimensional analysis of the determinants of contractual complexity

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Abstract

We present a novel perspective on the analysis of contract design, inspired by an extended transaction costs economics perspective and some recent contributions from the legal literature that use a broader more cognitive construct of contractual complexity. In contrast to previous studies on contractual complexity that only use objective measures, we argue that the degree to which a contract imposes a cognitive load upon contract parties should be taken as an important second, subjective dimension of contractual complexity. We develop a conceptual model of complexity that incorporates both dimensions of contractual complexity through which we investigate to what extent firm characteristics, transactional characteristics and the organizational routines of firms affect contractual complexity. For our empirical analysis we use a sample of nearly 300 R&D alliance contracts in the biopharmaceutical industry. We find that the two dimensions of complexity point at both overlapping and different aspects of the complexity of contracts.

(150 words)

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INTRODUCTION

In recent decades inter-firm collaborative agreements have gained increasing importance in the international economy and they have become the most common inter-organizational form through which firms engage in joint research and development (R&D) (Hagedoorn, 2002; Faems, Janssens, Madhok & Van Looy, 2008). The current understanding of these contractual collaborations does not seem to mirror the expanding role these arrangements play in the business landscape. For instance, little is known about the role of alliance contracts and the precise contract structure and design (see recently e.g. Robinson & Stuart, 2007; Mayer & Teece, 2008; Argyres, Bercovitz & Mayer, 2007). This lack of understanding might be caused in part by the fact that contracts have long been regarded as rather simple, low-dimensional constructs. Contracts, however, are not only a collection of promises as classical contract theory asserts, but they also refer to governance structures that regulate relationships over time (Furlotti, 2007). The degree of diversity in contractual arrangements is large and recently scholars have begun to determine this heterogeneity in reference to various degrees of contractual complexity.

This brings us to the point of why some contracts are relatively complex or simple. In drafting contracts, parties must constantly be aware of the specific characteristics of the transaction and the environment in which the transaction takes place in order to justify the relative complexity of a contract. Complexity triggers us to think about contract design. In understanding the complexity of contracts we gain insight in the costs that companies face in terms of designing, writing, implementing, controlling, and enforcing contracts that govern the relationship with their contractual partners (see e.g. Macleod, 2002).

Contractual complexity can show distrust and overwhelm the cognitive abilities of parties, absorb resources, and have other negative consequences[1]. Cognitive limitations stemming from bounded rationality will have *ex post* design implications: individuals drafting contracts must acknowledge that the ability of lawyers and laymen to comprehend contracts and to understand the interdependencies of various elements of contracts is limited. The incidence of mistakes increases with the length of contracts, the interrelatedness of provisions, and the complex language of the latter. Unfortunately, mistakes are usually caught only when a party attempts to determine his/her rights under the contract, at which point things usually are not going well.

Contractual complexity should also be of concern to courts and other adjudicators. The study of contracts will allow courts to develop a deeper understanding of contracting practices and processes and the analysis of contracting practices provides useful information at the level of enforcement. We may ask ourselves whether the variety in contract design should give rise to a differentiated enforcement of contracts. If the complexity of contracts is positively related to a misunderstanding of contracts and contract terms, complexity may increase the potential for contractual disputes. In that case, contractual complexity can be seen as a major cause of litigation.

In addition, a greater understanding of the complexity of contracts substantiates the debate on the proper content and role of contract law. As contract law is largely non-mandatory, firms contract in the realm of the freedom of contract and often develop rules tailored to their particular relationship. Subsequently, contract terms vary depending on parties' characteristics and goals, their shared understanding, transaction costs, the characteristics of the transaction, and the legal regime to which a contract applies.

Information regarding contract design is also food for thought for practitioners. Commercial contracts evolve over time in response to a complex and shifting set of economic and social influences (Buchheit, 2008). Clauses may be added, modified or dropped, and some clauses may loose their significance in a changing context. Adding clauses may come at a cost and we must ask ourselves whether more detail is always good (Eggleston, Posner & Zeckhauser (2001).

Drawing on Parkhe (1993), several authors model contractual complexity by counting a certain number of pre-defined clauses and enforcement mechanisms in a contract and rank them according to their stringency or their extensiveness (Reuer and Ariño, 2004 and 2007; Reuer et al., 2006; Barthelemy & Quelin, 2006; Anderson & Dekker, 2005; Ryall & Sampson, 2006, 2007). Other authors use the number of pages or words, or the amount of kilobytes of information in contracts to measure complexity (see e.g. Gillian, Hartzell & Parrino, 2007; Joskow, 1988; Poppo & Zenger, 2002; Robinson & Stuart, 2007; Solis-Rodriguez & Gonzalez-Diaz, 2008). Following a very different approach, Eggleston et al (2001) propose a broader construct of contractual complexity which includes the cognitive load necessary to understand a contract. This cognitive load indicates the effort and mental activity regarding a person's ability to process information. In the context of contracts, cognitive load refers to the extent to which parties are able to understand this contract, i.e. higher or lower levels of cognitive load imply that a contract is more or less complex and more difficult or easier to understand. As discussed by Eggleston et al (2001), an understanding of the role of cognitive load as the information processing capacity and information processing efforts of contract parties informs our perception of the actual complexity of contracts. Based on these suggestions, the perception of the complexity of R&D alliance contracts in our empirical analysis will focus on two dimensions: complexity in terms of the length of contracts and complexity as the level of the cognitive load of contracts.

Interestingly, despite the increasing attention for the role of complexity in inter-firm contracts, certainly in terms of theory development, the extant literature does not offer, as indicated by Masten & Saussier (2002:282), a "... unifying structure for the specification and testing of contract design hypotheses." Although we also face this absence of a unifying theory in the current paper, we think it is possible to present some preliminary steps in theory development through the introduction of an extended transactions cost economics perspective. For this theoretical perspective we combine building blocks from transactions cost economics (Williamson, 1996) that focus on the role of information asymmetry, asset specificity, and the strategic importance of transactions in the context of alternative modes of organization with elements of the dynamics capabilities approach (Teece, Pisano & Shuen,1997). The latter approach stresses both the importance of understanding the role of firms' innovative capabilities for their strategic positioning as well as the strategic importance of the legal protection of these capabilities. In addition, we will build on the evolutionary theory of the firm (Nelson & Winter, 1982) that combines elements of the other two approaches with an emphasis on an organizational routines perspective that highlights the effect that experience and learning have on the strategic and organizational choices of firms.

In order to close the gap between these general theoretical perspectives and the understanding of the determinants of the contractual complexity of inter-firm alliances, we will also draw on a range of related empirical and theoretical contributions from various disciplinary literatures such as industrial organization, finance, strategic management, law and economics, and legal theory. Our extended transaction cost economics perspective, in combination with insights from an eclectic body of contract-centered literatures, will focus on three levels of conditions that impact contractual complexity: firm characteristics, transaction characteristics, and the organizational routines of firms.

In the empirical analysis that we present, we study nearly 300 R&D alliance contracts in the US biopharmaceutical sector. These alliances were set up during the period 1996-2005 by 271 firms. Nearly 60% of these R&D alliances are established between US firms, the other 40% refers to combinations of a US firm and a foreign partner.

HYPOTHESES

An extended transaction cost economics perspective stresses the importance of understanding information asymmetries between alliance partners that create incentives for opportunistic behavior and as such this has certain implications for the degree to which inter-firm alliances are organized and framed in a particular contractual setting. Standard transaction cost economics (Williamson, 1996) explains that with increasing interdependence of firms in combination with information asymmetries, alliance partners, i.e. contract parties, are inclined to contractually specify a range of safeguards, dispute resolutions, and responsibilities that increase the complexity of contracts. From a more extended transaction cost economics perspective, alliances and their contracts are also to be seen in the context of the possibly asymmetric dynamic, innovative capabilities of firms as differences in these dynamic capabilities impact the organizational preferences of firms (Teece et al, 1997; Winter, 2003) and their choice with respect to the design of alliance contracts (Pisano, Russo & Teece, 1988).

Although the dynamic capabilities perspective stresses the role of the differences in endogenous firm capabilities, it also seems to accept the focus of transaction cost economics on inter-firm transactions through the role of the strategic importance of an alliance and its asset specificity as important building blocks of an analysis of alliances (Pisano, Shan & Teece, 1988). In a similar vein, although probably most prevalent in the evolutionary theory of the firm (Nelson and Winter, 1982), all three theoretical perspectives stress the importance of understanding the history of firms and their acquired organizational routines in their impact on the preferences for both particular forms of organization, such as alliances, and their contractual setting.

Based on our understanding of these general theoretical perspectives and a range of more specific contributions, that will be discussed in greater detail below, we will position a set of hypotheses at three distinct analytical levels at which the conditions that impact contractual complexity can be analyzed. At the level of firm characteristics that impact the complexity of inter-firm R&D alliance contracts, the literature suggests two important aspects of inter-firm asymmetry related to the difference between partners in terms of their R&D capability[2] and their information asymmetry. Given the two-party setting of R&D alliance contracts, the asymmetry between partners is more relevant for understanding how firms design their contracts than the absolute level of their R&D capabilities and their technological information. These firm characteristics in terms of R&D capabilities and technological information are expected to be only relevant in a comparative setting vis-à-vis the capabilities and information of a firm’s partner. At the level of the transactions to which an inter-firm contract refers, we will distinguish between the strategic importance and the asset specificity of the alliance activity. Finally, the level of organizational routines differentiates between the more general experience of firms with alliances and their partner-specific experience. In other words, the following hypotheses are formulated in the context of the attributes of the parties involved in an R&D alliance contract, the nature of the actual transaction governed by a contract, and the experience that parties have with these R&D alliance contracts.

Level of firm characteristics

<u>R&D capability asymmetry</u>

We expect the asymmetry in R&D capabilities of alliance partners, as an expression of their dynamic capabilities asymmetry in an R&D intensive environment (Winter, 2003), to have an impact on the degree to which firms prefer more or less complex contracts. It is important to stress that we refer to R&D capability asymmetries from a quantitative and not from a qualitative perspective. From a qualitative perspective, firms are expected to prefer collaborating with other firms that also have well developed R&D capabilities as this increases the probability of the success of their alliance. In general terms, this suggests that cooperating with firms with similar R&D qualities is to be preferred to working with firms with less developed R&D capabilities that 'bring little to the table' that can be used in the actual R&D cooperation. As stated by Baum et al (2000), cooperating with skilled innovators increases the probability for a firm to improve its technological performance and to learn new routines. In other words, in terms of the quality of the R&D capabilities of cooperating firms, we expect that both firms search for symmetric R&D capabilities inputs into the alliance.

However, from a quantitative perspective, firms with a smaller set of R&D capabilities base are expected to search for partners that offer a broader set of R&D capabilities that generate interesting additional perspectives for technological learning. For instance, Silverman and Baum (2002) established that the survival rates of new specialized biotech firms increased the more they collaborated with firms with a broader set of technological capabilities. Stuart (2000) found that firms that create alliances with partners rich in diverse and well-established technological capabilities turn out to become more innovative than firms that lack partners with this broad technological base. This suggest that for a firm with a smaller R&D capabilities base, partnering with a firm that possesses a broader, asymmetric, set of R&D capabilities might generate additional benefits in terms of learning about new technologies, through knowledge leakage, that goes beyond the breadth of its existing R&D capabilities.

Obviously, in an R&D alliance there is always a risk of unintended knowledge leakage in the R&D interaction between partners. However, when a firm has a wider range of R&D capabilities than its partner, there is a higher risk of knowledge leakage as a by-product of the R&D alliance that goes beyond what is intended in the primary objective of the alliance. Hill (1992) refers to this unintended knowledge leakage from the company with more R&D capabilities to its partner as the risk of second-order diffusion of technological know-how.

This second-order diffusion of know-how may enable the partner to acquire knowledge and improve its future R&D capabilities outside the knowledge range of the alliance. Given the appropriability hazards that a firm with more extended R&D capabilities faces, we expect that the less equal the quantity of R&D capabilities that both partners bring to the alliance, the more the partner that faces the risk of technology leakage from its broader R&D base is inclined to increase the complexity of the alliance contract through additional safeguards, monitoring clauses, control rights, and intellectual property rights.[3] Hence, we expect that:

H1: The larger the asymmetry between partners, in terms of their R&D capabilities, the more complex the contract of their R&D alliance.

Information asymmetry

Information asymmetry in the context of inter-firm alliances refers to the situation where one party to an alliance has more or better information, relevant to the alliance, than the other party. This information asymmetry can potentially create hold up problems when one party lacks the necessary information to monitor the tasks that are to be undertaken in a particular alliance. See for instance, Barnhizer (2005) who discusses a party’s access to information as an important source of bargaining power.

When firms that engage in an R&D alliance differ in the extent to which they possess information on the specific R&D tasks that have to be performed, the party that faces the potential risk of moral hazard has an incentive to put a range of clauses, control rights, safeguards and enforcement mechanisms in a contract turning this contract more complex. Lerner & Malmendier (2005) find that in R&D alliances where one party is largely responsible for the R&D financed by its partner, both parties have, depending on their position, an incentive to add a variety of different clauses such as termination rights, intellectual property rights, and elements of option contracts. This implies that when the partners in an R&D alliance have very different roles, e.g where one firm is largely responsible for the actual R&D and the other firm is responsible for financing this R&D, possibly in combination with complementary assets such as testing, production, etc., there is a built-in element of information asymmetry in the alliance. When firms engage in these information asymmetry-based R&D alliances, we expect that one or both partners have an incentive to increase the complexity of the alliance contract. Hence:

H2: The higher the degree of information asymmetry between partners, the more complex the contract of their R&D alliance.

Level of transactions

Strategic importance of R&D alliance

When an alliance is of strategic importance to one or both partners, e.g. because alliance activities come close to the core capabilities of one or both firms, theory related to an extended transaction cost economics perspective indicates that there is greater risk of opportunistic behavior of partners (Pisano et al, 1988). In that context, a range of safeguards from equity participation to contracts with monitoring clauses, control rights, and intellectual property rights, are warranted (Williamson, 1996). Vincent-Jones (1989) states that detailed contracts tend to be specifically negotiated wherever particularly complex and costly transactions are involved. These detailed and carefully written contracts specify the primary obligations of parties, the effect of certain contingencies, defective performance, and the possibility of legal sanctions. As a consequence, the strategic importance of an alliance has an effect on the degree to which firms are expected to draft extensive, complex alliance contracts (Ariño & Reuer, 2004; Reuer et al 2006).

Reuer et al (2006) indeed find that contractual complexity is positively associated with the strategic importance of an alliance. Related to the strategic importance of an alliance, Robinson & Stuart (2007) establish that the size of upfront payment, equity stake and the investments in the alliance are highly correlated with contract length: contracts are longer when the investments and the strategic importance of the alliance increase. Anderson & Dekker (2005) and Argyres et al (2007) find a positive relationship between the value of the transaction organized through an alliance and the detail of task descriptions in the alliance contract and the complexity and extensiveness of this contract. Hence:

> *H3: The higher the strategic importance of the R&D alliance to partners, the more complex the contract of their R&D alliance.*

Asset specificity of R&D alliance

Prior research that focused in particular on buyer-seller relationships found that asset specificity is an important transactional attribute that affects contract design (e.g. Joskow, 1988). This asset specificity refers to the degree to which investments create specialized transaction-specific assets that are not easily re-deployable and hence unique to a specific task. Higher asset specificity describes the extent to which a party, through these specific investments, is tied into an inter-firm relationship such as an R&D alliance. Although originally placed within a unilateral setting, where one party faces the risk of hold-up created by its partner (e.g. Williamson, 1983), the consequences of asset specificity in terms of hold-up can also be bi-lateral as both parties might have made specific investments and/or face exit and switching costs (see Joskow, 1988; Klein, 1988). For inter-firm alliances this implies that if asset specificity is high, there is a higher chance of holdup and thus parties are expected to negotiate more complex contracts which cover consequences of breach and termination as well as the legal processes through which such threats are handled (Dyer, 1997; Poppo & Zenger, 2002; Ariño & Reuer, 2007).

Reuer and Ariño (2004) suggest that when the investment in the specific assets for an alliance is high, it pays off to incur the costs of drafting complex contracts (see also Argyres & Mayer 2007). Reuer & Ariño (2007) find support for this hypothesis as their research indicates that contractual complexity is positively related to asset specificity. More specifically, they notice that the greater the transaction specific investment, the greater the number of contractual provisions and the more extensive the stringency of provisions built into an alliance contract. Poppo & Zenger (2002) and Anderson & Dekker (2005) find that increases in exchange hazards characterized by higher asset specificity, encourage more complex contracts. We expect that this role of asset specificity is also relevant in the context of R&D alliances, where the asset specificity of R&D alliance investments has specific consequences for the complexity of contracts. Hence:

H4: The higher the asset specificity of the R&D alliance activity for partners, the more complex the contract of their R&D alliance.

Level of organizational routines

General experience with R&D alliances

Extending the more general perspective of firm experience and routines (Nelson & Winter, 1982), there is a well-established body of alliance literature which indicates that the experience of firms with setting up alliances through a variety of partners has a positive impact on their capabilities to organize and manage future alliances (see Anand & Khanna, 2000; Lyles, 1988; Ring & Van de Ven, 1992; Sampson, 2005). This experience with both previous alliances and a variety of partners is expected to increase the organizational learning of firms which not only affects the actual management of newly established alliances but, as a major element in the institutionalization of setting up alliances, it can also affect the design of alliance contracts. We expect that firms that have little or no experience in setting up alliances will be inclined ‘to play it safe’ and to increase the complexity of their initial alliance contracts through a wide range of clauses that create safeguards, monitoring options, control rights, and intellectual property rights. From an organizational learning perspective, restricted contract design capabilities of firms with little alliance experience, that are still at an early phase of the learning-to-contract-curve, are expected to lead to more complex contracts than the contracts of more experienced firms that have gradually learned to set up less complex contracts that focus on an efficient contract design.

From a legal perspective, Collins (1996) mentions that market conventions may supplement the ‘contractual discrete communication system’ between contract parties. Contractual relations are understood to be embedded in existing market conventions and the familiarity of contract parties with these conventions increases with the transaction frequency. This implies that for experienced contract parties the conventions of the market may be sufficiently replete to dispense with the discussion of all but most central themes of contracts (see also Beale & Dugdale, 1975).

The routinized efficiency of contract design is also relevant from a transaction cost economics perspective which stresses that, although firms, due to their bounded rationality, are not able to design complete contracts, they can learn to customize their contractual relationships and improve on the efficiency of their otherwise incomplete contracts by experience (Williamson, 1996). Given the transaction costs of designing, monitoring and controlling complex contracts and the competitive pressures to minimize these costs, there is an incentive for firms to minimize the transaction costs of contract design and contract control. From a transaction cost economics perspective, experience with previous alliances might help firms to design more efficient and, ceteris paribus, less complex contracts. For firms with little or no experience, this implies that due their inexperience we can expect that their alliance contracts will be more complex that those of experienced firms. Hence:

H5: The smaller the alliance experience of parties, the more complex the contract of their R&D alliance.

<u>Partner-specific experience with R&D alliances</u>

Apart from the effect of the general experience that firms have with setting up alliances, we can also expect that the specific experience that firms have with one particular partner, through their prior ties, will affect the complexity of their alliance contract with that partner. Contributions by amongst others Gulati (1995), Nooteboom, Berger & Noorderhaven (1997) and Saxton (1997) indicate that previous collaborations between partners will have an effect on their relational trust. As this relational trust between partners develops further, there is a declining need for elaborate contracts with a range of monitoring and control options. Gulati's (1995) findings show that there is a decreasing likelihood that firms with prior ties set up elaborate equity-based alliances with extensive contracting as they replace these alliances by less complex contractual arrangements. In other words, as relational trust between firms develops through repeated interaction, there is less need for extensive contracting as this relational trust creates a certain degree of social control amongst partners that replaces contract-based monitoring and control.

These findings are also supported by legal scholars such as Collins (1996) who state that the inference of trustworthiness (expectations of trustworthy behavior) may be drawn from past dealings and previous transactions with a particular partner that proved satisfactory. One of the effects of this trustworthiness is that it reduces the need to specify in detail the precise content of the deal or to engage in close monitoring of the performance. Somewhat similarly, Parkhe (1993) demonstrates that prior alliances between firms will lower their expectations regarding the potentially opportunistic behavior of these partners in future alliances and as partners are inclined to look for fewer contractual safeguards their future alliances will be characterized by less complex contracts. See also Ciccotello & Hornyak (2000) and Hansen & Higgins (2007) who find that prior ties lead to fewer contractual safeguards and less complex contracts.

A slightly different line of argument was introduced by Zollo, Reuer & Singh (2002) who state that that prior ties facilitate the development of inter-firm administrative routines shared by alliance partners through which both firms develop a mutual understanding of their decision making style, their administrative routines, and their management systems. Given this knowledge about their partner, there is less need for detailed, complex contracts that attempt to provide for a range of monitoring and control mechanisms. On the other hand, if firms have no or very few prior ties and less knowledge about their partners or if relational trust has not yet developed, we expect that firms will favor more extensive contracts with their unfamiliar alliance partners. Hence:

H6: The fewer prior ties between alliance partners, the more complex the contract of their R&D alliance.

DATA, METHODS, AND SAMPLE DESCRIPTION

Contractual alliances occur frequently across a broad range of industries, however, they tend to cluster in risky, high-tech R&D settings (Hagedoorn, 2002). Drug development is a highly uncertain and expensive endeavor and it is not surprising that alliances are frequently used to organize R&D (Robinson & Stuart, 2007). Since the inception of the biotechnology industry in the mid 1970s, pharmaceuticals and biotechnology firms have partnered to form alliances. These collaborations allow pharmaceutical firms to gain access to the latest technological and scientific advances in biotechnology and to combine complementary resources in order to cope with the dynamics of innovation in drug discovery research (Hansen, 2001; Powell et al, 1996). Hagedoorn (2002) illustrates that especially in the biotechnology industry, collaborative activity has continued to grow steadily. Newly initiated R&D alliances involving pharmaceutical and biotechnology firms grew from a couple of dozens during the mid 1980s to several hundreds in 2000 (Hansen, 2001).

The pharmaceutical development process often begins with the identification and validation of ‘drug targets’, enzymes or receptors that trigger or block biochemical processes within a cell. These targets are screened against thousands of molecules with the aim of finding compounds that affect disease processes. When such ‘lead’ compounds are identified, they pass through several stages of testing and approval. The discovery/pre-clinical stage concerns laboratory/animal tests to control for toxicity and precedes the clearance request with for instance the US Food and Drug Administration (FDA) for human testing (see also Hausler, 2007). The pre-clinical stage is followed by three phases in which humans are used as test subjects. Phase I involves testing the compound on a small number of volunteers for dosage and toxicity. Phase II concerns a larger number of patients on which the drug is tested for efficacy/side effects. Finally, Phase III trials entail a controlled experimental design which tests for long-term adverse effects using a large group of human subjects. Phase III is followed by FDA review and possibly approval. Once approval is granted, additional tests may follow. The time path from the discovery stage to the marketing of a drug generally spans 10-15 years. Data suggest that for every 5,000 to 10,000 identified compounds, only 250 reach the pre-clinical testing stage (DiMasi, Hansen, Grabowski & Lasagna, 1991). DiMasi, Hansen & Grabowski (2003) find that only about 20% of the drugs that begin Phase I trials will finally be granted approval by the FDA. Even then, securing FDA approval does not guarantee success (Robinson & Stuart, 2007).

The organizational and contractual structure of the alliances among pharmaceutical firms and between pharmaceutical and biotechnology firms ranges from licensing agreements to more complex research agreements, including technology transfers, joint research and co-development agreements and minority equity investments (Hansen 2001). As of 1995, Pharmaventures, a UK-based information and consulting firm, has identified thousands of these various alliances in the healthcare and biotech sector in their PharmaDeals database. The collected deals are grouped into ten categories: licensing, technology access, collaborative R&D, rights, distribution/marketing, manufacturing/supply, business acquisition, funding, co-development, and marketing. For each agreement, the PharmaDeals database provides information on the names of the partners, type of contractual relationship, summary deal terms, upfront payment, product types, total deal value, territories, date deal signed, effective and expired, equity investment, milestone value and royalty value, relevant product areas and the technology field, press releases and where available actual contracts. These actual contracts were obtained from the U.S. Securities and Exchange Commission (SEC) filings and Pharmaventures' clients. Publicly traded firms are required by the SEC to file material documents. Firms tend to interpret this requirement conservatively and often file contracts specifying alliances as amendments to 10-K, 10-Q, S-1 or 8-K statements.[4] In addition, a number of state governments in the USA require privately held firms with employee stock options to file material documents, which are then made available to the public.

Our dataset covers R&D alliance contracts and additional information for the period 1996 through 2005. We collected information on alliances where the main focus is on R&D and for which PharmaDeals includes an actual legal document (contract). The sample of contracts falls within one of either two categories identified by the PharmaDeals database: co-development or collaborative R&D. Co-development is defined as "… two (or more) firms working together with the aim of developing a clinical-stage compound (…). Collaborative R&D is as co-development but used for preclinical or earlier stage research …" (PharmaDeals). Using this sample we are able to generate a set of contracts in a homogeneous contracting space, which facilitates the comparison of key contract features across alliances. In this manner, we can be assured that variation in contracting terms does not come from variation in the underlying industrial contracting environment, but instead from different solutions to a common contracting problem, which in turn may reflect underlying differences in firm and transaction characteristics. The preliminary sample comprised 587 deals for the period 1996-2005. We excluded all the agreements where:

- one of the parties is a government agency or university
- the alliance is a renegotiation or restatement of a previous alliance between the two firms
- there is no R&D component to the alliance
- one firm has a controlling interest in the other firm (greater than 50%)
- contracts involve more than two parties.

The final contract database contains a set of 309 contracts which was reduced to 291 contracts due to missing values. These contracts represent the first interaction between the firms as filed with the SEC within the period 1996-2005.

The agreements include both US (domestic) contracts, i.e. the contracting parties are both US-based firms (173 alliances), and international contracts, i.e. a US-based firm collaborates with a non-US based firm (118 alliances). A total of 271 firms were involved in the 291 contracts and roughly two thirds of the agreements were concluded between an established pharmaceutical firm and a start-up or emerging firm.

We collected additional information on for instance size, R&D, alliance experience, and prior ties between partners for the firms participating in these 291 deals. Our complete dataset combines information from PharmaDeals with data retrieved from firm annual reports, the MERIT Cooperative Agreements and Technology Indicators (CATI) database, Datastream, Compustat, and Corptech.

Dependent variable

Contractual complexity. In prior studies, contractual complexity has been measured using objective constructs such as the number of pages, words or kilobytes of the contractual document (Gillian et al, 2007; Joskow, 1988; Poppo & Zenger. 2002; Robinson & Stuart, 2007; Solis-Rodriguez & Gonzalez-Diaz, 2008). In their reflection on the assessment of contractual complexity, Eggleston et al (2001) propose a broader construct for contractual complexity that also includes the degree to which a contract imposes a cognitive load upon contract parties. This cognitive load refers to the extent to which people are able to understand this contract, i.e. a significant cognitive load implies that a contract is more complex and more difficult to understand (Eggleston et al., 2000). The basic idea behind this particular understanding of the role of the cognitive load of contracts is that increasing the incorporation of expected contingencies will raise the cognitive load of contracts. Also, calculating relevant payoffs for contingencies which might arise, demands an amount of mental effort needed to understand the intricacies of contracts. In addition, the way in which contract terms are formulated will influence the cognitive load and thereby the level of complexity of contracts. In that context, it is important to note that, as argued by amongst others Smith (2006), there is not necessarily a linear relationship between the length of contracts and the degree to which contracts impose cognitive difficulties.

As suggested by amongst others Brünken et al. (2003) and Corbalan et al. (2006), we take time-on-task, the time that it takes to read a contract, as a meaningful indicator of cognitive load as this reflects the difficulty or ease of a task. Time-on-task typically increases with the complexity of a task, in this case understanding a contract, and a high time-on-task points towards a high cognitive load of a contract. In a related theoretical setting, Rasmussen (2001) models the complexity of contracts in terms of the reading costs for contracting parties.

Following the above, we measure the complexity of a contract through the length of the contract in terms of the number of words[5] and its cognitive load, i.e. the time needed to read a contract (time-on-task). See Appendix I for a further description of the measurement of the complexity of contracts.

Independent variables

R&D capabilities asymmetry. For each firm we collected data on R&D expenses in millions of dollars. Average R&D expenses are calculated based on the R&D expenditures during the year of deal conclusion and the previous year. A ratio of R&D expenses is obtained for each deal (firm with larger average R&D expenses divided by firm with smaller average R&D expenses).

Information asymmetry. PharmaDeals categorizes each firm in the dataset as either 'Established', 'Global' or 'Start-up/Emerging'. Established firms are defined as "… companies with a history of profitability who generally operate on a limited territorial basis. Includes firms that have a global presence through distribution and marketing affiliates and partners." Global firms are defined as "… multinational companies with a true global presence, which are also included in the top 30 healthcare companies as ranked annually by MedAdNews." Start-up and emerging corporations are defined as "… new and emerging companies, including biotechnology, drug delivery and enabling technology companies. These are companies that have no record of sustained profitability." Following Lerner & Malmendier (2005), information asymmetry is indicated by the collaboration between established and global pharmaceutical firms, that have more general pharmaceutical research capabilities and production and marketing skills, and the start-ups and emerging firms that have specialized bio-pharmaceutical R&D skills. We use a dummy variable which equals 1 if the deal is concluded between an established or global and a start-up or emerging firm and 0 if otherwise.

Strategic importance. As a proxy for the strategic importance of an R&D alliance we measure the extent to which the intellectual property rights that result from an alliance are, according to the contract, shared equally between partners. Given the importance of intellectual property rights as a strategic tool in the pharmaceutical industry (Cohen, Nelson & Walsh, 2000), we understand the sharing of intellectual property rights between partners to indicate that both partners see the intellectual property rights that result from their R&D alliance as of such importance that they demand an equal share in intellectual property rights. Using a text analysis program, we obtained data on whether a contract provides for joint intellectual property ownership. We use a dummy variable which equals 1 if the contract provides for joint ownership of intellectual property and 0 if otherwise.

Asset specificity. As a proxy for asset specificity we measure the extent to which a contract provides for exclusive licensing rights. Exclusive licensing rights specify the limited use of a technology to a specific user, a geographic region, a specific length of time, and/or a specific field of use. In other words, exclusive licensing rights limit the degree to which a transaction-specific asset, i.e. the technology developed through an R&D alliance, can be re-deployed and as such they indicate the asset specificity of this technology. We use a dummy variable which equals 1 if the contract contains any exclusive licensing rights for either party and 0 if otherwise.

Experience. We calculate the average alliance experience for each firm per deal. Using the MERIT-CATI database (see Hagedoorn, 2002), we were able to obtain data on the prior R&D alliance experience of each firm, counting back five years from the year of deal conclusion. A five year window is widely accepted in the literature as an adequate period to measure the alliance experience of firms (see e.g. Gulati, 1999). For each deal we calculate the average R&D alliance experience based on the alliance experience of each partner.

Prior ties. Using the MERIT-CATI database, we were also able to search for prior ties between alliance partners, counting back five years from the start of the R&D alliance (see also Gulati, 1995). As in our dataset prior ties are usually limited to one previous tie, with very few partners having multiple prior ties, we use a dummy variable to indicate the existence of a prior relationship between the contracting parties. The dummy equals 1 if there are any earlier R&D alliances between partners, 0 if otherwise.

Control variables

Size asymmetry. Contributions to the alliance literature point out that the size of firms participating in alliances and in particular the size difference between partners can play a role in the risk perception of firms during the partnership formation process (e.g. Berg, Duncan & Friedman, 1982; Mytelka, 1991). This literature suggests that the size asymmetry of partners generates a higher appropriability hazard to the smaller firm due to the potentially opportunistic behavior of its larger partner. For instance, the literature on inter-firm cooperation through licensing indicates that when firms of different size engage in technology collaboration, larger firms attempt to dominate the agreement based on bargaining asymmetries that affect the terms of the agreement (Bessy & Brousseau, 1998; Caves, Crookell & Killing, 1983).

Size asymmetry is based on the total asset turnover ratio of both parties. For each firm we collected data on total asset turnover in millions of dollars. Average total asset turnover is calculated based on the total asset turnover of the year of deal conclusion and the previous year. A ratio of total asset turnover is obtained for each contract (firm with largest average total asset turnover divided by firm with smallest average total asset turnover) (Gillian, Hartzell & Parrino 2007; Ryall & Sampson 2007).

Year. As the propensity to engage in R&D alliance contracts may vary during the period 1996-2005, we included year dummies. This year dummy equals 1 if the deal is concluded within the specific year and zero otherwise.

Research stage. PharmaDeals provides additional information on the phase of the R&D underlying the agreement. PharmaDeals identifies two categories: collaborative R&D and co-development. Early stage collaborative R&D is characterized by high failure rates and the exact outcome of this kind of research is difficult to anticipate. Co-development of pharmaceutical products can be more readily specified. Hence, we expect the research stage of an R&D alliance to impact the complexity of contracts. We use a dummy variable which equals 1 if the deal concerns collaborative R&D and 0 if the deal concerns co-development.

Foreign partner. To control for the possibility of greater divergence in expectations in contractual disputes spanning national boundaries, we include a dummy variable which takes a value of 1 if the firms are headquartered in the same country (the US) and a value of 0 if otherwise (international deal). Firms are expected to have less information about foreign firms than about domestic firms and trust tends to emerge more readily between firms that share a similar social background, e.g. those that are domestic partners (Zucker, 1986). This also suggests that behavioral uncertainty and opportunistic behavior may be more likely to arise in cross-border alliances affecting the governance of alliances (see also Hagedoorn, Cloodt & van Kranenburg, 2005).

Equity investment. For every alliance contract we noted if any type of equity investment was present. Equity participation generates some control in the alliance and this control might affect the degree to which partners draft more or less complex contracts (see e.g. Robinson & Stuart 2007; Reuer & Ariño 2007; Hansen & Higgins 2007; Ryall &

Sampson 2007). Data was obtained by scanning each contract with a special text analysis program. A dummy variable was created which equals 1 if the contract provides for some type of equity stake and 0 if otherwise.

Same industry. Using additional PharmaDeals information and the SIC categorization we assigned each firm to a primary industry. The more firms are competitors in their main industry, the more they operate in similar product-markets and as direct competitors, we expect them to write more complex contracts due to a higher need for control in R&D alliances with competitors. A dummy variable is included which equals 1 if both partners are active in either the pharmaceutical or biotechnological industry. If at least one partner's primary activity is in another industry (not pharmaceuticals or biotechnology) the dummy variable takes on a value of 0.

Analysis

In the following, we will present count models where the dependent variable 'complexity' is defined as length of contracts in terms of the number of words and the cognitive load of contracts (time-on-task). We use negative binomial regression models that allow for the variance to exceed the mean (Hausman et al., 1984). A random effects model rather than a fixed effects model is used as the results of the Hausman specification test indicate that the random effects estimations are consistent and efficient.

The contracts that we analyze represent 'first interactions' between firms in the period 1996-2005 and a small number of firms appear in the dataset more than once. This occurs when firm A contracts with firm B and firm C separately; both the AB and AC contracts are in the sample. Since firm A's behavior in contract AC is probably not independent of firm A's behavior in contract AB, error terms may not be independently distributed. However, the independent distribution of the error terms is confirmed by the Durbin-Watson statistic and the Breusch-Godfrey test.

A concern with estimating the effect of asset specificity and strategic importance on contractual complexity in a negative binomial regression is the potential endogeneity that may bias estimates. Endogeneity arises when a regressor is correlated with the error term, thereby violating the exogeneity assumption (Wooldridge, 2002, 2006; Maddala, 2006). Asset specificity and strategic importance are measured through terms included in the alliance agreement and thus determined by contracting parties. As such, these two variables raise endogeneity concerns.

A common technique to tackle endogeneity is the use of instrumental variables (Bascle 2008; Wooldridge 2006). Instrumental variables are variables that are both uncorrelated with the error term and highly correlated with the endogenous regressor. In order to correct for endogeneity in our negative binomial models, we estimate a generalized linear model with a negative binomial distribution function and a log link function by method of instrumental variables ("qvf" in Stata). The qvf model is similar to a generalized linear model but has the ability to include instrumental variables, a functionality that was added to 'address measurement error, but may be utilized by the user for other purposes' (Hardin, Schmiediche & Carroll, 2003). In this case, we use the qvf model to correct for endogeneity. In our models we use 'Scale dissimilarity' as an instrumental variable for strategic importance and 'Breadth deal' for asset specificity.[6] These variables were selected through instrumental variable inference.

We also ran a robust 2SLS analysis with logged dependent variables (in order to simulate a negative binomial model) using the ivreg2 model in Stata, which generated similar results.[7] The ivreg2 model in Stata enables us to elaborately test various aspects of instrumental variable regression such as the relative weakness of the instruments (in first stage procedure regression results) and the endogeneity of the model as a whole. In particular, in order to select relevant instruments we reviewed a whole set of potential instrumental variables for each endogenous regressor. These variables are correlated with strategic importance on the one hand and asset specificity on the other hand, but remain uncorrelated with the error term and dependent variable, and were not incorporated in the original regression function. From this set of variables we chose those variables which rendered the highest correlation with asset specificity and strategic importance, respectively. In order to test for the relevance of the potential instrument variable for our model, we reviewed the ivreg2 first stage regression results including relevant F statistics. Breadth of deal and asset dissimilarity each rendered an F–statistic with a value of around 9, which according to the literature indicates that these variables are relevant instruments.

In addition, a Durbin-Wu-Hausman (DWH) test was performed under the robust 2SLS estimation using the 'orthog' and 'endog' functions, which are robust to various violations of conditional homoskedasticity (non-*i.i.d* errors). The DWH test examines whether the residuals of the regression of all exogenous variables on the suspected endogenous regressor are significant when included in the original model; under the null hypothesis the specified endogenous regressors can be treated as exogenous. The DWH test for the length dimension and cognitive load dimension is not significant for both asset specificity and strategic importance, with the exception of the length dimension where instrumenting for strategic importance yields a marginally significant DWH. In the following, we report both our negative binomial and qvf instrumental variable estimates for each dimension of contractual complexity.

RESULTS

Table 1 provides the descriptive statistics and the correlation matrix. Table 2 and 3 present the results of the negative binomial regression analyses. Table 2 (models 1-4) presents the results for contractual complexity in terms of the length of contracts, table 3 (models 5-8) presents the results for the cognitive load dimension of contractual complexity in terms of the time-on-task. The first models reported in tables 2 and 3 are the basic models with the control variables. The other models include the independent variables. Models 2 and 6 give the results for the standard negative binomial regressions. Models 3, 4, 7, and 8 present the results with the instrumental variables. The size of most samples used in the regressions is somewhat smaller than 291 due to additional missing values. In the following, we first discuss the results for the length dimension of contractual complexity before we turn to the results for the cognitive load dimension of contractual complexity.

-------------- insert Table 1 about here -----------------

-------------- insert Table 2 about here -----------------

-------------- insert Table 3 about here -----------------

Hypothesis 1 predicts that the larger the asymmetry between partners in terms of their R&D capabilities, the more complex the contract for their R&D alliance. This hypothesis is supported, see models 2-4, as we find the expected positive effect. Hypothesis 2 concerns the degree of information asymmetry and predicts that the degree of information asymmetry between partners is positively related to contractual complexity. This hypothesis is supported in the models 2-4. The hypothesis related to the strategic importance of the alliance (hypothesis 3) predicts that the higher the strategic importance of the alliance for one or both partners, the more complex their R&D alliance contract. This hypothesis is supported in models 2 and 4 but not in model 3. Asset specificity has, as predicted by hypothesis 4, a positive impact on contractual complexity, i.e. asset specific investments increase the complexity of R&D alliance contracts (see models 2-4). Hypothesis 5 concerns the general alliance experience of parties and predicts that the smaller the experience, the more complex their R&D alliance contract. However, models 2-4 show a reverse effect: the greater the experience of parties, the more complex their R&D alliance contract design. Hypothesis 6 argues that prior ties can substitute for formal safeguards in alliance contracts leading to lower levels of contractual complexity. This hypothesis also does not receive support as our findings suggest a significant, reverse effect (see models 2-4).

Interestingly, we find some similar but also some different results for the cognitive load dimension of contractual complexity, see table 3. Similar to the results for contractual complexity in terms of the length of contracts, information asymmetry (hypothesis 2), asset asymmetry (hypothesis 4) in models 6 and 7 are supported. Prior ties (hypothesis 6) also has a comparable opposite effect as found for the length of contracts. The other independent variables, that refer to hypotheses 1, 3, and 5, appear to have little or no impact on the cognitive load dimension of contractual complexity.

Turning to the control variables, it appears that, with the exception of the research stage and equity investment, these controls generate no impact.[8] For both dimensions of contractual complexity, the results for the research stage illustrate that earlier stage agreements (collaborative research) referring to preclinical research are generally less complex than later stage agreements (co-development) referring to clinical trials phase 1 or above. It appears that when the research outcome is still uncertain, parties do not know yet what to expect and the contractual agreement is less complex. However, when parties have more certainty that some output may result from their collaboration and they have to invest more resources (larger trials etc), parties will draft more complex contracts. Interviews with experts in the field reveal that parties indeed experience the research stages in this manner and will invest in contractual complexity accordingly. Equity investments appear to have some positive effect on the complexity of these contracts (length), see models 1-3. Firm size asymmetry has a positive, albeit marginally significant, effect on the complexity of contracts in terms of their cognitive load.

In addition, we considered a number of (unreported) moderating effects of equity investments, expecting that the governance of R&D alliances through partial ownership would decrease the need for more complex contracts. As such we expected that equity investments in combination with larger R&D capabilities asymmetry, larger information asymmetry, higher strategic importance of alliance, and higher asset specificity of alliance would lead to less complex contracts. We also considered a number of other possible interaction effects, mainly related to size asymmetry, alliance experience, and prior ties. However, none of the tested interaction effects were significant.

DISCUSSION AND CONCLUSIONS

As explained in the above, our study is of an exploratory nature and applies the theoretical input from an extended transaction cost economics perspective in combination with a diverse body of disciplinary literatures that include legal studies, applied industrial organization, finance, strategic management, and law and economics. In addition, our understanding of the role of the cognitive load of contractual complexity is largely influenced by the applied psychology literature. Against this varied theoretical background, it is interesting to note that we found some remarkable similarities and differences between the impact that partner characteristics, transaction level attributes, and the routines of contract parties have on both dimensions of the complexity of inter-firm R&D alliance contracts.

Our findings indicate that, as suggested by the transaction costs economics and dynamic capabilities perspectives, asymmetries between contracting parties in terms of their information asymmetry affect both dimensions of the complexity of their R&D alliance contracts. When one contract party has a relevant information advantage, this can create potential hold up problems for the other partner that might lack the necessary information to monitor certain tasks that are to be undertaken through the alliance. This implies that when the partners in an R&D alliance have very different roles, e.g where one firm is largely responsible for the actual R&D and the other firm is responsible for financing this R&D, possibly in combination with complementary assets such as testing, production, etc., there is a built-in element of information asymmetry in the alliance (see also Lerner & Malmendier, 2005). Our research suggests that when firms that engage in an R&D alliance face information asymmetry, this asymmetry is translated into contracts that are indeed found to be more complex.

At the transaction level of R&D contracts, our findings that refer to the asset specificity of an R&D alliance support the understanding of the complexity of inter-firm contracts that is largely influenced by transaction cost economics. The higher the asset specificity of the alliance activity, i.e. the more limited the use of the technology developed through the alliance, the more specific the investments made and the fewer the alternative options for use of the technology, the more partners specify the stringency of provisions and the more complex a contract becomes both in terms of its length and its cognitive load.

When it comes to the organizational routines of contracting firms, in terms of the more specific experience with particular partners through prior ties, it turns out that these routines have an opposite effect to what we expected. Contrary to our expectations, learning to contract through a history of previous alliances, shared experience, and perhaps even the emergence of joint inter-firm administrative routines leads to more, instead of less, complex contracts. Although our initial understanding of the effect of prior ties is founded in a number of legal, economic and management literatures, there is a recent stream of publications that point at similar findings as ours. Argyres, et al (2007) indicate that prior ties with particular firms can have learning effects in the opposite direction: through this repeated interaction firms get a better understanding of the task descriptions for both partners in the alliance. These task descriptions become more detailed and lead to contingency planning that is incorporated in subsequent contracts that are then gradually becoming more complex. In related work, Mayer & Weber (2005) found that prior contracts between partners invite firms to add useful provisions based on what they learned from their previous contracts. Ryall & Sampson (2006) also found that repeated alliances between partners leads to more detailed and complex contracts with additional contractual safeguards, monitoring clauses, control rights, and intellectual property rights clauses. In the end, the inclusion of many of these clauses will lead to more extensive contracts that are complex in terms of both their cognitive load and their length**.**

There are also a number of interesting factors that explain the complexity of these inter-firm R&D alliance contracts as captured by the length of contracts. As expected from a dynamic capabilities perspective, the larger the R&D capabilities asymmetry between firms, the more complex their R&D contracts. This suggests that firms with more R&D capabilities than their alliance partners fear unintended knowledge leakage to partners with fewer R&D capabilities. More complex, i.e. lengthier, contracts that include a range of clauses such as additional safeguards, monitoring clauses, control rights, and intellectual property rights clauses offer a monitoring option to firms in an attempt to avoid unintended knowledge leakage through an R&D alliance.

In terms of transaction level factors, as suggested by both transaction cost economics and a dynamic capabilities perspective, the higher the strategic importance of an R&D alliance to partners, the more complex these R&D alliances seem to become. The higher the strategic importance of an R&D alliance, e.g. when both partners share the intellectual property rights signaling their interest in the alliance, the more effort is made to draft extensive alliance contracts that translate into more complex, i.e. lengthier, contracts.

Finally, for the length dimension of contractual complexity, the organizational routines of contracting firms, in terms of their general experience with R&D alliances, has the same opposite effect that we found for the more specific experience with particular partners. Contrary to our expectations, learning to contract through a history of previous alliances with a variety of firms leads to more complex, i.e. lengthier, contracts. As with the specific experience through prior ties, this finding confirms some recent studies by Argyres et al (2007) and Ryall & Sampson (2006) that established that the general experience with contracting leads to more detailed and complex contracts. These contributions and the current finding suggest that the organizational routines that firms have through previous inter-firm R&D alliances may improve their contracting capabilities through which they learn which contractual safeguards, monitoring clauses, control rights, intellectual property rights clauses, etc. to add to their contracts. Contracts are organic documents and each event that firms face adds 'scar tissue' to the contracting experience of firms (Buchheit, 2008). As practitioners indicate, a party with more experience will know exactly which issues are important and should be addressed. As firms gain more general contracting experience, they will routinely 'add on' to agreements and thereby increase the complexity of contracts.

The second dimension of the complexity of these inter-firm R&D alliance contracts refers to the degree to which a contract imposes a cognitive load upon boundedly rational contract parties. More specifically, this cognitive load refers to the effort and mental activity imposed on a person's or a contract party's ability to process the information in a contract. In other words, the higher the effort and mental activity to process the information found in a contract, the higher the complexity of this contract. Interestingly, our findings suggest that this cognitive dimension of contractual complexity is affected by a smaller number of factors than were found relevant for the complexity of contracts in terms of their length. Only asset specificity, information asymmetry, prior ties, research stage, and size asymmetry of firms play a role in explaining the complexity of R&D alliance contracts in terms of their cognitive load.

The role of asset specificity is particularly interesting as it enables us to further clarify the cognitive load dimension of contractual complexity. The higher the asset specificity of the alliance activity, i.e. the more a contract refers to the limited use of the jointly developed technology in terms of specific users, geographic region, a specific length of time, and/or a specific field of use, the more specific the investments made and the fewer the alternative options for use of the technology, the more these contracts are seen as complex contracts. The fact that asset specificity also affects the cognitive dimension of complexity may be due to the types and number of clauses which are added to the agreement. These types of clauses usually relate to royalty payments, price adjustment, usage rights, clauses which may be difficult to understand due to complicated payment structures (see also Eggleston et al., 2001). These 'payment' clauses are also often dependent on factors incorporated in other clauses, which means that the interrelatedness between contract terms increases. This in turn affects the comprehensiveness and thus the cognitive dimension of the complexity of contracts.

The effect for size asymmetries between companies refer to higher appropriability hazards due to the potentially opportunistic behavior of the larger partner and lower ex post bargaining power for smaller partners (Barnhizer, 2005; Bessy & Brousseau, 1998). Given this market power asymmetry, smaller partners have an incentive to favour a contract that facilitates the monitoring of the alliance through clauses that refer to specific responsibilities, control rights, enforcement mechanisms, and a number of other contractual safeguards. The larger partner in an R&D alliance probably prefers a less complex contract as this economizes on the transaction cost of a more complex contract but, given its control and monitoring resources, this preference is less critical than the incentive for its smaller partner to favour a more complex contract. Our field research indicates that the smaller party often thinks its larger counterpart might behave opportunistically. Legal counsels indicate that a smaller party thus has a strong urge to write out what happens in every scenario. Apparently, this does not lead to a more complex contract in terms of its length but our findings indicate that when there is a size asymmetry between contract parties the different incentives, discussed in the above, are translated into a contract with a higher cognitive load.

A general conclusion, based on this study is that our findings demonstrate that, as suggested by Eggleston et al. (2001), the two dimensions of complexity point at both overlapping and different aspects of the complexity of contracts. In that sense, it is indeed interesting to understand contractual complexity as a broader construct that goes beyond length as a one-dimensional indicator of complexity. Understanding the role of cognitive load as the information processing capacity and information processing efforts of contract parties does seem to add to our perception of the actual intricacy of the complexity of contracts.

Obviously, our contribution also has its limitations that can be translated into suggestions for future research. It would be interesting to see whether measuring the cognitive load of contracts could be extended to a sample of legal professionals (corporate lawyers, legal counsel). Given the limitations in terms of having access to these professionals, this would most probably imply that respondents are to evaluate a smaller sample of contracts, but even a small sample of inter-firm contracts could provide a ‘real life’ look into the professional perception of the complexity of contracts. In addition, the current paper is based on an overall measurement of complexity along two dimensions. Future research could benefit from a more in-depth analysis of elements of contractual complexity in terms of the different contract clauses and their interactions that are expected to increase the level of contractual complexity. Also, the current paper is based on a set of about three hundred contracts, limited to one particular industry, one group of alliances, i.e. R&D alliances, and the sample is very US focused. A larger sample with a multi-industry and international perspective and a range of inter-firm contracts that go beyond R&D can most probably provide a more thorough understanding of the contracting process between firms. Despite these limitations, we hope this contribution is a step forward in a more general endeavor to improve our empirical understanding of the role of contracts in the world of inter-firm collaboration, alliances, and various other forms of inter-organizational transactions and exchanges.

Table 1 Descriptive statistics and correlation matrix

	Variable	Mean	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1.	Length in words	15929	9525.5	1.0000															
2.	Time on task	52.456	38.817	0.3759	1.0000														
3.	R&D capabilities asymmetry	6.6568	2.0258	0.0447	-0.0057	1.0000													
4.	Information asymmetry	1.9256	0.5384	0.0373	0.0365	-0.3926	1.0000												
5.	Strategic importance	0.6084	0.4889	0.2641	0.0399	0.0540	-0.0500	1.0000											
6.	Asset specificity	0.6311	0.4833	0.2906	0.1169	0.0076	0.0357	0.0553	1.0000										
7.	Experience	9.2379	8.6832	0.2452	0.1608	-0.2705	0.1499	-0.0451	-0.0318	1.0000									
8.	Prior ties	0.4725	0.5001	0.1678	0.1334	-0.0353	-0.0725	0.0535	0.0635	0.2724	1.0000								
9.	Size asymmetry	10.542	22.363	0.1056	0.1699	0.0928	-0.0124	-0.0785	-0.0131	-0.0560	-0.0407	1.0000							
10.	Year	1999.7	2.2957	0.3066	0.1528	0.1009	-0.0352	0.0562	-0.0862	0.1693	0.0585	0.0600	1.0000						
11.	Research stage	0.6634	0.4733	-0.1608	-0.0071	-0.0181	-0.1032	0.0320	-0.0547	0.1407	0.1960	-0.0950	0.0511	1.0000					
12.	Foreign partner	0.4207	0.4945	0.1059	0.1244	-0.2730	0.1728	-0.0986	0.0077	0.1389	0.0145	0.0668	0.0916	-0.0801	1.0000				
13.	Equity investment	0.1812	0.3858	0.1974	-0.0116	0.0557	0.0628	0.0206	0.1945	-0.0745	0.0631	0.0505	-0.0448	-0.0890	-0.0879	1.0000			
14.	Same indusry	0.8285	0.3776	0.0969	0.0773	0.0240	-0.0948	0.0986	0.0580	0.1861	0.1359	-0.1558	0.1505	0.0088	-0.0298	0.0533	1.0000		
15.	Breadth deal	2.1942	1.2796	0.1166	0.0982	-0.0364	0.0459	0.0629	0.1843	0.0728	0.1840	-0.1016	0.0216	0.1798	-0.0320	0.0235	-0.0795	1.0000	
16.	Scale dissimilarity	-0.2062	0.4912	0.0798	0.0411	-0.4145	0.3116	-0.1253	0.0015	0.1503	-0.0649	0.0823	0.0298	-0.0570	0.1079	0.0506	-0.0267	-0.0576	1.0000

Table 2 Results for contractual complexity in terms of length, negative binomial, instrumental variables regression

	Model 1	Model 2	Model 3	Model 4
R&D asymmetry		0.045**	0.051*	0.036*
		(0.015)	(0.021)	(0.016)
Information asymmetry		0.246**	0.276**	0.182*
		(0.082)	(0.104)	(0.092)
Strategic importance		0.296***	-0.401	0.275***
		(0.057)	(0.461)	(0.058)
Asset specificity		0.363***	0.352***	0.657*
		(0.059)	(0.073)	(0.295)
Experience		0.012**	0.010†	0.013***
		(0.004)	(0.005)	(0.004)
Prior ties		0.179**	0.227**	0.142*
		(0.058)	(0.084)	(0.062)
Size asymmetry	0.001	0.001	0.000	0.002
	(0.002)	(0.001)	(0.002)	(0.001)
Year (1997)	-0.025	0.049	0.026	0.090
	(0.103)	(0.112)	(0.116)	(0.112)
Year (1998)	0.039	0.050	0.187	0.093
	(0.123)	(0.127)	(0.149)	(0.134)
Year (1999)	0.009	0.081	0.006	0.146
	(0.116)	(0.119)	(0.150)	(0.131)
Year (2000)	0.021	0.083	0.041	0.159
	(0.102)	(0.115)	(0.124)	(0.137)
Year (2001)	0.167	0.218†	0.173	0.341*
	(0.113)	(0.126)	(0.148)	(0.153)
Year (2002)	0.315*	0.332*	0.307*	0.424**
	(0.124)	(0.139)	(0.154)	(0.160)
Year (2003)	0.607***	0.455***	0.559***	0.481***
	(0.145)	(0.127)	(0.146)	(0.138)
Year (2004)	0.323*	0.241†	0.322*	0.273†
	(0.132)	(0.136)	(0.150)	(0.145)
Year (2005)	0.747***	0.909***	1.277***	0.862**
	(0.150)	(0.246)	(0.337)	(0.286)
Research stage	-0.186**	-0.286***	-0.279***	-0.268***
	(0.064)	(0.064)	(0.078)	(0.065)
Foreign partner	0.087	0.038	-0.035	0.042
	(0.061)	(0.056)	(0.082)	(0.060)
Equity investment	0.293***	0.170*	0.205*	0.104
	(0.079)	(0.067)	(0.081)	(0.089)
Same industry	0.125	0.011	0.117	-0.036
	(0.080)	(0.074)	(0.109)	(0.080)
Constant	9.425***	8.483***	8.804***	8.408***
	(0.106)	(0.199)	(0.293)	(0.242)
Log likelihood	-2999.398	-2924.305		
LR test	102.59***	158.48***		
Endogenous regressor			Strategic importance	Asset specificity
Instruments			Scale dissimilarity	Breadth deal
N	291	288	288	288

† p<0.10, * p<0.05, **p<0.01, *** p<0.001
Standard errors are in parentheses

Table 3 Results for contractual complexity in terms of cognitive load, negative binomial, instrumental variables regression

	Model 5	Model 6	Model 7	Model 8
R&D asymmetry		0.046*	0.039	0.035
		(0.021)	(0.024)	(0.023)
Information asymmetry		0.469***	0.437***	0.407**
		(0.115)	(0.125)	(0.133)
Strategic importance		0.078	0.395	0.073
		(0.075)	(0.537)	(0.082)
Asset specificity		0.190*	0.186*	0.642
		(0.075)	(0.081)	(0.400)
Experience		0.007	0.009	0.008
		(0.005)	(0.006)	(0.005)
Prior ties		0.272***	0.242*	0.222*
		(0.078)	(0.097)	(0.093)
Size asymmetry	0.003*	0.003*	0.004†	0.003†
	(0.002)	(0.002)	(0.002)	(0.002)
Year (1997)	0.086	0.183	0.200	0.201
	(0.157)	(0.164)	(0.156)	(0.142)
Year (1998)	0.085	0.146	0.121	0.188
	(0.186)	(0.178)	(0.180)	(0.177)
Year (1999)	0.186	0.248	0.315†	0.331*
	(0.167)	(0.162)	(0.185)	(0.156)
Year (2000)	0.064	0.114	0.158	0.234
	(0.138)	(0.160)	(0.157)	(0.155)
Year (2001)	0.192	0.294†	0.349†	0.436*
	(0.165)	(0.173)	(0.202)	(0.190)
Year (2002)	0.483*	0.468*	0.498*	0.586**
	(0.194)	(0.185)	(0.221)	(0.219)
Year (2003)	0.199	0.110	0.081	0.145
	(0.203)	(0.185)	(0.192)	(0.190)
Year (2004)	-0.084	-0.126	-0.130	-0.098
	(0.216)	(0.223)	(0.212)	(0.236)
Year (2005)	0.771***	1.044***	0.897*	1.065***
	(0.214)	(0.299)	(0.357)	(0.280)
Research stage	-0.054	-0.203*	-0.206**	-0.176*
	(0.080)	(0.081)	(0.080)	(0.085)
Foreign partner	0.120	0.019	0.043	0.009
	(0.082)	(0.080)	(0.101)	(0.084)
Equity investment	-0.003	-0.105	-0.110	-0.211
	(0.104)	(0.094)	(0.101)	(0.133)
Same industry	0.191*	0.156	0.096	0.108
	(0.090)	(0.101)	(0.133)	(0.104)
Constant	3.577***	2.688***	2.576***	2.513***
	(0.144)	(0.265)	(0.335)	(0.310)
Log likelihood	-1324.618	-1288.128		
LR test	41.49***	77.96***		
Endogenous regressor			Strategic importance	Asset specificity
Instrument			Scale dissimilarity	Breadth deal
N	280	277	277	277

† p<0.10, * p<0.05, ** p<0.01, *** p<0.001
Standard errors are in parentheses

Appendix I The measurement of contractual complexity

The length of contracts as an objective measure of contractual complexity is measured through the number of words in a contract. The electronic copies of the contracts provided by PharmaDeals are presented in a comparable layout in pdf-format. The document conversion feature of a text miner was used to convert all the documents into a readable ASCII file. The text miner provides us with information on the number of words in each contract.

To measure the cognitive load of these contracts, sixty graduate students of the Faculty of Law of XXXXXX University in XXXXXX were asked to read contracts and report the time spent on reading each contract. This choice for students might raise some concern as, compared to professionals, students lack professional experience and are generally younger, which may lead to a different attitude than one would expect for managers and corporate lawyers who would otherwise deal with these contracts. The option of having these contracts read by managers, corporate lawyers, and legal counsel to assess the cognitive load of the sample of contracts was considered. However, both the reading of the relevant literature on the use of practitioners and the consultation of a number of experts made it clear that in practice it would be impossible to have a survey of hundreds of contracts, with an average of fifty pages per contract, read by a group of practitioners. Moreover, research on this topic provides significant evidence that students are indeed valid surrogates for professionals. Comparing professional and student behavior, many studies do not find a substantial difference in behavior (see e.g. Abbink & Rockenbach, 2006; Banks, Colin & Porter, 1994; Hughes & Gibson, 1991; King, Smith, & Van Boening, 1992).

Somewhat similar to the methodology applied in a recent study by Hagedoorn & Hesen (2009), respondents were asked to report the time spent reading each contract and as such an objective indirect measure was obtained**:** time-on-task. Time-on-task provides a meaningful measurement as this reflects the difficulty or ease of a task. Time-on-task typically increases with complexity and a high time-on-task points towards a high cognitive load (see e.g. Brünken et al., 2003; Corbalan et al., 2006). A representative ‘dummy’ contract was first administered to all respondents to measure the within-group homogeneity of the respondents. The results for this test indicated that each respondent could be taken as representative for the group of respondents as a whole and each respondent received a randomly distributed small number of up to five contracts.

Additional information on the details regarding the set-up and procedures for the measurement of the cognitive load of these contracts can be obtained from the authors.

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[1] See for example Buchheit (2008) who, in reference to the recent financial crisis, states that this was not only due to the complexity in engineering modern financial products but also due to the complexity in legal contracts that memorialize the transactions.

[2] Given the focus of our study on R&D alliances in a high-tech environment, R&D capabilities are to be taken as representative of the dynamic capabilities of firms.

[3] As a counter-argument, one might argue that a smaller firm with a more specialized set of R&D capabilities faces appropriability hazards from its larger partner. As far as there is an element of information asymmetry in that argument, that topic is discussed in the second hypothesis. With regard to the size asymmetry of firms, we control for this asymmetry in our empirical analysis.

[4] See Overdahl (1991) for more information on the specific requirements and issues concerning contract filings with the SEC. Under the SEC requirements, firms file for their most substantial deals. Thus there is a tendency of overrepresentation of larger and publicly owned firms. Small firms are present in these filings but only when they partner with public firms who file with the SEC. The choice of contracts may not be a random phenomenon. However, other authors using a similar type of dataset (see e.g. Hansen & Higgins 2007; Higgins 2007; Sampson 2005) conclude that a systematic bias in contract type and activity is not present in the recorded agreements.

[5] The number of words, number of pages, and the kilobytes of information in these contracts turned out to be are highly correlated (between 0.95 and 0.99).

[6] *Breadth deal* refers to the number of interest areas, covered by an alliance contract. Alliance contracts in the database may cover up to eight different areas of interest as identified by PharmaDeals. These areas of interest as such are not classified in the R&D alliance contracts but categorized separately by PharmaDeals. *Scale dissimilarity* is based on the total number

of employees of both parties. For each firm we collected data on total number of employees. Average employee number is calculated based on the total number of employees of the year of deal conclusion and the previous year. A ratio of total number of employees is obtained for each deal (firm with largest average total number of employees divided by firm with smallest average total number of employees). The correlation coefficient between our independent variable *size asymmetry* (a ratio based on total asset turnover) and instrumental variable *scale dissimilarity* (a ratio based on the number of employees) is 0.091.

[7] This 2SLS estimation is very sensitive to finite-sample bias caused by e.g. weak instruments. As suggested by Bascle (2008) we therefore also ran the instrumental variable regression in ivreg2 with limited maximum likelihood (LIML), Fuller's modified LIML (Fuller) and Moreira's conditional likelihood ratio (CLR). These regressions provide similar results to the 2SLS estimations. Note that the equation is exactly identified (one instrument for each endogenous regressor) and the LIML estimation is in fact the 2SLS estimation (Bascle 2008).

[8] The international scope of the alliance for example has no effect. Experts in the field confirm this finding and indicate that in this sector, the fact that one partner is foreign does not significantly affect the complexity of the contract, with some exceptions. For example, one of the partners of a US law firm, specialized in negotiating and drafting these types of agreements, revealed that he was once involved in negotiations with a European pharmaceutical. Just prior to the negotiations this party had been exposed to a huge US product liability case. The firm was thus very worried about liability issues and it had become fearful of the US legal system in general. This fear was strongly expressed by the executive board, which pressured the lawyers involved to really focus on drafting lengthy provisions concerning (product) liability, representations, etc.