CONTRACTS, ORGANIZATIONS AND KNOWLEDGE GOVERNANCE: AN EMPIRICAL INQUIRY INTO INTER-FIRM TECHNOLOGY AGREEMENTS

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There is more to Contracts than Incompleteness: A Review and Assessment of Empirical Research on Inter-firm Contract Design

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ABSTRACT:

This paper aims at achieving a greater understanding of how contracts operate in practice through a review of recent empirical literature on inter-firm contract design. Our focus on the structure of contractual agreements differentiates this review from others that dedicated ample coverage also to the antecedents of the decision to contract and of the choice of contracting versus integration.
Our framework develops Stinchcombe's (1985) hypothesis that contracts are an organizational phenomenon. This allows us to uncover considerable but unevenly distributed evidence on a number of organizational processes formalized in relational contracts, which partially overlap with the processes that are observed in integrated organizations. It also enables us to describe contracts in terms of a larger number of dimensions than is commonly appreciated.
The paper summarizes the evidence by proposing a general and tentative framework to guide the design of relational contracts, discusses a number of lingering issues, and outlines directions for further research on contracts as an organizational phenomenon.

Keywords: contracts, governance, inter-organizational research, alliances, literature review

1. Introduction

Contracts, in the sense of legally enforceable agreements, are a time-honored, fundamental institution of economic and social life that has become the object of systematic empirical investigation by economists and business scholars only little more than three decades ago. The economic theory of contracts has evolved from the failures of general equilibrium theory (Salanié

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2005: 2). Subsequent developments, in the mid 1970s, marked a substantial effort to turn away from the abstraction of the general equilibrium model and take into greater account the complexity of the interaction between the contracting parties. Yet, the 'theory of contracts' that emerged out of this attempt, was still a highly stylized description, that pleaded for an "expanded theory of contract" (Goldberg 1976b), to match a parallel development in legal scholarship toward more realistic representations (Macneil 1974). By removing the assumption that actors have complete, unconstrained rationality, transaction cost economics (TCE) has imparted a considerable thrust to the movement toward analyzing actual contracts (Williamson 1975). Yet, the following years were punctuated with calls from legal scholars and economist alike to "establish, rather than assume" how contracts operate in practice (Macaulay 1985), to develop a more detailed understanding of how contracts operate in "a real-world setting" (Coase 1992), and to study "the actual formalized *documents* that we call contracts" (Suchman 2003: 96). This article aims at enhancing our understanding of real-world inter-firm contracts through a review of empirical literature on contract design, under the working hypothesis that contracts are an organizational phenomenon.[1]

There are already a number of competent survey papers on the empirical analysis of contracts in inter-firm relations, which focus on different aspects within the broad issue of contracting. Some are concerned with inquiring into the validity of one particular theory of contracting (normally TCE), that is, of assessing how much empirical support there is for its testable propositions (Shelanski, Klein 1995; David, Han 2004; Boerner, Macher 2005). Others couple that focus with an inquiry into where TCE has been applied (Rindfleisch, Heide 1997) or restrict themselves to the evidence concerning the make-or-buy decision (Vannoni 2002, Klein 2005). Still others focus on an organizational form – hybrids – which when established between multiple legal entities often involves contractual governance (Menard 2004). Finally, Masten and Saussier (2002) cover a large spectrum of questions related to contracting (the decision to contract, the design of contractual agreements and contracting versus vertical integration), thus dedicating relatively limited coverage to each of them. In the last analysis, the Lyons (1996) study is that which is closer in focus to this review. However, while Lyons reports evidence from many different sources, including some which rely on quite aggregated data, we intend to review articles where evidence relates to the actual formalized document. Moreover, our focus on contract design, that is, on the structure and content of contractual agreements, also differentiates us from most of the above mentioned works, where the bulk of the evidence relates to the choice between formal contracting and any other alternatives (informal contracts or integrated structures).

[1] The meaning of this expression will be made explicit in Section 2.

Unlike several previous surveys, this study does not limit itself to the evidence on relationships pointed out by a specific theoretical perspective. Rather, we identify a number of processes and dimensions and review whatever regularities have been uncovered, both in theory testing exercises and in exploratory investigations alike.

By design, much of the data presented here relate to the modest, microanalytic, intracontractual level. While the primary, direct implication of the evidence uncovered is the consolidation of a prescriptive contingency framework for contract design, we claim that as a whole, our findings indirectly challenge current research on contracting at quite a fundamental level. In particular, we aver that they question the taken-for-grantedness of the idea of contractual incompleteness with the associated emphasis on extra-contractual governance devices.

The plan of the paper is as follows. Section 2 develops a framework for conducting the review and Section 3 specifies the criteria of sample selection. Actual literature review is accomplished in the following two sections, which are dedicated respectively to substantive and procedural elements of contracting (Sections 4) and to dimensions of the contract as a whole (Section 5). Section 6 is dedicated to the assessment of our findings. Section 7 concludes and points to directions for further research.

2. Organizing the literature review: a theoretical framework

The reliance of early economic theory on a rather abstract representation of contracting has brought about at least two consequences. One has been a relative disregard of the temporal dimension of contracts (Goldberg 1976b: 48). This tendency has interacted with the "legal centralist" assumption that courts work in "an informed, sophisticated, and low cost way" (Williamson 1983) and led to a relative neglect of the procedural aspects of contracts. By contrast, realizing that contracts may span over non-negligible time periods, at minimum fosters the appreciation that contractual terms may require adjustment. Moreover, if court adjudication is costly and imperfect, contracting parties may shift the locus of decision-making and adjustment (…) from the courts to the transactors" (Masten 2000: 34) and fill the contract with aspects traditionally pertaining to enforcement. The concept of 'relational contract' (Macneil 1974) captures these and other objections to the traditional notion of contract. Following Macneil's groundbreaking contribution the concept of relational contract has gained currency within the economic and managerial literature (see, for example, Crocker and Masten 1991). However, to the best of our knowledge, we lack a systematic account of the main processes encompassed by relational contracts. Moreover, the popular notion of relational contract emphasizes extra-contractual means to

complement the contract, rather than processes admitted to contractual specification (Grandori 2006).

A second consequence has been that contracts have been thought of as rather low-dimensional constructs. In addition to realizing that contracts have longer or shorter durations, until recently the economic and managerial literature seemed to measure the heterogeneity of contracts only in terms of higher or lower completeness.

There is one perspective that may help us appreciate both the procedural aspects of contracts and their multidimensionality. Setting out from the observation that contracts are often observed when TCE would expect integrated structures, Stinchcombe (1985) argues that contracts perform the same functions as integrated structures.[2] Integrated organizations, he argues, have elements that create structures that perform functions amid certain types of uncertainty. Having to serve the same functions, he further contends, contracts can be expected to incorporate, at least to some extents, the same elements of integrated structures. A shorthand way of expressing this idea is that contracts are an organizational phenomenon, in the sense that contracts may specify not just pricing provisions – which can be thought of as expressions of market governance – but also mechanisms that are more frequently observed in organizations, like norms, rules, negotiation, voting, authority, etc.. In turn, since those mechanisms differ 'in kind', and are employed to perform different functions, they need not correlate with a single contractual dimension, say, completeness. Thus, contracts partake in the complexity of organizations and their dimensions need to be systematically analyzed.

Here two qualifications are in order. That the governance of inter-firm relationships is high on coordination and procedural aspects has been well known to the organizational literature on inter-firm networks (e.g. Grandori 1997b, Ménard 2004, Nooteboom 2004). However, while acknowledging that contractual and procedural coordination are not orthogonal (Parkhe 1993) organization theory has treated them as quite separate aspects of inter-firm relationships (e.g.: Sobrero, Schrader 1998). Thus, the novelty lies in the claim that *the contract itself* contains aspects of coordination. The second qualification is that while we sympathize with Stinchcombe's contention, we shall not claim that all inter-firm contracts always need to score high on coordination: in many situations contracts akin to the discrete contract archetype may work perfectly well. Thus, what needs to be studied is under which conditions procedural coordination becomes a significant component of contracts.

[2] Throughout his exposition Stinchcombe referred to 'hierarchies'. We assume that he borrowed the term from TCE itself, without implying that the organizations that are substituted by contracts necessarily score high on hierarchical intensity. For this reason we prefer to use the terms 'integrated structures' or 'organizations'.

As witnessed by the articles mentioned before, a review of empirical literature on contracting may be organized in several alternative ways. Here we shall categorize the empirical evidence in a way that addresses the two gaps just mentioned. We propose first of all that contracts consist of a *transactional* part and of *procedural* elements. Within the first term we designate those sections where the parties commit to undertake specific performance in exchange for reciprocal undertakings of the counterparty. Commitments on tasks, resources, outputs and remuneration provisions are the main items in the transactional part. With the second, we designate rights and processes that are intended to serve purposes of dynamic adaptation, integration and preservation of a shared understanding. Among the procedural elements, we identify processes of *decision-making*, to discover the actions that the parties have to undertake to produce the quasi-rent, or to adjust them, if they were envisaged from the outset; rules, or *restraints*, that infuse predictability in the relationship; rights that underpin the *enforcement* of promises through the manipulation of payoffs; *monitoring*, that is instrumental to both enforcement and decision-making. Other elements that possibly might be encompassed within this procedural section are goal statements and term definitions, which delineate the meaning shared by the parties. While certainly important, in the review section we shall not discuss these two items due to a dearth of coverage in the extant empirical literature.

The contrast between transactional and procedural elements parallels the opposition between 'substantive' and 'procedural' (Simon 1976). We claim that that contrast is also rooted in Macneil's (1974) distinction between promise and non-promissory processes, though not made perfectly explicit therein. Finally, we find similarity also with the framework employed in Brousseau (1995) who summarizes the main functions of contracts in the coordination of actions, the enforcement of promises and the sharing of the quasi-rent of the cooperation, and assign each function to a different governance 'mode' (coordination, enforcement, and remuneration mode). Clearly the first two are related primarily to adaptation and integration, while the last one corresponds to our transactional section.

We shall apply this framework to the review of literature that analyzed contracts at the level of individual contractual clauses. As to those studies that focused on the dimensions of contracts, that is, on measurable characteristics of the contract as a whole (or, at least, on characteristics that are largely separable from individual contract terms), we shall organize them according to the four constructs of *duration*, *complexity*, *specificity* and *contingency planning*. While the first two require no comments, the others may sound unfamiliar. We shall argue that they are more adequate labels for two distinct dimensions that are often referred to as 'completeness'. Potentially, several other meaningful dimensions could be defined, as pointed out by Suchman (2003) who proposes asking

also how 'flexible', 'permeable' or 'durable' a contract is. However we restrict ourselves to those on which empirical investigation have actually been conducted. But before we start the review, we shall briefly specify the criteria we adopted for sampling the literature.

3. Sampling criteria

As already mentioned in the Introduction, the focus of our review will be on empirical studies of formal contract design in inter-firm relationships. Making it explicit that we restrict ourselves to 'formal' contracts is by no means redundant, since a number of studies have addressed informal, not legally enforceable agreements and revealed that they can be effective governance structures in industries as diverse as rail freight or lobster catching (Shelanski, Klein 1995).

As to restricting our investigation to studies of 'contract design', this is intended to leave outside the scope of our survey those empirical investigations where the explanandum is the choice between discrete governance alternatives, like 'pooling contract' vs. 'joint venture' (Sampson 2004), 'formal contract' vs. 'trust' (Woolthuis, Hillebrand, Nooteboom 2005) or between discrete contract forms like 'company-owned', 'lessee-dealer' and 'open-dealer' (Shepard 1993). Stated differently, it means that we require that in the studies we review contract terms be considered as a design variable.[3] On the opposite end of the spectrum, this leaves out also those studies that take a contract term for granted and focus instead on the *level* of one or more variables where the decision is assigned by contract to the parties.[4] Additionally, focus on inter-firm relationship leaves out other fairly well investigated fields, notably, that of employment contracts.[5] A further qualification is that by 'empirical studies' we mean those based on observation of real-world contracting, either by means of contract analysis or by questionnaire survey. Hence, we shall not review the testing of contracting theories based on experimental approaches.[6] Finally, we shall focus our search preferentially on articles written in the last decade, making exceptions when we feel that particular contractual processes are underrepresented in recent literature. Although we are not particularly concerned with achieving comprehensiveness, we trust that not many important articles strictly fulfilling the above-stated criteria have escaped our search. A reader interested in comprehensiveness may complement this article with the reviews mentioned above, though their focus is partially different.

[3] Indeed, this requirement wipes away the bulk of the TCE-inspired empirical literature on contracting and restricts the target population to a few dozen articles.
[4] For clarity's sake, this means neglecting essentially those studies in the specialized literature on franchising that have investigated the antecedents of variables like the level of the 'initial fee', 'royalty rate', etc.. The interested reader may refer to Lafontaine and Slade (1998) for an excellent review of the empirical literature on franchising.
[5] We neglect also some specialized literature, like that on public debt and agricultural contracts.
[6] Readers interested in this kind of studies may refer to a paper by Keser and Willinger (2002).

4. Transactional and procedural elements of contracting

Our review begins with the presentation of the empirical evidence concerning the contracts' transactional part and procedural elements, while in Section 5 it will focus on the evidence concerning various contractual dimensions. Based on our framework, commitments on tasks, resources and outputs belong to the transactional section of the contract. Yet empirical investigations that are relevant to these items normally focus on the specificity of contractual terms in general and on the extent to which they are expressed in contingency form. Thus, due to the different level of analysis we shall review evidence on these items in the section of contract dimensions.

4.1. Transactional elements: remuneration and risk allocation

Remuneration provisions are one contractual mechanism through which many goals are simultaneously pursued. Through compensation mechanisms the parties share the quasi-rent of the collaboration, provide incentives to adopt efficient behaviour, allocate risk, promote efficient adaptation and balance different types of hazards. During the life of a contract, the remuneration of the parties may require adaptation. However, since price-adjustments have often a zero-sum quality (Williamson 1979), revisions are effected rarely, often in a formulaic way, so that in the ultimate analysis, what is subject to adaptation is not the contractual provision per se, but the actual remuneration. On account of their salience and their relative stability, remuneration provisions may be regarded as a substantive aspect of the contract, its core, and contrasted to other, more procedural parts. Indeed, this motivates the almost exclusive attention dedicated to them by early studies of contracting[7].

Understandably, due to their centrality remuneration provisions have been the object of a large amount of investigation, which would be quite hard to summarize here satisfactorily. Accordingly, we shall rely on the reviews by Lyons (1996) and by Masten and Saussier (2002) to provide a concise account of the findings concerning the sharing of risk and the provision of incentive to effort, while we shall focus on those contracting problems that arise from the existence of specific investment.

With regards to *risk sharing*, Lyons summarizes the extant theories by saying that the contracted payment scheme should reflect the parties' relative attitudes to risk, and that risk sharing,

[7] "Previous literature [focused] only on the strictly 'monetary' aspects of the contracts" (Arrunada, Garicano, Vazquez 2001: 257). "Empirical transaction-cost research on contract design has looked primarily at three types of provisions: incentive provisions, pricing structures and price adjustment methods" (Masten, Saussier 2002: 285).

via royalties or profit sharing, is more likely if risks are large. However, the empirical literature he surveys provides no support for both hypotheses, even in sectors, like franchising and agriculture, where sharing, respectively through royalty payments and sharecropping, is the norm. A practice that is consistent with risk sharing is payment on a cost-plus basis, which is sometimes observed in large projects between the general contractor and its subcontractors. However, Lyons notices that since this practice requires open-book accounting, it may be equally a device to extract the full gains from trade, rather than to absorb risk.

As to *effort incentives*, the main testable proposition of the extant theories is that when effort by one party affects the costs or benefits of the other, contracts should include explicit incentives, through trading off incentives against inefficient risk-bearing by the agent. Here the evidence available is more consistent with the theory. For example, franchising royalty rates across franchises tend to vary with the importance of the effort of the parties. However, Lyons (1996) reports also evidence by Bhattacharyya and Lafontaine (1995) who observe that in profit sharing contracts, payment rules tend to be simple and linear (unlike the complex incentive schemes of the theory) and quite stable across time and across agents of the same principal. Finally Lyons (1996) observes limited use of incentive contracts outside particular business relationships like franchising, Japanese keiretsu's and technological licensing. His hypothesis is that in order to attribute value added to a particular relationship, one party has to be uniquely dependent on the other, but this condition is rarely obtained. More commonly, the effort input is surrounded by 'noise' that confounds the measurement of the quality output. This hypothesis has been confirmed in a recent study by Kalnins and Mayer (2004) that in the context of IT service contracting found that greater incentive intensity is associated with a reduction in measurement problems.

When transactions are backed by substantial specific investments, durations tend to be long, and pricing structures may be used *to promote efficient adaptation*. A notable example of research in this stream is found in Masten and Crocker (1985). Based on a database of natural gas contracts, the authors analyze the antecedents of 'take-or-pay', or minimum-bill provisions, which require purchasers to pay for a contractually specified minimum quantity of output. As better explained in Crocker and Masten (1988), these clauses can be interpreted as penalties for efficient breach of contract, mechanisms that set appropriate incentives for contractual performance and provide flexibility in long-term contracts while reducing the number of clauses that are liable to misinterpretation or deception.[8] Masten and Crocker's findings are that the percentage of 'take'

[8] Hubbard and Weiner (1986) have also interpreted take-or-pay provisions as efficient responses to the need for adjustment in long-term contracts. DeCanio and Frech (1993) show how an efficiency interpretation of take-or-pay provisions in natural gas supply is more convincing than alternative arguments based on market-power, and provide an estimation of the efficiency gains entailed by vertical contracts with minimum bill provisions.

obligation varies significantly, and in the predicted direction, with characteristics that affect the value of the commodity in alternative uses. The lesson to be drawn here is that the need to strengthen the incentives for contractual performance decreases with conditions that alleviate the 'small number' situation facing the party which has invested in specific assets. According to Masten (2000: 36) these findings support an "incentive interpretation over the alternative view that take-or-pay provisions serve distributional or risk-sharing purposes".

In long term contracts pricing structures may need to be chosen also with an eye on *balancing different types of hazards*. A study by Crocker and Reynolds (1993) is normally presented as an attempt to prove that the degree of contract completeness is endogenous to the relationship, but it tells a lot also about how to choose between alternative pricing provisions.[9] In the setting they analyze (military equipment procurement), contracts are very structured and compensation provisions can take five alternative arrangements differing in the degree in which they allow for ex-post adaptation. Fixed-price complete contracts, that put risks on the supplier while giving him high-powered incentives, are susceptible to maladaptation. Conversely, in the pricing solution were ex-post negotiation is less constrained and risk is shared, the parties face the possibility of hold up. The data Crocker and Reynolds analyze relate to 45 airplane engine procurement contracts. Expected opportunism of the supplier is found to be conducive to higher incentives and less risk sharing, while task uncertainty is found to favour an opposite arrangement. Incidentally, a negative relationship between uncertainty and incentive intensity has been found also in the above-mentioned study by Kalnins and Mayer (2004) on a much larger dataset with 394 observations.[10] One lesson from Crocker and Reynolds (1993) is that 'opportunism' is not to be assumed; rather, in real-world contracting situations it is a trait of character that the parties try to gauge based on available information.[11] The second lesson is that as contractual performance increasingly involves unforeseen or nonquantifiable contingencies, if both parties can make a contribution to reduce it through continuous negotiation of specifications, the efficient contracting solution is an agreement entailing risk-sharing.

A similar balancing of different risks through the pricing mechanism – though in more discrete form – is also visible in the context analyzed by Corts and Singh (2004). These authors investigated the two typical pricing solutions (turnkey and dayrate) that are commonly observed in contracts for offshore oil-drilling, a context characterized by task uncertainty and asymmetric information. The first one is essentially a fixed price contract, which ties the actual compensation of

[9] We shall discuss the implications of this study for contract 'completeness' in section 5.4.
[10] This study also found that contracts associated with lower incentive intensity tend to be chosen as prior relationships between the parties (measured at the site level) increase.
[11] In Saussier's (2000) reading of this article Crocker and Reynold's decision to focus on the probability of each contracting party to behave opportunistically was due to data limitations that did not allow measuring asset specificity.

the contractor to their ability and effort to reduce the cost of works. Obviously, a turnkey contract also places the risk of the project entirely on the contractor's shoulders. The flipside of this risk allocation arrangement is that empirically observed turnkey contracts require "carefully enumerating many contingencies and detailing the project specifications ex ante, making it very costly to change the project specifications once the project is underway". The alternative solution corresponds to the cost-plus contract in the construction industry and entails an agreement that "is simpler to write and gives the buyer more flexibility in altering the specifications as the project proceeds; however, this flexibility comes at the cost of introducing a moral hazard problem, as the agent may bill the principal for excessive materials and labor" (Corts, Singh 2004: 231). This is case-study evidence that in order to work properly, pricing provisions require that the formality of the contract takes certain values. In particular, high powered incentives require a low level of ambiguity in the specification of tasks. The authors analyzed a database of 1874 oil-drilling projects, coded from secondary data, and found that task uncertainty and the frequency of interactions on prior projects between the contracting parties reduce the probability that the high-powered incentive solution (turnkey) is chosen. The interest of this study lies in the fact that it reveals that empirically the adoption of high-powered incentives forces the parties to trade safeguards in a socially inefficient way. In fact one party is induced to offer the other better safeguards in the form of a higher programmability of the task (greater detail of project specifications) although this clashes with their own cognitive limits, thereby increasing the risk of contract maladaptation.

In the context analyzed by Corts and Singh as well as in all the typical profit sharing contracts, profits and risks are shared based on an allocation scheme defined ex-ante. However, the sharing of profits and risks can also be agreed ex-post. In this case the common wisdom would be that the sharing be based on each party's marginal productivity. In reality also a 'democratic' solution is feasible. In the case studied in Dekker (2004) where the collaboration investigated had team production characteristics, the sharing of the surplus was based on a rule that being open to the possibility of some manipulation, due to its implementation technicalities, also needed the ex-post mutual agreement of the parties to ensure medium term viability.[12]

In sum, the studies reviewed support the idea that in situations characterized by some form of reliance on the counterparty, the flexibility of the specification of remuneration performance is sensitive to the conditions of behavioral and task uncertainty, and requires a comparable flexibility in the specification of task obligations. Studies on compensation provisions in contracts involving

[12] "For cost reductions in operating and maintenance activities, which are difficult to measure with RIB's [company name] cost data, the partners in good faith simply agreed to 'negotiate a reasonable estimate' of the savings, to come to a fair division of the alliance's financial benefits" (Dekker 2004).

joint-action are rare and stimulating, and sometimes they reveal quite unconventional arrangements on this, most focused upon, contractual mechanism.

4.2. Procedural elements

4.2.1. Decision making

When contract duration is non-negligible, the terms agreed may require adaptation. In certain cases, the contracted over matter is so uncertain that performance requirements cannot be defined at the outset and the contracting parties must establish mechanisms for substantial "post-contractual planning" (Macneil 1974). In either case contracts may require decision making. One theoretical perspective that has implicitly stressed the importance of decision-making in relation to contracts is the incomplete contracts theory (ICT) (Hart 1995). However, while ICT emphasizes the optimality of concentration of decision rights (unless the assets under each party's control do not affect the other's marginal return on investments (Hart 1995: 45-6), actual contracts exhibit various patterns of allocation.

In long term contracts price adjustments are often effected through *negotiation*, not necessarily as a consequence of conduct designed to evade performance, but as a result of processes enshrined into contract language. The antecedents of the resort to negotiations have been investigated by Crocker and Masten (1991) in the context of natural gas supply and in the above-mentioned article by Crocker and Reynolds (1993). The former study finds that in contracts with longer duration and higher rigidity in other provisions, the price adjustment process switches from redetermination (adjustment by formula) to renegotiation.[13] The latter finds that as task uncertainty increases and the supplier's proclivity to opportunism decreases, the pricing mechanism becomes increasingly less specified, and for extreme values of those variables, price is determined through an almost totally unstructured ex-post negotiation. Overall, these findings are consistent with known properties of negotiation, which is viable even under high informational complexity and conflict of interests. Moreover, they indicate that negotiation may complement other contractual means to supply contracts with the required flexibility.

It is useful here to mention another of the studies already reviewed which investigates the adjustment of remuneration through options to exercise rights of *unilateral decision*. In the context of natural gas supply, Masten and Crocker (1985) find that the higher the factors alleviating the supplier's dependence, the less constrained the decision rights granted to the buyer are.

[13] Methodologically this study deserves mention for proper econometric handling of the *simultaneity* of dependent and independent variables (values for 'duration' and 'take or pay' estimated from separate regression and fed as independent variables into the model of price adjustment).

Third party decision-making is also not unheard of in contracts. For example, Stinchcombe (1990: 225-6) mentions that contracts for construction and large engineering projects "quite often contain language to the effect that the contractor is to accept the orders of a specified person (… typically called "the Engineer"…) on all change orders". Resolution of disagreements on technical issues through industry experts is provided for rather routinely also in pharmaceutical biotechnology contracts (Furlotti and Grandori 2007). Unfortunately, we do not know of any study that tackled this issue systematically.

A number of investigations concerning the allocation of decision rights in contracts have drawn inspiration from ICT, and have focused on the lopsidedness of the allocation of control rights between the contracting parties. To the extent that these studies focus on the concentration of decision-making, they can be considered as investigations on the use of *authority* in contracts.

One study in this perspective, Lerner and Merges (1998), is also an early example of an empirical investigation through large-sample quantitative analyses of a large number of clauses of R&D contracts.[14] The main discovery of the exploratory section of the paper is that control rights are parsed finely. "Practitioners suggest no single control right stands out as critical. Rather, it is the accumulation of rights to control contingencies that makes an alliance particularly favorable to the R&D or to the financing firm" (Lerner, Merges 1998: 134). After the exploratory section, the analysis shifts to the investigation of the antecedents of the *total number* of control rights, and it is framed as a test of Aghion and Tirole's (1994) control model. Consistent with the model, the results confirm that the allocation of rights is strongly affected by the relative financial conditions of the contracting parties, an aspect often underplayed by the ICT tradition. The empirical findings also seem to contradict Aghion and Tirole, inasmuch as they show that in alliances negotiated at early stages of the discovery process, when the input of the R&D firm is supposedly more critical, R&D firms are allocated fewer control rights.[15]

Kaplan and Strömberg (2003) analyze the actual contracts between venture capitalists and entrepreneurs, with the expressed purpose of "informing theory". Venture capital contracts set up an ongoing relationship that is supposed to last for a long period. Accordingly much of their contractual provisions do not relate to a specific task. Rather, they allocate particular control rights, set up governance structures and establish procedures that are supposed to steer the company through many unforeseeable contingencies. The authors regroup these variables in four major

[14] Strictly speaking the data analyzed are not exclusively contract clauses since the variables are coded from information collected by a specialized industry analyst that relies on a variety of sources, besides contracts.
[15] Given the puzzling nature of these results, it is a bit unfortunate that the authors did not discuss in detail the issue of endogeneity since it is perfectly conceivable that the financial strength of the R&D firm is affected by the number of patents it holds, the proxy for project maturity.

groups of rights: residual cash flow, board, voting, and liquidation rights.[16] The major finding of their analysis is that various rights are allocated separately (as found also by Lerner and Merges, 1998), and are not perfectly correlated: ownership and decision rights need not be perfectly aligned. This supports a view that control is more multi-dimensional and continuous than commonly thought, and that it can be established contractually. Rights are distributed approximately as predicted by the major extant theories, in particular by the classical principal-agent and by control theories. In particular, in the control model of Aghion and Bolton (1992) the project yields both monetary benefits that are verifiable and transferable to the financier, and private benefits that are non-verifiable and go only to the entrepreneur. This introduces a conflict of interest. The model predicts that the higher the profitability of the project and the lower the conflicts of interest, the more control moves from the investor to the entrepreneur. Kaplan and Strömberg's findings are consistent with this model, inasmuch as in ventures with greater initial uncertainty about viability, the venture capitalist receives more board and voting control and the entrepreneur receives less.[17]

Kaplan and Strömberg further carry on their investigation in a later paper (2004). Here the analysis focuses on the *antecedents* of selected incentive and control mechanisms (e.g.: founder cash flow incentives, board rights, staging of funds), modelled independently from one another. The difference with the previous paper is that in order to measure the independent variables the authors rely on a wholly different source of information: the venture capitalists' own assessment of risk.[18] One reason of interest lies in the fact the study provides a rare test of *task complexity* (operationalized as "difficulty of execution risk") as a predictor of contractual clauses.[19] The results of the analysis are supportive of the idea that internal risk (hidden information, hidden action, disagreement, and hold-up) is a powerful predictor of contractual characteristics. In particular it is associated with a greater allocation of authority to the venture capitalists (VC) in the form of board control.[20] Conversely, task complexity is not significantly correlated with greater authority to the VC, while it impacts positively and significantly on contractual terms that are intended to reduce the

[16] Clearly only some of them relate to decision-making.

[17] Consistent with the predictions of agency theory (Holmström 1979), the paper also found that the pay-performance sensitivity of entrepreneur's remuneration decreases as asymmetric information about venture quality declines.

[18] Since the variables come from a variety of documents - not just from the contract - and are often common between successive contracts, it can be said that the unit of analysis is the *deal* rather than the contract.

[19] In this paper subjectivity in the measurement of this and other independent variables clearly could be an issue. To circumvent this problem the authors supply readers almost literally with each sentence in the investment analyses documents that relate to the focal independent variable, and the way it was coded.

[20] "Higher internal risk is associated with more VC control, more contingent compensation to the entrepreneur, and more contingent financing in a given round (…) Overall, we interpret these results as very positive for the agency theories (…) External uncertainty is also related to many contractual features. Like internal risk, higher external risk is associated with more VC control and more contingent compensation (…) with increases in VC liquidation rights (…) These findings are highly inconsistent with optimal risk sharing between risk-averse entrepreneurs and risk-neutral investors" (Kaplan, Strömberg 2004: 2199).

entrepreneur's incentive to leave.[21] In our opinion this suggests that authority is powerless in the face of 'epistemic' uncertainty and the remedy is to be expected from mechanisms that lock-in the human assets and preserve the continuing association of resources.

Another contractual setting where authority has been found to be quite important is franchising. Franchising contracts are most often analyzed with principal-agency theoretical lenses. Therefore one would expect that their contracting problems can be solved through the arrangement of a proper set of incentives. However Arruñada et al. (2001) find that in that setting authority also plays a non-negligible role. In particular, they observe that franchising contracts in automobile distribution assign the manufacturer various "completion rights" that allow him to "render more precise and to adapt to environmental changes the obligations of the parties" (Arruñada et al. 2001: 259).[22] The authors posit that the allocation of authority to the car manufacturer should be positively related to horizontal network externality, that is, to the possibility for the dealers to damage brand reputation through improper behavior; and to the principal's reputation, probably the main protection dealers have against principal's opportunism (Arruñada, Garicano, Vazquez 2005). The authors find that these hypotheses are supported by the evidence offered by a database of 23 franchising contracts.

One motive of interest in this study lies in the fact that it carries out an investigation of the complementarities among contractual clauses. Through the analysis of conditional correlations, some pair-wise complementarities are uncovered. In particular authority is found to be complementary with termination rights, which suggests a complementarity between decision-making and enforcement mechanisms. While this analysis represents a progress over studies investigating provisions in isolation, the method adopted does not allow us to see whether contractual clauses are bound together in wider patterns.

To summarize, even in inter-organizational relations that do not involve the creation of legal entities, the parties may become subject to the 'fiat' of some actor, as a result of the contractual governance.[23] The power to fiat may be assigned to either party, to both parties, to both parties jointly and also to third parties. Contractual adjustment through joint decision making tends to increase when the rigidities in the contract are greater, the task uncertainty higher and the history of

[21] "Execution risk is significantly positively related to founder time vesting provisions and negatively related to contingent compensation and VC liquidation rights" (Kaplan, Strömberg 2004: 2200).

[22] Just to mention a few, the manufacturer has the authority to decide the sales targets, the size and décor of the show room, to set the maximum authorized price, etc.

[23] Here we are using the term 'fiat' simply in the sense of a right to make decisions, even against the will of the counterparty. Following Williamson (1991) it could be argued that in a contractual relationship such a right is qualitatively different from that of an internal organization, since "courts will refuse to hear disputes between one internal division and another" over technical issues (Williamson 1991: 274). However, such a difference is no longer clear if the parties wave their rights – as they often do (Ryall and Sampson 2003: 14, Grandori and Furlotti 2007: 29) – to bring disputes to courts.

the parties of past litigations lower. Contractual assignment of rights of unilateral decision is more generous the less consequential those decisions for the party subject to them are. Control rights assigned contractually can be parsed almost at will. A party that is assigned enough of them can exercise actual control, regardless of the ownership of assets. The distribution of rights among the parties is sensitive to efficiency consideration: fewer rights are assigned to the party with a conflict of interest. However, the actual allocation of control is also significantly influenced by the parties' respective bargaining power at the time of entering the agreement. Finally, assignment of decision rights to one party seems to be complementary with the simultaneous assignment of means of enforcement to that party.

4.2.2. *Enforcement*

"Economic theories of contracting for the most part give little specific attention to enforcement issues; the presumption being that the courts will make sure (subject only to verifiability constraint) that whatever terms contracting parties arrive at are fulfilled" (Masten 2000: 26). If this portrait of economic theories of contracting is accurate, we can say that at least in this respect empirical studies are making a significant contribution to the advancement of our understanding, inasmuch as some studies have undertaken to investigate if and to what extent contracts set up mechanisms for self-help.

The mechanisms examined in the above-mentioned study by Arruñada et al (2001) are second-party termination rights.[24] The rationale for considering termination rights a mechanism for enforcement is provided by Klein and Leffler (1981), who argued that the existence of a flow of quasi-rent, coupled with the threat of termination, is sufficient to assure performance if the parties perform repeat transactions. The authors find that in the context of automotive dealership franchising, manufacturers' termination rights are positively and significantly related to variables proxing the horizontal externalities arising from dealers' shirking and, as seen before, that termination rights are called for (complementary with) by the presence wider decision rights of the franchisor.

Lerner and Malmendier (2005) investigate enforcement mechanisms in the context of biotechnology research agreements. They observe that contracts in this setting often assign unilateral termination rights coupled with expanded access of the financing firm to the intellectual property of the alliance. The authors propose a model that interprets this feature of biotechnology R&D contracts as a way for the financing firm to achieve a higher expected payoff from the collaboration than in the alternative case of contracts without such option, when the research output

[24] Arruñada et al. (2001) also consider monitoring rights. We shall treat monitoring as a separate dimension and report their findings later.

is non contractible and the R&D firm is cash constrained.[25] The rationale for this explanation is that the parties may remedy the shortcomings of contractual incompleteness (meant as the impossibility to contract over the exact nature of certain tasks and to prevent that the partner engages in multitasking) by assigning decision rights that govern the actions of the other party. The authors underline that this represents a departure from previous models that emphasized the allocation of firm ownership.

The empirical part of the paper tests propositions developed in the theoretical model.[26] The findings indicate that non-contractible output, a proxy for contract incompleteness, significantly affects the probability that the R&D contract contains termination and intellectual property reversion rights. The authors also discuss at some length how the results can be better reconciled with their property-rights explanation rather than with alternative stories based on uncertainty and asymmetric information.

Contractual hostages are one particular type of contractual enforcement mechanisms that operates in a pre-emptive way, that is, that does not require ex-post affirmative action, unlike termination rights. Helm and Kloyer (2004) analyze the bonding function of hostages in the context of R&D interfirm cooperation. In such setting, they argue, the R&D exchange supplier faces a double risk. The first and foremost is that the buyer insights into his own knowledge foster the creation of a competitor. The second risk is that the potential for supplier's return on his (largely intangible) specific investment is threatened by his dependence on the buyer and by the uncontractibility of a basis for shared revenues when the R&D exchange concerns early stages of the research process. As suggested by TCE, Helm and Kloyer posit that those risks could be controlled by contractual hostages supporting an option for the supplier to negotiate a share of continuous returns when the prospects for producing a marketable product become clearer. Further, the authors analyze an array of contract clauses that could play the role of hostages thanks to the possibility they entail in blocking or impeding the production and marketing of a final product.[27] Using a database of 98 questionnaire observations, Helm and Kloyer show that empirically some such hostages are perceived to be effective by the R&D suppliers that actually had them included in a contract, the more so the higher the uncontractibility of research output.

[25] It must be noticed that the contract the authors focus upon only improves the payoff of the financing firm, not the overall surplus. Therefore the allocation of property rights it establishes is profit-maximizing for the financing firm only if it is assumed that the R&D firm is financially constrained, hence unable to compensate the financier for agreeing to a different arrangement.

[26] The dependent variable is operationalized in two alternative ways. All the operationalizations deliver approximately the same results. The operationalization of the main independent variable (non contractibility of output) takes advantage of a particular feature of biotechnology research, where it is easy to classify projects according to the fact that a lead product candidate is specifiable or not at the time of the agreement.

[27] These clauses include supplier's threats, like the right of exploitation of further developments of the contractual project, and buyer's commitments, like the right of the supplier to be informed about further developments.

In the context of business-format franchising, Bercovitz (1999) investigates post-termination non-compete covenants that, she argues, enhance the credibility of the franchisor's threat to seize (or render worthless) the hostages posted by the franchisee. Her findings are that the strength of these type of safeguards increases positively and significantly as the free riding hazard rises.[28]

One study by Ryall and Sampson (2006) focuses on the antecedents of the inclusion of enforcement mechanisms in the contract, without asking which of the parties controls them. These authors have developed a scheme to code variables from actual content of technology alliance contracts, and have measured two items relating to penalties.[29] In a sample of 52 such contracts that involve actual joint development Ryall and Sampson find that every item of penalties is present at least in 11% and at most in 32% of contracts. The salience of these means of enforcement is increased by the fact that in the majority of the contracts in their sample the parties waive rights to court access for disputes. The authors do not test any specific hypothesis, yet besides providing descriptive results, they conduct formal statistical analyses of the sample focusing on the relationship between proxies of relational mechanisms and the use of penalties in contracts.[30] Two of the proxies are found to affect positively and significantly the level of penalties while the control for uncertainty (breadth of technology) is found to have a negative impact.

A case-study by Dekker (2004), analyzes how greater contractual formalization (when feasible) may be a sufficient safeguard to the parties, and how it is called for by an increase in dependency. In the buyer-supplier alliance analyzed, the parties had a long standing business relationship in which many issues, including intellectual property, had never become sensitive. The decision to strengthen the relationship into a strategic alliance brought to surface the fact that deeper interaction could expose them to different risks, both related to proprietary knowledge: the supplier could be exposed to the spillover of sensitive information while the buyer was risking excessive dependence on technical knowledge that was only partly codified. These concerns were cured through reciprocal concession of commitments, supported by greater formalization of intellectual property rights (IPR). Unlike the context analyzed by Lerner and Malmendier (2005), here IPR's main function was not to generate incentives to exert effort; rather, it had a simpler, more defensive purpose of preventing expropriation. Thus, an additional contribution of this paper is to bring to our attention the fact that the appropriation concerns that must be dealt with may extent beyond the sharing of the financial proceeds from the exchange, and also include intermediate and ancillary resources that the parties bring to the collaboration.

[28] 'Free riding hazard' is a variable capturing the interaction of the brand-name value and the spillover of the effects of franchisee's improper behavior on the rest of the franchise.
[29] The items considered are 'financial penalties for underperformance' and 'right to terminate for underperformance'.
[30] The authors analyze also the influence of relational mechanisms on other contract terms. We shall present other results from this study in Sections 4.2.4 and 5.4

In sum, contracts do set up mechanisms that reduce the need to rely on court adjudication for enforcement. One way to reduce the probability of non-performance, whether opportunistic or accidental, is greater contractual formalization. When formalization of some aspect of the relation is unfeasible, contracts may deter non-performance either through the assignment of certain decision rights or through contractual hostages. The intensity of either form of enforcement tends to increase with the dependence of one party upon the other.

4.2.3. Rules and restraints

'Restraints' is a legal term that is frequently used in competition law and policy, which was introduced in the economic theory of contracting most probably by Klein and Murphy (1988). Klein and Murphy do not explicitly define it. Instead, they refer to a series of practices that are commonly understood as such. A definition is found in Lafontaine and Slade (2005), but it refers generically to "any restriction that is imposed by one member (…) on the other member of the relationship".

While research on restraints usually addresses their consequences for competition and social welfare, a study by Brickley (1999) analyzes them as efficient responses to certain contracting problems. Brickley focuses on the three contractual clauses (restrictions on *passive ownership*, *area development plans* and *mandatory advertising*) that are specific to franchising contracts, that he interprets as a means of providing incentives to exert effort in a principal-agent relationship. In his model 'restrictions on passive ownership' have the effect of restricting the agent from allocating effort to other outside activities, thereby reducing the opportunity cost of working at the unit; 'area development plans', by granting the agent a claim on multiple positions, internalize some effects of the agent's effort and reduce the horizontal free-riding problem;[31] finally, 'mandatory advertising' cures the free-riding problem by setting a minimum level for an observable input to be supplied by the agent. His findings are supportive of the hypothesis that use of these clauses increases with the intensity of various measures of horizontal externalities.

While an incentive interpretation is credible for the first two restraints, it is much less so for the third one. With 'mandatory advertising' the franchisee is forced to provide the required performance not by implicit incentives, but by the explicit prescription of an easily observable and verifiable input.[32] In our opinion this restraint is better seen as governance by rules. While in principle the franchisor's main concern should be with the output of the relation (the royalties),

[31] As argued by Klein and Murphy (1988), as long as the marginal return to a franchisee is only a fraction of the total return of an extra sale, the franchisee chooses to provide a lower amount of services than would be optimal from the point of view of the whole franchising network.

[32] The prescription of a specific amount of advertising does not remove the externality, so that the marginal return to the agent of additional expenditure is lower than his marginal cost. Thus if actions could not be observed, the franchisee would still have an incentive to free ride.

amid uncertainty about the process that delivers the best outcome, all the franchise stands to gain by the setting of rules that infuse predictability in the relationship, by prescribing specific behavior, while saving cognitive effort in terms of search, calculation, negotiation and conflict resolution. If this interpretation is correct Brickley's finding would indicate that in relational contracts, the prescription of specific behavior through rules increases with the level of externalities. Overall, the role of rules in contractual governance has been the focus of very little investigation. Yet the evidence available indicates their use in contracts is influenced by contextual factors that deserve further analysis.

4.2.4. Monitoring

Monitoring may be considered as an integral part of the enforcement apparatus (Brousseau 1995). Indeed agency theory (Jensen, Meckling 1976; Fama, Jensen 1983) sees it principally as a cure to conflicts of interests. However, monitoring may be useful also to prevent non-performance that is simply accidental or caused by insufficient skills. Thus, there are reasons to analyze it as a process not entirely explained by the same factors as enforcement.

Arruñada et al. (2001) investigate the use of monitoring in franchising relationships as a device to control for franchisee's moral hazard. They estimate the regression coefficients of the number of monitoring rights assigned by the contract to the franchisor on three independent variables capturing the cost of horizontal externalities arising from possible agent's misbehaviour, as in their analyses of control and termination rights, and find that greater risk and consequentiality of shirking is significantly associated with more obtrusive monitoring. Additionally, they find that the intensity of monitoring rights is complementary with the use of incentives, as is to be expected.

Another study of franchising contracts (Bercovitz 1999) also measures the presence and the levels of contract terms relating to monitoring. However, since these variables are found to have very little variation (with a presence in over 90% of contracts), the sample is deemed unsuitable to test hypotheses about monitoring.

Kaplan and Strömberg (2003) provide evidence on monitoring in the form of data and analysis on board rights in venture capital financing contracts. Besides supervising and evaluating top management, the board serves other functions related to corporate decision-making. However, Kaplan and Strömberg find out that in venture capital financing board rights (the number of seats allocated to the entrepreneur, to the financing company and to third parties) can be, and actually are, separated from voting rights through explicit agreements, particularly in case of adverse circumstances. This separation allows us to assume that 'board rights' in that sense are somewhat decoupled from authority and decision making, and are an acceptable proxy of the supervisory and monitoring dimensions of contracting. Two major findings of Kaplan and Stromberg on this point

are that board rights allocated to the venture capitalist can be state-contingent (typically they increase with default on dividends), and, overall, they tend to be higher if the company has no revenues at the time of financing. These findings may be taken to suggest that enhanced supervision and monitoring by the principal are required when financial adversities render mistakes more costly and when a short track record makes it more difficult to assess the founder's type.

Dekker (2004), in the above mentioned study of a buyer-supplier alliance, also observes a significant role for monitoring, in an alliance were explicit incentivization is also provided for. In the focal alliance two organizational structures in particular – the alliance board and ex-post mechanisms like open book accounting – contributed to the monitoring function and were instrumental in the reduction of information asymmetry between the partners.

The role of monitoring in inter-firm contracts has been explored also in the above-mentioned study by Ryall and Sampson (2006). These authors find that each of the seven items of monitoring they have developed is present in at least 15% and at most in 46% of contracts and that one of their proxies for relational capabilities (prior deal experience, with any partner) affects positively and significantly the level of monitoring.

In sum, several of the authors reviewed see a role for monitoring in contracting. Empirical evidence confirms that monitoring is a relevant process dealt with in relational contracts. Available evidence is not abundant and it supports hypotheses based on agency theory and ICT. On account of its significance and on the dearth of research about it, this is an issue that warrants further investigation.

5. Contract dimensions

Economists' contractual benchmark is the complete contingent claim contract. 'Complete' means that it leaves no possibility to improve efficiency by an ex-post adjustment of actions. Ex-ante this is achieved by figuring out contingencies and prescribing a joint-surplus maximizing action in correspondence to each them.

As explained in Masten (2000), originally the complete contingent claim contract was conceived as an analytical device to model general equilibrium, rather than as a model of contracting per se. Thus, it is no wonder that it is a highly unrealistic depiction of real-world contracts. Sooner or later the assumption of 'completeness' had to be relaxed. Recalling this genealogy helps in understanding that 'incompleteness' is to be understood simply as "possibility to improve efficiency ex-post" and that its main corollary is the need for governance devices in

addition to the prescription of behavior. However, this change of assumptions also inspired a stream of research that focused on measuring the 'degree of completeness' or related concepts.

Once the assumption of completeness is endogeneized it becomes apparent that it is impossible to achieve the virtues of the contractual ideal type by increasing just one particular contract dimension. Yet, this fact was not immediately realized, and studies in this stream have used a variety of denominations and operationalizations for constructs that implemented the program of endogeneizing "completeness". We shall regroup them under three labels – complexity, contingency planning and specificity – that correspond to three contractual strategies that are supposedly effective in fulfilling two competing requirements: reducing the risk of non-performance and ensuring the possibility of harmonious ex-post adaptation.

However, before "completeness" became an issue, economists and business scholars had already observed that contracts differed in the duration dimension, and had started to investigate it empirically. Thus, following the order by which contract dimensions have become problematic, we shall begin our review from duration.

5.1. Contract duration

According to Klein, Crawford and Alchian (1978) and Williamson (1979) contract duration is a fundamental design variable in the case of exchange backed by transaction-specific investment. In fact, long term contracting is supposed to save the bargaining costs of repeat negotiations, which would be unavoidable if sequential spot contracting were selected instead. However, a longer term also increases the potential for maladaptation. Therefore, opposite transaction costs must be traded-off against each other in deciding the actual contract term.

In an early study of duration Joskow (1987) analyzed the effect of asset specificity on the duration of contracts for coal market transactions between coal producers and electric utility operators.[33] The analyses were carried out on a database of 277 observations of contract variables coded from secondary sources. The results strongly supported the hypothesis that higher specificity is conducive to longer duration. Other studies that provide evidence consistent with TCT's view of duration are Goldberg and Erickson (1987) and Pirrong (1993).

In recent years, an empirical investigation of contract term was performed by Ciccotello, et al. (2004). The authors argue that while previous research has found long-term contracting to be an efficient response to hold up risks associated with investment in transaction-specific *tangible* capital, the same thing should also be true when the investment involved is in *intangible* capital (human

[33] We take this article to represent a series of four that Joskow published between 1985 and 1990 on contracts between coal suppliers and electric plants.

capital). For a given level of investment, the hold-up risk – they maintain – increases with the novelty of the technology. In fact, the more novel the technology the higher the probability that the behaviors stipulated in the agreement will become inefficient at later dates. A test was performed on a database of secondary data on 582 cooperative R&D agreements between Air Force agencies and other partners and lead to the rejection of the null hypothesis that technological novelty has no influence on contract duration.[34]

The possibility that transaction costs *increase* as a consequence of longer contract duration was empirically analyzed by Masten and Crocker (1985). Their investigation strategy sets forth from the idea that in certain markets like natural gas supply, price regulation induces the parties to engage in non-price competition by offering each other non-optimal contract terms (like 'take-or-pay' provisions). In turn, since a consequence of these suboptimal provisions is to raise the potential liabilities of contractual exchange, the presumption is that they would lead to shorter contracts. This proposition was tested on a database of 280 observations of contract terms from a public survey. Contract duration was regressed on incentive distortions and other control variables. The results were largely supportive of the hypothesis: the prospect of inefficient adaptation reduces the willingness of the parties to engage in long-term contracting.

Developing the idea that duration also increases contractual rigidities, Crocker and Masten (1991) investigate the process by which the parties restore flexibility in long term contracts. While the study is properly an investigation into the antecedents of different types of renegotiation provision, it can be seen as providing indirect evidence on the complementarity between price adjustment clauses, duration and explicit breach penalties (take-or-pay)

In sum, these studies confirm that duration is an effective safeguarding device to protect reliance in a variety of contexts, that its benefits must be traded off against the costs it entails, and that its effectiveness is enhanced by the simultaneous use of mechanisms that define admissible dimensions for adjustment. Other studies alert us to the fact that there are contexts like manufacturing where the variability of specifications and perhaps other characteristics of investment make duration less well suited to protect specific investment (Lyons 1994). Future studies may ponder the function served by duration in contexts like technology development and licensing, where long-term contracts are observed, yet duration seems to be have little or no variance (Brousseau, Coeurderoy, Chaserant 2006).

[34] The authors discuss at some length an issue of identification (whether contract duration reflects hold-up risk or the fact that it takes longer to complete a novel project) and conclude that upon controlling for task characteristics that may influence project length independently of contracting hazards, contracts for novel technologies are still significantly longer than contracts for more mature ones. However, the authors had to make do with the limited information about task characteristics that is available in their dataset. Hence there is room for future studies employing richer databases to try isolating project effects and contracting effects.

5.2. Complexity

Contracts are incomplete, we are told, because of the limits of our cognitive capabilities. As a result we must figure out other devices to prevent information problems, motivation problems and incomplete commitment problems. However – one could reason – the higher the stringency of the language and the harder the exertion in foreclosing the possibilities of misbehavior, the more closely real-world contracts would approach the complete contract archetype. This is approximately the reasoning that inspires the research on contract complexity. As a result of greater drafting effort – it was thought – the contract should be longer, include a higher number of clauses and provide for a larger array of enforcement mechanisms.

One early empirical study that investigated these ideas is Parkhe (1993). Actually, this study concerned itself with the wider problem of explaining differential performance of strategic alliances as a function of their structuring. However, Parkhe considers part of this structuring to be both the contractual aspects of the cooperation, and non-contractual governance mechanisms. Despite dedicating only tangential attention to the formal contract, Parkhe devises an operationalization of the degree of "contractual safeguards" that would influence many later studies on contracts in the strategic management perspective (Deeds, Hill 1999; Reuer, Ariño 2002, 2003, 2004; Reuer, Ariño, Mellewigt 2003). What he does is to look at the presence in contracts, or absence thereof, of some clauses (out of a total set of nine) that embody the enforcement apparatus. He assumes that he can rank them in order of "increasing stringency" so that he can assign them a stringency score and summarize them in an index of "ex-post deterrents". Given such operationalization, we think it suitable to consider this a study of 'complexity'. Parkhe's substantive finding is that the intensity of these contractual safeguards is negatively related to the "shadow of the future", that is, to the intended duration of the alliance and to the ease with which the partner's actions are observed.

Another study that is relevant in this context is Luo (2002). Luo realizes that what had attracted attention until the time of writing – the intended 'completeness' of contracts – is actually a cure to two distinct problems: that of motivation and that of incomplete commitment. Hence, he argues, 'completeness' must itself be a multidimensional concept, comprising what he calls 'term specificity' and 'contingency adaptability'. The former "concerns how specific and detailed the terms are". The latter is "the extent to which unanticipated contingencies are accounted for and relevant guidelines for handling these contingencies are delineated in a (…) contract" Luo (2002: 905). This claim is empirically validated because his study finds that the questionnaire items chosen to operationalize the two constructs load on two separate factors in the expected way, and have a high Cronbach alpha in both cases. To our understanding the content domain sampled by 'term

specificity' has little to do with the articulation and extensiveness of the contract. The reason why we enlist this study here is that some scholars have considered 'term specificity' as an alias of 'complexity' and has drawn inspiration form Luo (2002) for investigations on complexity.

Poppo and Zenger (2002) test the idea that the complexity of the contractual governance apparatus employed in outsourcing relations in information services increases with the intensity of exchange hazards. The interesting aspect of this paper is the fact that exchange hazards are not only spelled out as the risk of opportunism, but also include the environmental uncertainty associated with technological change. The authors find the regression coefficient of the latter factor to be negative. Their interpretation is that as uncertainty becomes very severe managers may lose confidence in contracts.

Ariño and Reuer (2002, 2003, 2004) build on Luo (2002) and explain that 'contract complexity' (the number and stringency of the provisions provided) is conceptually distinct from 'contract completeness' (the extent to which the contract accounts for unanticipated contingencies). However, departing from Luo, they propose that lack of detailed knowledge about the transaction a contract refers to (which is most often obtained in cross sectional comparisons of contracts), makes it impossible to compare contracts along the second dimension. Hence they focus on contract complexity and rely on Parkhe (1993) for its operationalization. As to its antecedents, the authors argue that contract complexity increases with the strategic importance of the alliance and with variables that can be interpreted in terms of behavioural and environmental uncertainty. The empirical analyses of Ariño and Reuer (2003), based on 88 responses to a questionnaire administered to dyadic alliances, generally support these relations, particularly the one between complexity and strategic importance. However, variables relating to environmental uncertainty are not significant in several specifications of the model.

An interesting part of this study is that besides estimating models of complexity the authors also explored whether 'complexity' is itself multidimensional. They applied factor analysis to the contract clauses and found that they loaded on two factors, labeled by the authors 'partner control' and 'operations control'. Unfortunately, the limited size of the sample and the small number of contractual clauses that were coded somewhat limit the significance of this exercise.

Another study that provides evidence on contract complexity is Anderson and Dekker (2005). This dimension is referred to by the authors as 'extensiveness' and is operationalized as the number of contract terms included in the contract, out of a pre-defined set of 24. The authors investigate the impact on contractual complexity of all the canonical TCE dimensions of transactions and find them to be significant and of the expected sign, except for uncertainty. Given the context investigated, the authors think that 'size' of the project captures the risk of hold up

better than 'frequency'. Quite unsurprisingly 'size' turns out to be by far the most significant antecedent of complexity.

Overall, we think that the available evidence on complexity and its antecedents is not very compelling, except perhaps the finding relating complexity with indexes of transaction 'size' and 'importance'. Thus, the strongest indication we have that the greater the contractual hazards the more an efficient contract *ought* to be complex, is perhaps one finding in the above-mentioned study of Helm and Kloyer (2004: 1120): "The *perceived* control of both components of exchange risk increases with a *growing number* of contractual hostages" (our emphasis).

5.3. Contingency planning

As discussed by Bernheim and Whinston (1998), empirically, contracts are incomplete in two different senses. First they may make actions less sensitive to verifiable events than would appear optimal. Second, they may fail to specify verifiable obligations of the parties. The investigation undertaken by Mayer and Bercovitz (2003) corresponds to the first of these two notions, and to the contingency adaptability aspect of the question of 'completeness'. Mayer and Bercovitz ask to what extent the parties resort to 'contingency planning'. Their operationalization of the construct grades contracts on a three-point scale based on the degree to which they develop explicit response rules for specific classes of events. The variable is coded from the actual content of 386 contracts. The authors find that the use of contingency planning in a contract is positively related to the level of *task interdependence* and to the *appropriability of proprietary technology*, and negatively related to the *cost of specifying contingencies*. [35]

Based on the same database, Argyres, Bercovitz and Mayer (2007) also find that contingency planning is positively affected by *prior relationships* between the parties. While the result is open to the interpretation that a history of frictions advises the adoption of greater safeguards under the form of stricter contingency planning, the authors subscribe to an alternative reading that repeat interactions allow the partners to develop relation-specific routines, and lower the cost and effort of explicitly planning for contingencies. The findings of a previous multiple case

[35] The last of these relationships is fairly easily understandable. The first and the second one warrant a little clarification. As the authors explain, "contingency planning can place limits on how much of the supplier's proprietary technology must be revealed in the event of changes to the schedule or the addition of new features" and "the parties can outline exactly what access is allowed and what steps will be taken if certain problems occur that may impact the use of the supplier's proprietary technology" (Mayer and Bercovitz 2003: 14-15). This explanation makes clear that contingency planning, *qua* planning, not only enhances flexibility but also specifies, and thus constrains, how the parties will respond to certain changes. To the extent to which contingency planning constrains responses, it is a little surprising that it has been found efficient in situations characterized by one type of interdependence that *prima facie* could be described as 'reciprocal'. In fact under those conditions organization theory would typically recommend coordination by mutual adjustment, rather than by plan (Thompson 1967). Although the coefficient of *task interdependence* is significant at a very high confidence levels, we think this is an issue that requires further investigation.

study carried out by Argyres and Mayer (2004) in the same setting also favor the latter interpretation.[36]

Another paper that addressed the issues of the foresight of contingencies in contracting is Elfenbein and Lerner (2005) that studied this problem in the context of alliances between internet portals and other partners. A peculiar characteristic of the setting is that the realization of contingencies – in the sense of levels of performance of the parties – would be cheaply observed and verified. However, as a matter of fact, contracts are often left less complete than would actually be feasible. Elfenbein and Lerner interpreted this with the help of recent literature on information and control, that proposes that offering (state contingent) control rights to a potential partner in an alliance, is a means by which an agent can signal its quality and its goal congruence. The point of this literature is that the value of the signal to the principal is higher the greater the noise contained in the performance measure and the greater the uncertainty about the congruence of the contracting parties' objective.[37] Consistent with the theoretical model the study finds that a proxy for the anticipated conflict of interests and uncertainty impact positively and significantly on the use of contractual contingencies of performance. Although this study is remarkable in many respects, one should not draw normative implications too hastily. The theory tested is recent and reverses some of the implications of the earlier works, the sample used is relatively small, and the contracts analyzed were frequently signed between start-ups with little prior alliance experience. Overall, we should regard this evidence as tentative.

In this context it is worth remembering the above-mentioned classical study of Masten and Crocker (1985) that allows a dual reading of its findings in terms of contract adaptability. As said above, their study shows how long-term contracts can achieve considerable flexibility through the simple inclusions of a unilateral option ('take-or-pay'), without resorting to many clauses that are liable to misinterpretation or deception. Moreover, in section 4.2.1 we mentioned how decision-making also serves the purpose of adaptation. These examples indicate that in different contexts adaptability may be achieved through a variety of structural and procedural elements.[38] Thus adaptability is better thought of as an emergent property of contracts, rather than as a dimension, and "contingency planning" is a dimension that measures the intensity of use of one particular

[36] Other findings of Argyres, Bercovitz and Mayer (2007) are mentioned in the Section 5.4.
[37] As noise increases, "the difference in the cost of providing the control right for high and low quality firms becomes greater" (Elfenbein and Lerner 2005: 7).
[38] One caveat is in order. We do not claim that unilateral options are suitable to enhance the adaptability of all the types of contracts. At minimum one should be aware that the use of certain unilateral options, like stipulated damages, "requires that most of the uncertainty associated with performance be only on one side of the transaction. If there were uncertainty also on the other side, the penalty stipulated *ex-ante* could lead to inappropriate incentives *ex-post*" (Crocker, Masten 1988: 329).

strategy to achieve efficient adaptation. As seen above, this strategy is increasingly resorted to the greater the ex-ante conflicts of interests and the lower the cost of specifying contingencies are.[39]

5.4. Ambiguity and specificity

While enlisting contingencies is sometimes an unwieldy way of increasing the adaptability of a contract, an alternative strategy is more feasible, although it has its own downside.[40] As noticed by economist Al-Najjar (1995) one way to restore flexibility in a contract is to introduce ambiguity, that is, to state broad requirements without restricting the parties to specific actions. This corresponds to the second notion of incompleteness according to Bernheim and Whinston (1998). Scholars familiar with actual business contracting practices agree that this strategy is quite common. For instance, Turner (2004) informs us that fixed price contracts for construction projects can be based on "fixed design", on "scope design" or on design based on "cardinal points", clearly in an increasing order of specification ambiguity. Although empirical studies generally do not address the issue of 'ambiguity' we can gather some empirical evidence from studies designed to investigate its opposite: contract 'specificity', or contract 'detail'.

The study by Ryall and Sampson (2006), already mentioned for its implications about monitoring, has tried to capture contractual detail through six items that measure the degree to which required inputs, expected outputs and division of intellectual property rights are fully specified. While rich in terms of measuring contract content, Ryall and Sampson's database is somewhat limited in terms of information on transaction characteristics and other contextual variables. Thus it only allows the authors to analyze contractual complexity in terms of characteristics of the *relationship*. Their key findings are that contracts are *more detailed* when firms have prior deal experience, and have engaged in prior deals with the same partner. These findings point to the existence of a learning effect in contracting, whereby the capacity to draft detailed contracts increases with the experience.[41]

Argyres, Bercovitz and Mayer (2007) also undertake to investigate whether the learning entailed by prior relationships between the parties lowers the cost and effort of writing more specific task obligations. The authors fail to find support for this relationship, but find evidence of

[39] Subject to the disclaimer as per note 35, contingency planning also increases the higher the task interdependency between the parties.

[40] "Actual contracts incorporate few if any explicit contingencies" (Masten 2000: 29)

[41] While the authors interpret their findings as indicative also of complementarity between contractual and social governance, we prefer to say they indicate an impact of the 'shadow of the past' on contractual governance. In fact, past alliancing experience is not an element of 'governance', susceptible to design. Rather, from a design perspective it can be regarded as a dimension of the transaction.

complementarity between task description detail and contingency planning. Moreover, since the efforts at planning for contingencies that are made for one contract are associated with increases in the extensiveness of task descriptions in later contracts, the authors can demonstrate quite unambiguously, that the causal mechanism driving complementarity is the existence of learning spillovers.

Another study that informs us about the use and limits of ambiguity in contracting is Corts and Singh (2002). The interested reader may refer to the comments on this paper we made in the section on remuneration and risk allocation. Here we just remark on the implication that the optimal level of contract detail has to be decided by trading off the benefits of controlling moral hazard against the costs of increasing the risk of maladaptation that specification entails. In fact, Corts and Singh find that contracts based on more ambiguous term specification are increasingly opted for when previous experience with the same partner assuages the fear of moral hazard.[42] Similarly, the above-mentioned study by Brickley (1999) may be considered as evidence that the precision of behavior prescriptions in franchising increases with moral hazard (horizontal externalities).

Also the study by Crocker and Reynolds (1993) contains a message about this dimension and its antecedents: ambiguity is endogenous to the relationship and "transactors' choice of contract terms reflects a trade off between the specification costs and rigidities associated with specifying detailed performance obligations (…) and the greater flexibility but higher expected cost of establishing the terms of trade *ex post* (Masten 2000: 37)".[43] Among the factors that call for more ambiguous specifications is task uncertainty, while a known propensity of the contracting party for litigiousness advises a better definition of contractual obligations.

Mayer (2006) also investigates the relationship between contractual specification and contracting hazards. In the context of IT service provision, the potential reusability of knowledge-intensive work ("knowledge spillovers") may create a conflict between the client, interested in seeking a product optimized to its environment, and the supplier, who may sacrifice optimality to enhance the chance of later reuse. Mayer finds that a greater detail in the specification of task associates positively and significantly with a proxy for reusability.

One final work concerning contract ambiguity is provided by Saussier (2000) who analyzes 29 contracts between Electricité de France and its private suppliers that deliver coal to riverside power plants. Saussier purposes to develop the investigation of Crocker and Reynolds (1993) and to

[42] This result is in contrast with what has been found by Ryall and Sampson (2006). However, it must be noticed that while in Ryall and Sampson (2006) contract detail is a six-values polychotomous variable, in Corts and Singh the parties are faced only with a stark choice between 'turnkey' and 'dayrate'. Thus, parties that opt for more detailed contracts (turnkey) have to accept an accompanying sharp increase in maladaptiveness.

[43] For precision's sake, Crocker and Reynolds use 'completeness' instead of 'ambiguity' but the contract characteristic they measure better captures the dimension of ambiguity.

extend the measurement of contract 'completeness' to multiple clauses. However, unlike his models, Saussier does not measure a *level* of specification for each clause and operationalizes 'completeness' as the number of the clauses, out of a set of six, that are specified in the contract. To appreciate the importance of different operationalizations consider that in Crocker and Reynolds more 'complete' contracts are the simplest (fixed price) while in Saussier they have the largest number of clauses. We aver that this is due to Crocker and Reynolds defining completeness *intensionally* (by an external criterion) and Saussier *extensionally* (by the items it contains). Thus although Saussier's contribution is quite innovative in some respect (it is the first paper that endogeneizes the level of asset specificity) its findings do not relate directly to the topic of this section.[44]

In sum, contract specificity is a relevant dimension that is negatively impacted on by uncertainty and positively by behavioral hazards. At least in certain settings, it appears that the existence of relational enforcement mechanisms also favors greater contractual detail.

6. Discussion

The evidence collected in our review of literature, is almost entirely related to dyadic relationships, interactions taking place over a significant time span. Thus, although in the remainder of this article we may use the expression 'contracts' without further qualifications, it should be borne in mind that our statements apply essentially to contractual relations. A second disclaimer is that extant literature on remuneration provisions is particularly rich and well reviewed. Therefore our discussion will focus particularly on the procedural elements and on contractual dimensions

We think that the literature reviewed provides ample evidence of the usefulness of the organizational perspective advocated by Stinchcombe (1985), although we have focused on processes and dimensions, rather than on mechanisms, as originally proposed by Stinchcombe. Contracts are not just collections of promises, as emphasized by classical legal scholarship. They are also "constitutions" that establish procedures to govern the relation over time, as already proposed by Goldberg (1976a: 428). However this review allows us to underscore emphatically a couple of points. First, that the requisite procedural coordination of inter-firm organizations is established, to a considerable extent, *in* the contract. Second, that those procedures support not just 'adjustments' of almost complete plans, but also the discovery of suitable actions, and the adaptation, if not the discovery, of the goals of the relationship, as in venture capital financing agreements or in contracts for joint exploratory R&D.

[44] Saussier finds that the dependent variable is positively affected by asset specificity and negatively by uncertainty.

Among the various classes of operating mechanisms, the procedures for decision-making and for the enforcement of promises have received the greatest attention. Contracts provide amply for decision-making procedures. At times, the allocation of decision rights is highly concentrated, the more so the greater the information asymmetry and the risks it entails. Yet their actual allocation is not entirely explained by efficiency reasons, but may be influenced also by the parties' bargaining powers (Lerner and Merges 1998). Thus one party may be subject to another's 'fiat' as a result of contract instead of integration. While ICT-inspired studies focus on the lopsidedness of decision rights allocation, contractual relations often use negotiation to adapt performance. If properly designed, post-contractual negotiation procedures may be acceptable to the parties, and need not end up in haggling or hold up. Contracts increasingly feature this process the lower the behavioral hazards faced by the parties and the higher the task uncertainty. Based on the known properties of negotiation, we can assume that negotiation is unsuitable in the case of extreme information asymmetries (Grandori 1997a), but this has not been investigated in the studies we have reviewed.

Contractual relations often also set up the means for their own enforcement. These include certain action rights that affect the relation as whole, explicit penalties, rights that give rise to threats and commitments. One indirect indication about the effectiveness of those means is the fact that parties often waive rights to court access for disputes or create obligations that would be difficult for a court to enforce (Ryall & Sampson 2006: 4). The intensity of use of procedures for self-enforcement tends to increase with the intensity of behavioral hazards and with the uncontractibility of output. There is also a little empirical evidence that higher allocation of decision rights to one party is complementary with greater assignment of enforcement rights to that party.

Contractual governance serves its purposes not only through the enforcement of the original promises, or through an affirmative process of decision making, but also through *rules* and vetoes, to make the behavior of the parties more predictable and more congruent with the stated goals of the relation. One common use of rules in contracts is to generate incentives for the parties to invest greater effort in the relation, through the foreclosure of opportunities. This justifies the label of restraints, which is used sometimes to indicate also obligations of positive behavior, not strictly related to the accomplishment of tasks. The working of this operating mechanism in contracts has received limited attention. Available evidence indicates that greater behavioral hazards are conducive to more restraints and that greater task complexity associates with more severe restrictions to exit on the party holding critical capabilities.

Another little investigated process is monitoring. Yet contracts do assign monitoring rights, to the point that in some settings, like franchising, monitoring terms may look more as boilerplate provisions rather than real design variables. The few available studies indicate that the assignment

of monitoring rights increases with behavioral hazards and with their consequentiality for the goals of the relation and that monitoring rights are complementary with monetary incentives. The evidence concerning monitoring and the other processes investigated, is summarized in Table 1 in the Appendix.

Before we move to contractual dimensions, let us comment on a few findings that would represent anomalies in an ICT perspective. ICT generally predicts an all or nothing solution to the problem of contracting: either a contract is totally complete or it is not entered at all.[45] However, the contracts actually observed are clearly not 'complete'. Yet they assign several decision rights that altogether shift the balance of control in favor of one party or the other. These rights are not particularly difficult to parse (Lerner and Merges 1998). Thus, in order to gain control, one party need not 'buy' residual, and partly irrelevant, decision rights through asset ownership. The second anomaly can be appreciated in contrast with ICT's view that the salience of the ownership of physical assets is owed to the impossibility to assign residual control rights over human assets (Hart, 1995: 29). While, absent slavery, that impossibility surely holds in a strict sense, in practice contracts can establish powerful devices, like incentives and restraints, to lock human assets in a relationship and to exert effort and capabilities in its interest (Kaplan, Strömberg 2002), again, without the 'power' entailed by asset ownership.

As to contractual dimensions, common representations seem to appreciate little more beyond the contracts' higher or lower incompleteness and their longer or shorter duration. Our review has documented that more dimensions have been investigated and that still others await investigation. We have assessed that 'completeness' is a misleading label for an empirical construct: the ideal type of complete contract performs functions that impose competing requirements to boundedly rational actors. In the real world these functions need to be served by multiple mechanisms whose impact on contractual dimension is impossible to capture with a one-dimensional construct. Table 2 in the Appendix provides a concise summary of the evidence concerning the antecedents of four contractual dimensions.

Through the observation of the same processes in different contracting contexts this review of literature adds content to the notion *relational contracts.* It lays the foundation for analyzing relational contracts on the basis of their elementary building blocks, and not simply as one archetype opposed to the discrete contract. The notion of relational contract that emerges from our analysis lends itself quite straightforwardly to measurability and to structural-contingency contract design. Although in practice contract relations may benefit from the support of non-economic

[45] Saussier (2000:191) made this point, while acknowledging one attempt by Hart and Moore (1999) to develop a theory of 'partial' incompleteness.

exchange factors "such as social exchange, the motivation of kinship, of friendship, of altruism (…) and of the other psychological and social phenomena" (Macneil 1974: 732), in principle, relational contracts do not need them to be distinguished from discrete contracts: there are structural differentiating elements that are internal to the formal document.

As to designing relational contracts, what has been observed only supports a very general and tentative framework, yet one that is based on observable characteristics of the transaction and of the relation, and not simply on the goals of the parties and on juridical typologies. Such framework would recommend that in the case of transactions characterized by substantial *asset specificity*, the parties should draft contracts of longer duration and greater complexity than in the opposite case of generic assets. More generally, in the face of *behavioral hazards*, contracts should be more complex, prescribe performance more in detail and strive for greater planning of contingencies. The increase in these dimensions would be partly the result of greater formalization of processes for enforcement, behavior control and monitoring. When the hazards relate to hidden action, greater effectiveness of monitoring can be expected if the contracts simultaneously resort to explicit incentives. As to providing flexibility to such contracts, decision-making through negotiation should be used sparingly. Rather, the parties should choose from a roster of alternative means encompassing authority, neutral third parties' decision making, formulaic adjustments, and penalties for efficient breach. Additional circumstances, like the feasibility and the costs of these devices, or the extent of the principal's moral hazard, should guide the selection within this repertoire.

Under conditions of external *uncertainty*, contracts should be longer, if conditions of asset specificity also prevail. Yet contracts could be simpler, and their specification of obligations less detailed. Greater provision for decision-making should be used to specify the parties' obligations as the relationship unfolds. One kind of uncertainty is that which leads to the *uncontractibility* of the output expected from the relation. When this condition couples with substantial informational asymmetry, a lopsided distribution of both decision rights and rights of enforcement may also serve efficiency, and not just reflect a possible imbalance of the bargaining powers of the parties.

The precise level at which all these design variables should be set, may depend also on other factors, like the shadow that the future and the past project on the relation, through the experience the parties have acquired from past transactions, social norms (if any were developed), the expected length and size of the stream of future payoffs, as well as the ease with which they can be observed. The evidence available is rather scarce, and tentatively suggests that the shadow of the past may help greater process formalization, while the shadow of the future supports expectations of self enforcement and reduces the marginal benefit of formalization.

7. Conclusion

This paper has applied an organizational perspective to the assessment of a sample of empirical studies on contract design where stated foci of investigation were sometimes different from ours. Moreover, the studies related to a number of rather heterogeneous settings. Yet the framework we developed has proved reasonably successful in identifying a few common processes and dimensions under the evidence yielded by the literature reviewed. We think that an organizational perspective on contracting can be developed further and is promising of progress both form a methodological and a theoretical point of view.

From a methodological perspective, it should enable us to make sense of the variety of contractual solutions in a reasonably general way, and to overcome our reliance on discrete juridical typologies (e.g. a franchising contract, a joint venture contract, a consortium contract, etc.) or on endless lists of content (R&D, commercial, production, etc.). One example of such reliance is found in research on strategic alliances where a certain governance characteristic, say, hierarchical control, is assumed to be a monotonic function of alliance *form* (e.g., Oxley 1997). While propositions based on that hypothesis may withstand empirical tests, from a normative point of view they imply a much more restricted set of possibilities for governance design than actually feasible.

Second, this perspective should encourage us to draw from the repertoire of coordination processes that organization theory has investigated, both at the organizational and inter-organizational level, and to start a systematic inquiry into whether, and to what extent, these processes are also formalized in contracts.

Third, the consolidation of a framework for analyzing contracts according to common dimensions and processes may help overcome the consequences of the practical difficulties of doing empirical research on contracts. Empirical research on contracts is severely constrained by problems of data availability. As a reflection of such difficulties, studies based on actual contract content are still very few. In the sample we surveyed they were only 11 out of 35 (see Table 3 in the Appendix) despite our bias in favor of that type of data source.[46] These difficulties are not going to disappear any time soon. Therefore, it is important that our understanding of relational contracts is based on the whole range of available evidence, and not just on the small subset of studies that deal precisely with the sector of our concern (e.g., land tenure, franchising, venture capital, etc.). However, this requires the development of a general framework.

[46] The actual figure is smaller than it appears. In fact, some of the studies that investigated actual contract content based most of their analyses on readily-available variables coded by industry analysts, who did not necessarily have specific theoretical concerns in mind.

From a theoretical perspective, the findings of our review of empirical literature indicate that contracts differ from one another by a considerable number of processes and mechanisms, which they incorporate to serve different functions. The extent of such heterogeneity is such that it cannot be captured satisfactorily by variations along a single dimension. This fact is loosely reflected in the various dimensions that different studies have focused upon. However, on the whole the various dimensions investigated have been derived conceptually, have not been clearly distinguished from one another and have not been satisfactorily reconciled with the various mechanisms adopted at the intra-contractual level. This state of things opens up the possibility of a research program that investigates contractual dimensions empirically, in a more grounded and systematic way and that generates empirical taxonomies based on those dimensions.

Another implication from our review is that contracts can employ multiple mechanisms of different kinds to solve the problem of adaptation. The richness of this panoply of mechanisms seems to indicate two consequences. First, adaptability needs not to subtract substantially from enforceability. Second, the classical recipes of ICT and TCE – ownership and hierarchy – are not the only ways to achieve flexible enforcement. The highly documented use of contracting in settings where trust and the shadow of the future cannot be presumed also indicates that the burden of solving this conundrum cannot be put entirely on social governance.

If contracts can do without the standard means of adaptation and have a rich set of devices to choose from, perhaps incompleteness is not as serious a problem as could be inferred by the frequency with which it is postulated in the literature. Therefore, the question of how exactly, and by which combinations of assignments of rights and of coordination mechanisms can flexible enforceable contracts be designed, turns out to be a relevant program for conceptual and empirical research alike. Recent studies are exploring the idea that a hierarchization of the contractual matters is a key to solving the puzzle (Grandori and Furlotti 2006, 2007) but considerably more investigation will be required to develop, operationalize and test this or alternative hypotheses.

Achieving the progress we have envisaged also requires overcoming certain specific limitations. First, we have to enhance our understanding of how various contractual mechanisms combine together. Contractual provisions are chosen simultaneously. Yet the bulk of the available evidence has been produced by analyses of single provisions, in isolation. There are also a few examples of works addressing the issue of complementarities. Yet this issue definitely requires more investigation.

Second, we need to improve our measurement techniques. While the studies reviewed practically indicate that it is possible to analyze contractual relations at a more microanalytic level

than is common in the majority of the extant empirical literature on contracting *lato sensu*, in passing our investigation has also revealed problems of validity and reliability of certain measures of contract variables. The blame is not to be put entirely on empirical researchers. As is evident in the section on contractual dimensions, problems often originate in hazy definitions of the constructs' content domains. Yet, undeniably, there is also a need for better operationalizations.

In sum, focusing on these and other limitations of current analytical apparatus, under the hypothesis that contracts are an organizational phenomenon offers a clear and challenging research agenda, one that promises to reveal that there is more to contracts than just incompleteness.

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Appendix

Table 1: Antecedents of contract procedural elements

Dependent construct	Studies reviewed	Independent construct	Observed direction	Evidence
Decision making	Crocker & Masten 1985, 1991 Crocker & Reynolds 1993 Lerner & Merges 1998 Arruñada et al. 2001 Kaplan & Strömberg 2003, 2004	Behavioral hazards	-	*
		Task uncertainty	+	**
	Notes • Evidence enlisted above refers to antecedents of *joint* decision rights • 'Behavioral hazards' encompasses both a motivation dimension and the consequentiality of potential non-performance Further empirical evidence • Unilateral decision rights are assigned more generously the less consequential they are for the party subject to them • Fewer decision rights are assigned to a party having a conflict of interests • Allocation of decision rights between the parties is influenced by their respective bargaining power • Decision rights assigned to a principal are complementary with the assignment of rights of enforcement • Decision rights need not align perfectly with ownership			
Enforcement	Bercovitz 1999 Arruñada et al. 2001 Dekker 2004 Helm & Kloyer 2004 Lerner & Malmendier 2005 Ryall & Sampson 2006	Behavioral hazards	+	***
		Uncontractibility of output	+	**
		Task uncertainty	-	*
		Shadow of the past	+	*
	Further empirical evidence • Complementarity between enforcement mechanisms and wider decision rights Notes • Studies focused on highly heterogeneous means of enforcement termination rights, penalties, various threats and commitments			
Rules and restraints	Brickley 1999	Behavioral hazards	+	*
	Further empirical evidence • Greater task complexity associates with more restrictions to exit on the party holding critical capabilities Notes • Little investigated mechanism			
Monitoring	Bercovitz 1999 Arruñada et al. 2001 Kaplan & Strömberg 2002 Dekker 2004 Ryall & Sampson 2006	Behavioral hazards	+	**
		Shadow of the past	+	*
	Further empirical evidence • Complementarity between monitoring and monetary incentives • Greater monitoring rights to financier contingent on alliance financial adversities			

Note: 1) The studies enlisted contain evidence that is related to the contract procedural element of the corresponding row, but not necessarily to each independent construct affecting it; 2) ***: relation backed by multiple convergent empirical evidence and theory; **: relation backed by convergence of limited empirical evidence and theory; *: relation regarded as tentative on account of limited evidence, idiosyncratic context or pioneering theory.

Table 2: Antecedents of contractual dimensions

Dependent construct	Studies reviewed	Independent construct	Observed dir.	Evidence
Duration	Joskow 1987 Goldberg & Erickson 1987 Pirrong 2003	Asset specificity	+	***
	Ciccotello et al 2004	Uncertainty	+	*
	<u>Further empirical evidence</u> • Longer duration may increase certain transaction costs • Duration is complementary with contractual adjustment mechanisms			
Complexity	Parkhe 1993 Poppo & Zenger 2002	Transaction size and importance	+	**
	Ariño & Reuer 2003 Helm & Kloyer 2004 Anderson & Dekker 2005	Asset specificity	+	*
		Behavioral uncertainty	+	
		Environ. uncertainty	-	
	<u>Further empirical evidence</u> • Contrasting evidence of relationship between relational governance and contract complexity <u>Methodological problems</u> • Lack of unifying theoretical structure hampers specification of hypotheses • Difficulty to gather good information on both the contract and its context forces scholars to make do with available proxies			
Contingency planning	Mayer & Bercovitz 2003 Elfenbein & Lerner 2004	Conflict of interests	+	**
		Cost of specifying contingencies	+	*
	• Little investigated dimension			
Contract specificity	Crocker & Reynolds 1993	Uncertainty	-	**
	Brickley 1999 Saussier 2000 Corts & Singh 2002 Mayer 2006 Ryall & Sampson 2006	Behavioral hazards	+	**
	<u>Further empirical evidence</u> • Contrasting evidence hints at possible U-shaped relationship between relational enforcement mechanisms and contractual governance or at mediating role of other contextual variables on relational enforcement mechanisms			

Note: 1) The studies enlisted contain evidence related to the contract dimension of the corresponding row, but not necessarily to each independent construct affecting it; 2) ***: relation backed by multiple convergent empirical evidence and theory; **: relation backed by convergence of limited empirical evidence and theory; *: relation regarded as tentative on account of limited evidence, idiosyncratic context or pioneering theory.

Table 3: Empirical studies by data source

Study	Core DV	Data
Goldberg and Erickson 1987	Duration, adjustment processes	Case study
Mayer and Argyres 2004	Planning for contingencies & others	Case study
Pirrong 1993	Duration	Case study
Dekker 2004	Outcome control; Behaviour control	Case study
Argyres, Bercovitz, Mayer 2007	Contingency planning; Task description detail	Contract data
Arruñada et al. 2001	Principal's discretion	Contract data
Elfenbein and Lerner 2004	Contingent rights	Contract data
Kalnins and Mayer (2004)	Incentive intensity	Contract data
Kaplan and Strömberg 2002	Selected incentive and control mechanisms	Contract data
Kaplan and Strömberg 2004	Selected incentive and control mechanisms	Contract data
Lerner and Malmendier 2005	Termination rights	Contract data
Lerner and Merges 1998	Control rights	Contract data
Mayer 2006	Task description detail	Contract data
Mayer and Bercovitz 2003	Contingency planning	Contract data
Ryall and Sampson 2006	Contract completeness/ complexity	Contract data
Anderson and Dekker 2005	Contract extensiveness	Questionnaire
Deeds and Hill 1998	Contractual safeguards	Questionnaire
Helm and Kloyer 2004	Perceived control of transaction risks	Questionnaire
Luo 2002	Contingency adaptability; term specificity	Questionnaire
Parkhe 1993	Contractual safeguards	Questionnaire
Poppo and Zenger 2002	Contract complexity	Questionnaire
Reuer, Ariño 2002	Contract complexity	Questionnaire
Reuer, Ariño 2003	Contract complexity	Questionnaire
Reuer, Ariño 2004	Contract complexity	Questionnaire
Reuer, Ariño and Mellewigt 2003	Contractual safeguards	Questionnaire
Bercovitz 1999	Various monetary and non-payment related clauses	Secondary
Brickley 1999	No passive ownership; specification of inputs; area development plan	Secondary
Ciccotello et al. 2004	Duration	Secondary
Corts and Singh 2002	Compensation provision	Secondary
Crocker and Masten 1988	Duration	Secondary
Crocker and Masten 1991	Price adjustment processes	Secondary
Crocker and Reynolds 1993	Completeness	Secondary
Hubbard and Weiner (1986)	Minimum purchase requirement %	Secondary
Joskow 1987	Duration	Secondary
Masten and Crocker 1985	Compensation provisions	Secondary

An Empirical Taxonomy of Technology Alliance Contracts

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ABSTRACT

Although contracts are characterized by a certain logical and artifactual unity, the typical approach of economic and organizational studies focuses on particular contract clauses. Another common perspective, that addresses contracts as unitary entities, directs the attention to the choice between axiomatically defined alternative governance forms, with little or no investigation of empirical types. This state of things reflects the lack of an accepted framework for the development and testing of hypotheses about contract design. This study tries to redress this situation by analyzing actual contracts as configurations of a wide array of elements. In developing an analytical framework, this study develops a perspective that considers contracts as an organizational phenomenon, expands the set of mechanisms considered beyond incentive provisions and pricing structures, and includes procedural elements inspired both by organizational theory and by the empirical literature on contracting. The constructs so identified are applied to the analysis of a set of pharmaceutical biotechnology agreements. We employed categorical principal component analysis to determine underlying dimensions that differentiate among different contracts. Cluster analysis then produced an empirical taxonomy of these technology agreements.

KEYWORDS: Governance, contracts, configurational research, strategic alliances, biotechnology, joint R&D, principal components analysis, cluster analysis.

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1. Introduction

Contracts provide an important lens to analyze inter-organizational relationships (IORs) and the cross-boundary activities of organizations (Williamson, 2003). Obviously, contracts in general, and, *a fortiori,* formal contracts, do not exhaust the complexity of the governance of IORs (Sobrero and Schrader, 1998; Ménard, 2004). Yet, the large number of conceptual and empirical investigations focusing on inter-firm contracts is in witness of the fact that this institution is considered to be a fundamental aspect in the structure of inter-firm relationships.

Transaction cost economics has been at the forefront in the investigation of governance forms and it has inspired the bulk of the empirical literature on contracting (Shelanski, Klein 1995; Rindfleisch, Heide, 1997; Boerner, Macher, 2005; Furlotti, 2006). One fundamental tenet of TCE is that "transactions which differ in their attributes are aligned with governance structures, which differs in their costs and competencies, in a discriminating (mainly transaction-cost-economizing) way" (Williamson, 1991, p. 277). Yet, by Williamson's own admission TCE has given disproportionately more attention to the dimensionalization of transactions than to that of governance forms (Williamson, 1991, p. 270). The same article that conceded this point also tried to redress the imbalance: it identified a few dimensions along which governance forms differ, proposed a typology of contracts and argued that a close correspondence exists between contractual types and discrete governance forms.[47]

Obviously, considerable progress has been made with regards to dimensionalizing governance since then, as documented for instance in Ménard (2004). Yet, with regards to contracts, the state of the art is still rather dissatisfactory under several respects. First, conceptual efforts have not led to a widely shared agreement about contract dimensions.[48] Second, for the large part empirical analyses of contracts have favored a reductionist approach and have focused on selected contractual terms considered in isolation. Finally, as to assigning contracts to classes, we have not progressed much beyond the conceptual typologies developed by Williamson in his 1979, 1985 and 1991 works.

To help redressing this state of things, this study investigates empirically the dimensions of a sample of inter-firm alliance contracts and produces a taxonomy through multivariate analyses. Obviously, any such endeavor would run into formidable practical problems if attempted on as broad ranging a population of IORs as that covered in conceptual typologies. Thus, we have

[47] For the sake of preciseness, throughout his 1991 article Williamson argues that different governance forms are supported by different forms of contract *law*. However, several passages in that article may induce the reader to establish a one-to-one correspondence with different contractual types simultaneously available at a given point in time for the governance of different types of transactions.

[48] For example, the framework proposed in Ménard (2004) differs from Williamson's (1991) and from Brousseau's (1995).

restricted our analysis to a sample of contracts of pharmaceutical biotechnology alliance, in the belief that even at the level of a narrow population we would be able to identify distinct clusters, while reducing undesirable heterogeneity.

Our findings are that it takes a larger number of dimensions than currently popularized, to explain a reasonable amount of the variance in the contractual clauses. The factors we identified can be interpreted pretty clearly in terms of concepts rooted in the theory. However, unlike proposed by TCE, hierarchical intensity does not seem such a distinctive factor of different alliance agreements. Contracts do belong to different groupings. Some of the contractual types are defined by dimensions that are not commonly emphasized by organizational economics and better understood when economic explanations are expanded with insights drawn from classical organizational literature.

The paper proceeds as follows: the next section reviews relevant extant literature and the following develops a conceptual framework. Section 4 describes our dataset and the variables we have selected to observe the contractual structure. The method and the results of our quantitative analysis are then explained in Section 5. Section 6 is dedicated to the assessment of our findings and Section 7 concludes with a discussion of the limitations of the present study and of directions for further research.

2. Review of literature

This section reviews selected literature that has taken a configurational approach to the question of analyzing governance forms and contractual governance in particular.[49] This discussion may usefully start from the works of O.E. Williamson. Although several of his earlier books and articles are also relevant to the topic, his ideas are perhaps best developed in Williamson (1991). Here, his configurationist stance is clearly expressed by his definition of governance forms as "syndromes of attributes" (Williamson, 1991: 271). Besides, Williamson explicitly mentions the type of contract law that applies as an important differentiating factor of archetypical governance forms. Williamson's stated aim is to establish a connection between the institutional environment and the institutions of governance. While this unifies two areas of institutional economics that until then had remained disjunct, his stance on this point seems too deterministic. The different contract law regimes he mentions (classical, neoclassical and forbearance) are borrowed from Macneil (1978), with some adaptation. However, rather than with contracts Macneil was concerned with 'the

[49] For the defining traits of configurational approaches the reader is referred to Meyer, Tsui and Hinings (1993) and the other articles in the same issue of The Academy of Management Journal. For a comparison of configurational and complementarity approaches see Whittington et al. (1999).

response of the legal system' to long-term trends in economic relations and in contracting practices. His argument was that contract law and legal doctrines have evolved over time from the classical to the neoclassical model in response to changing societal needs, which are reflected particularly in the increasing relevance of complex transactions. Projecting such trends into the future, Macneil envisioned a further evolutionary step and the acceptance by contract law of a 'relational' model, although, he added, "no such system as yet exist in American law". By contrast, although Williamson refers fairly consistently to "contract law" regimes, the impression conveyed throughout his paper is that at any point in time a menu of three alternative contractual forms is offered to contracting parties and that the appropriate form will be chosen basing on the characteristics of the transaction.[50] Perhaps in practice a 'forbearance' legal model may be a foregone conclusion for parties contemplating a unified governance form.[51] However, if we restrict our attention to contracts between independent parties Williamson's point seems questionable from both a historic and a juridical perspective. First, the classical and neoclassical contract doctrines are separated in time by a span of several decades. Thus, after the *Restatement (Second) of Contracts*, that epitomizes the shift of US contract law from a classical to a neoclassical model (Macneil, 1978) archetypical classical contracts may not be a viable option any longer, while before it neoclassical contracts were not.[52] Second, the suspicion that the institutional environment determines the institutions of governance only to a point is particularly strong when the focal institution is the contract. As argued by L.M. Friedman, the law of contract "concerns and provides legal support for the residue of economic behavior left unregulated." As a result, "contract law is basically negative, passive and untechnical" (Friedman, 1965: 23). This being the case, in a given transaction the parties have considerable degrees of freedom with regards to the choice of the contractual configuration, and what types of contracts get selected remains a question open to empirical investigation. Thus we must look for other explanations of the heterogeneity that is observed in actual contractual agreements.

In his 1991 paper, Williamson tackles also another hitherto relatively neglected issue, namely that of establishing what are the key attributes with respect to which contractual governance structures

[50] For instance, Williamson mentions the thirty-two year coal supply agreement between the Nevada Power Company and the Northwest Trading Company as a 'neoclassical contract'.
[51] However, it must be noticed that when one manifestation of the model of forbearance, the "business judgment rule" (whereby courts normally do not exercise regulatory power over the activities of corporate managers) comes into play, we are not talking about contract law any longer, but rather of corporate law (Bainbridge, 2002: 269-286).
[52] The *Restatement (Second) of Contracts* are abstract propositions of law, drafted by leading scholars under the auspices of the American Law Institute, designed to clarify and simplify existing common law. We leave aside the question, debated in Gilmore (1995) of whether, and to what extent, actual courts decisions ever reflected a classical model.

differ.[53] Leaving aside adaptation, a quality that is better thought of as a property of governance forms, rather than a mechanism, the two attributes that Williamson considers are incentive-intensity and administrative control. Here we find Williamson's discussion wanting in two respects. First, administrative control is not well defined.[54] Second and more relevant, administrative controls are treated essentially as the dual of incentive intensity. In fact, Williamson argues that when incentives are dampened, administrative intensity has to increase to take the place of the discipline of the market. As a result, the two 'instruments' actually define a single factor. The wider context of the discussion, that extols the virtues of hierarchy when conditions of dependency obtain, further strengthens the impression that despite Williamson's discussion is somewhat nuanced, he simply differentiates governance forms basing on the degree of hierarchical intensity. This seems to be also Oxley's understanding when she writes that "the logic of transaction cost economics suggests that more hierarchical alliances will be chosen for transactions where contracting hazards are more severe" (Oxley, 1997: 388).

The discussion so far should have made clear that 'hierarchical intensity', as intended by TCE, is essentially a label to contrast organizational forms that display extreme levels of autonomous adaptation from those that score high on coordinated adaptation. Thus, this dimension is based more on the properties of governance forms than on their constituting elements and it is unlikely to provide a powerful criterion to tell apart but the most general governance archetypes. Furthermore, from an organizational design point of view, this dimension tells us little about the extent to which under different circumstance actual contracts ought to incorporate hierarchy, in the specific sense of a formalized system of authority, let alone other coordination mechanisms.

Despite these limitations, the recognition that certain traits of governance forms may vary along a continuum marks an evolution over the strong opposition between market and hierarchy that was typical of early TCE (Williamson 1975). However, Stinchcombe (1985) had already taken a more radical stance. His position is that contracts have to perform the same functions of hierarchies amid the same kind of uncertainty, and that they do so by incorporating the same elements of unified structures. As to which these elements are Stinchcombe proposes a quite detail listing of mechanisms, classified within five classes: 'command structures', 'incentive systems', 'standard operating procedures' 'dispute resolution procedures' and 'nonmarket pricing'. These propositions are corroborated by examples that Stinchcombe draws from a large variety of contractual situations,

[53] Strictly speaking Williamson does not refer only to the formal contractual governance. Yet the examples he mentions are taken from actual agreements or refer to issues that are typically regulated by explicit contractual clauses (e.g.: dispute settlement mechanisms). Thus it is safe to assume that his argument can be constructed essentially as a dimensionalization of contracts.

[54] Monitoring, career rewards, penalties and a few others are mentioned as examples of administrative controls (Williamson, 1991: 280).

but do not seem to have inspired much systematic empirical investigation and to-date Stinchcombe is seldom quoted in the TCE-inspired literature.

The realization that extant theories provide too coarse an apparatus to compare and differentiate different hybrids led Brousseau (1995) to develop his own framework, basing on a synthesis of TCE and agency theory. Brousseau summarizes the main functions of contracts in the coordination of actions, the enforcement of promises and the sharing of the quasi-rent generated by the cooperation. From these three functions he derives three 'modes' that can be understood as operational mechanisms to provide the parties with dynamic stimuli to perform certain processes. These 'modes' encompass authority and routines, hostages and supervision, and remuneration and risk sharing rules. Clearly, while still sketchy, this dimensionalization is finer grained than Williamson's. Brousseau operationalized these construct into seven variables and gathered observational data through interview surveys. His dataset included 78 valid responses relating to as many inter-firm coordination arrangements that belong to settings as different as manufacturing, wholesale distribution and financial services. Through multiple correspondence analysis Brousseau extracted two dimensions. The first, labeled *degree of specificity*, measured whether a contract implements or not a specialized governance. The second, labeled *degree of asymmetry*, contrasts the specification of a centralized authority to decentralized decision-making and ex-ante sharing of output. Furthermore, through hierarchical clustering Brousseau obtained four classes that were interpreted as "market-type" contracts, "co-operative" agreements, "long-term" agreements, and "hierarchic" contracts.

This study supports our contention that Williamson's dimensionalization was too straight a jacket to compare for empirically observable governance forms. At the same time it leaves some important questions open to further investigation. One is whether the contractual heterogeneity that Brousseau observes owes only to the extreme diversity of the setting, or it is a reflection of contextual variables more specific to the firm, the task or the transaction. Another is whether the application of correspondence analysis to a set of only seven variables defined axiomatically can produce enough new insight into the dimensions of contracts or "tautologically echo[es] one's pre-existing cognitive schema" (Suchman, 1994: 315).

Suchman (1994), on his side, carried out a multivariate analysis of 78 venture capital financing agreements that addresses particularly the second of these concerns.[55] His investigation is part of a wider inquiry into the role of institutional intermediaries in the structuration of an organizational field. Through content analysis, Suchman measured about 400 variables, spanning 16 substantive

[55] The contracts analyzed by Suchman relate to a wide array of industries, though it appears that most of the agreements related to ICT and biotechnology deals.

areas, that were connected more to contracting practices than to organizational economics theories. Several of those variables directly mirror the content of rather standard contract language. Using INDSCAL, a variant of multidimensional scaling, Suchman reduced the complexity of venture capital contracts to two dimensions. Through a regression of selected variables against the INDSCAL coordinates Suchman determined that dimension 1 reflects the extent to which a financing agreement explicitly delineates the various rights and obligations of the contracting parties, while dimension 2 seems to be related with the anticipated duration and intensity of the relationship between the start-up and its investors. The hierarchical clustering carried out by Suchman on the INDSCAL dimensions yielded five groupings that were amenable to interpretation as meaningful contractual archetypes.[56] These results support the idea of a multidimensionality of contractual agreements. Contractual dimensions "seem to counterpoise "rights" issues on the one hand against "relational" issues on the other – recreating a dichotomy frequently invoked" (Suchman, 1994: 223). Equally interesting is that data reduction techniques *fail* to find a dichotomy of 'pro-company' and 'pro-investor' contracts, which is how the trade press and incomplete contract theory often frame the discussion.

Another valuable contribution on contract dimensions is provided by Ménard (2004). Strictly speaking this conceptual article is not a review of literature, yet it brings to bear a large amount of empirical evidence on hybrids. Although it is more concerned with multilateral than with bilateral hybrids and it investigates also complementary governance mechanisms, this article has a lot to say also on the dimensionality of formal agreements in dyadic interfirm relations. According to Ménard, contracts have at least five dimensions: the number of partners, duration, the specification of requirements, the specification of how adaptation is to be achieved, and the extent to which they specify safeguards. Other mechanisms that can fit into contracts, like the use of authority or restrictive provisions, are discussed in the section on complementary mechanisms. Ménard takes a configurational view ("none of these characteristics is entirely specific to hybrids. It is their combination that gives hybrids a typical content" (p: 363)). However complementarity is assumed rather than established and little or no indications are provided as to which mechanisms need to combine.

The articles reviewed so far describe a trajectory of progressive expansion of the concept of contract. As argued in Masten (2000) the origin of this trajectory lies in the works of Arrow and Debreu that equated (complete contingent claims) contracts to pure market transactions. Gradually, contracts came to be understood as instruments that can incorporate elements of conscious

[56] The clusters so identified were labeled 1) weak contracts; 2) pre-programmed contracts; 3) legalistic contracts; 4) close contracts; 5) flexible contracts.

adaptation, notably command structures and enforcement mechanisms. However, both mechanisms require that it be possible to specify proper behavior. Thus, when this condition does not obtain these mechanisms should come under strain. Moving from these considerations Grandori (2005) proposed that under conditions of radical uncertainty an alternative and more efficient contracting strategy to the specification of task obligations would be centered on ensuring a continuing association of resources "no matter what", as a pre-condition of a progressive discovery of desirable outcomes. This element of uncontingent commitment is the basic defining characteristic of an association, and is best typified by a marriage contract. Accordingly, Grandori (2005) proposed that beside greater or smaller incentive and hierarchical intensity, contracts have an "associational" dimension and that agreements would score high along it under conditions of radical uncertainty. Three case studies of ICT alliances were found to be broadly supportive of this expectation (Grandori and Furlotti 2006a).

3. A conceptual framework

So far we have referred rather loosely to contracts in general. Perhaps it is time to make clear that our concern goes first and foremost with contractual relations that involve at least some degree of joint actions or of common use of resources. Contract that deal exclusively with transfers of property rights fall outside the scope of this study. Accordingly, the framework that is developed here is tailored primarily to the analysis of contracts of the former type.

As mentioned in the Introduction, previous literature has for the most part neglected the investigation of the internal fit that under conditions of efficiency is likely to bind various contractual clauses, and has focused typically on just one or a very small number of provisions at a time, in the belief that they could be considered as 'sufficient statistics' of the contractual complexity.[57] While such hypothesis has seldom been the object of systematic investigation, the studies it inspired have helped defining the array of elements contractual governance is made of. Accordingly, our attempt to develop a conceptual framework may be configured essentially as an exercise into ordering the variety of the contractual mechanisms.

All the contributions reviewed hitherto may be usefully summarized by making reference to Ian Macneil's famous 1974 article. Probably, the central message in that study is that contracts are projections of exchange into the future: doing something now that limits choices otherwise available in the future (Macneil, 1974: 719). This way of seeing contracts emphasizes a basic

[57] "Previous literature [focused] only on the strictly 'monetary' aspects of the contracts" (Arruñada, Garicano, Vazquez 2001: 257). "Empirical transaction-cost research on contract design has looked primarily at three types of provisions: incentive provisions, pricing structures and price adjustment methods" (Masten, Saussier 2002: 285).

tension which is inherent in all contracts: that between *planning* – our present representation of what the future ought to be – and *adaptation* – the alterations and further specifications of the original plans that need to be done, or to be resisted, as the future unfolds. Moreover, this perspective draws attention to the *duration* of the contractual relationship, a dimension that obviously affects heavily the precision and the means by which we can plan the future. The contractual dimensions mentioned in the articles reviewed can rather accurately be described as instantiations of these three elements. The tension between plan and adaptation is certainly at the core of the contractual problem and will be reflected also in our conceptual framework. The relation between these two terms mirrors that between *substance* and *procedure*. Thus, contractual elements can be usefully distinguished between those that structure the relation and display considerable stability during the life of the contract, from the procedural elements that are designed to provide the contract with flexibility and dynamic adaptation.

However, focusing on the tension between plan and adaptation is closely related to seeing inter-organizational relations as goal-directed systems, and bears also the limitations of that perspective (see, for instance, Vanberg, 1994). To counter that risk we need to concentrate not only on what IORs are directed at, but also on what they are based upon. Such view emphasizes the type of resources, and the extent, to which they are combined for common use. This seems to be one of the messages in Grandori (2005) and will also be integrated in our framework. If resource commitments provide the foundations a system of collective action is built upon, they may usefully be subsumed within the substantive part of the contract.

Contractual elements that affect the governance properties of the contract are observed at different levels. While we have characteristics that can be predicated of the contract as a whole, others mechanisms and processes are observed only at an intra-contractual level and are often located in specific clauses. Duration is certainly one characteristic that pertains to the level of the contract as a whole. Another is the length of the contractual document, which can be considered as a proxy of how much in detail the future is planned in a given relationship. At the level of the contract we must also gauge the extent to which the contract displays a conscious awareness of the future and sets devices to deal with future contingencies that are explicitly spelled out. The attitude towards the future is an expression of time sense, which, according to Macneil (1974) is a primal root of contracting. Following his terminology we shall call this construct the contract's degree of presentiation.

When applied at the intra-contractual level, our framework help us identifying among the core substantive elements of the contract those that regulate the allocation of the output of the IOR (be it a flow of revenues or an item of stock, like new inventions) and the basic obligations undertaken.

For each of these – remuneration provisions, the assignment of property rights and the commitments concerning tasks and resources – in principle it would be relevant to ascertain the degree of their specification (how in detail they are planned) and how they distribute among the contractual parties.

As to the procedural aspects, *decision making*, *monitoring*, *enforcement*, and *dispute resolution* are obvious processes serving the purpose of adaptation on which there seem to be a certain consensus in the literature. Others, like *procedural coordination*, are normally considered to be aspects of extra-contractual governance (e.g.: Sobrero and Schrader, 1998). However, prior investigations (Grandori and Furlotti 2006b) and a cursory glance at the contracts in our sample, reveal that technology alliance contracts are replete with mechanisms for procedural coordination. Thus we think it important to try to measure this aspect as well. *Restraints* are the final mechanism we consider. This expression refers to contractually-imposed restrictions on the behavior of the parties. On account of their stability, restraints might be considered a substantive aspect. However, in a business context it is unlikely they can be described as being at the 'core' of the contractual matters. Restraints may be considered as a means to apply an organizational pressure on the contracting parties in order to infuse predictability in their behavior. If restraints are understood as mechanisms to limit undesirable flexibility of the relation, it may be appropriate to include them among the procedural aspects of the contract. As for the substantive elements, an empirical investigation should try to measure at least the presence or absence of these procedural mechanisms and, whenever possible, it should try to determine the degree of their specification as well as their distribution among the parties. For the reader's convenience the contractual elements mentioned above are enlisted in Table 1 in the Appendix, which summarizes the framework just exposed.

4. Data and measures

Our study analyzes a sample drawn from a population of technology alliances in the field of pharmaceutical biotechnology. Several characteristics of this industry make it a particularly convenient setting to explore issues of contractual governance. First, since the eighties the industry has been characterized by a vibrant alliancing activity. Second, although a lot of collaborations are supported only by handshake deals (Powell et al., 1996: 120) a large number of alliances is established through a formal contractual agreement. Furthermore, many participants of this industry are small start up companies. These firms are under the combined pressure of the need to raise finance through public offerings and to gain legitimacy through an accurate disclosure of company information. As a result many biotech agreements are filed as material contracts to the U.S.

Securities and Exchange Commission (SEC), despite the SEC's rules that mandate public filing are not free from ambiguity.[58] Finally, although plain licensing also abounds, many pharmaceutical biotechnology collaborations involve the production of novel outcomes through joint activities, which makes coordination a non-trivial task.

The contracts have been provided by Recombinant Capital (Recap), a San Francisco Bay Area-based consulting firm that manages some of the largest and most detailed biotech business intelligence databases in the world. As of October 23, 2006 Recap's databases contain 23,687 high-level summaries of biotech alliances commenced since 1973. In order to take advantage of additional information that Recap collects from the business press, companies' presentations, and various additional sources, as well as to cross-check our coding of variables with that accomplished by professional contract analysts, we focused on those alliances that have been analyzed in detail by Recap. As of the date of accessing it,[59] the database included about 1700 alliances, clearly too many given our purpose to carry out a detailed analysis of contract content.

Our sampling criteria excluded first of all those alliances where one of the parties was a non-business organization, in the belief that that might introduce excessive heterogeneity in the sample. Second, being interested primarily to technology cooperation we excluded those alliances that did not include any element of R&D, and focused exclusively on the granting of licenses, production, marketing, the setting of standards, the assignment of assets or options, etc. The selection was based on the value of a measure of contract type coded by Recap's analysts. We excluded also alliances where both parties were pharmaceutical companies. While it might be interesting to investigate whether industry membership made a difference in terms of alliance governance, these alliances were numerically too few to expect statistical significance.

At the next step, we assessed that we would like to have both 'early stage' and 'late stage' alliances equally represented in our sample. By 'early' and 'late', we mean an alliance entered before or after a lead molecule has been discovered. It can be argued that having determined or not whether a molecule shows activity against a certain target is one important factor that is likely to impact significantly on the tasks to be pursued, and a reasonable proxy of the technological uncertainty facing the alliance partners. Through random choice we selected a total 280 alliances stratified in such way that each class encompassed 50% of the alliances. At this stage we noticed that Recap's database offered us a coarse but convenient means to bias the sample toward successful alliances. In fact, it contains a flag to identify those alliances that were terminated ahead of time. While not necessarily the result of governance inadequacy, early termination may be an indication of some

[58] It is estimated that over 40% of biotech agreements are filed as material contracts. Source: Recombinant Capital website (www.rdna.com) accessed November 13, 2006.
[59] November 11 2005.

unforeseen trouble in the relationship. This allowed us to exclude an additional 40 alliances. Then, through random selection we picked the 79 alliance contracts that compose our sample, again with a constraint of approximately equal representation of early stage and late stage alliances. Finally, a team of two raters analyzed the contracts during the period from December 2005 to August 2006 and measured those contract attributes that are described in the next section.

4.1. Identifying contract terms

From a wide roster of governance variables we selected an initial set of 27 variables to sample the conceptual domains described in Section 3. The variables are enlisted in Table 2. Most of the variables are binary, one is three-category polychotomous, and one is continuous. In questions about the presence of a certain governance mechanism in the contract, a value of two corresponds to an affirmative answer, whereas a value of one indicates that the mechanism is not used. Five variables require selecting a category that describes the type of a contractual mechanism. In these cases, the lower value indicates the type we suppose to be associated with arms' length contracting and higher values corresponds to the types presumably associated with increasing relational governance. Here we briefly describe each of the 27 variables.

At the level of the contract as a whole we measured the length of the collaboration agreement, in double-spaced page equivalents (#1) and the project duration (#2). In empirical studies of contracts it is common to measure contract duration. However, in the context of pharmaceutical biotechnology alliances the duration of each contract is essentially a random variable. In fact, since the sought for outcome is one or more patentable inventions, a typical contract establishes its own term at the expiration of the royalty payments on licensed technology. Except in the case when it preexists the collaboration, licensed technology could be patented at any time during a period of several years, and then it would enjoy patent protection for 20 years from filing date. As a result, the agreement would last for as many years from the filing date of the last patented invention. Thus, rather that focusing on contract duration we preferred to observe whether the research and development activities envisaged in the contract are assigned a specific time bracket (whether strictly close ended or extensible) or are to be conducted as ongoing activities. Theoretically, the specification of a time bracket has been identified as one of the defining elements of the temporary organization (Lundin and Söderholm, 1995).

The second group of variables measures whether the contract deals with uncertain events by means of presentiation. In particular we ask whether the amount of compensation to be paid to the R&D firm is affected by any contingency at all, like, for instance, the level of sales of competing products grabbing a certain market shares in a given country (# 3). Moreover, we ask whether the parties

explicitly establish who among them shall bear the cost of third party licenses that may become needed to achieve the goals of the alliance (# 4).

The third set of variables addresses the degree of specification of certain contractual commitments. Task specification (# 5) is measured by asking whether research and development activities the R&D party is required to perform within the framework of the alliance are simply mentioned or are articulated in greater detail.[60] In those cases where the R&D party is not requested to carry out any such activity, we entered a missing value and later we treated it in the analysis as a separate category. Some alliances explicitly specify the number of scientific personnel employed by the R&D firm, often on a year-by-year basis (# 6). Others prescribe that the personnel assigned to alliance-related activities have sufficient skills (# 7).

As to monetary rewards, we ask first whether the parties share the costs of the project or whether one of them acts as a financier and reimburses the R&D firm of expenses incurred (#8). Then we observe whether lump sum payments (called 'milestone payments' or 'benchmark amounts' in the jargon of technological alliances) are tied to the achievement of certain verifiable events, like the filing of an Investigational New Drug application, the completion of Phase I clinical trials etc. (#9). Finally, we ask whether the allocation of the continuous rewards – that are envisaged by the vast majority of pharmaceutical biotechnology alliances – is just based on revenues (usually in the form of royalties on net sales) or it is based on profits and margins, thus requiring a higher level of mutual disclosure and risk sharing.

The next group of variables measures whether the R&D firm (#11) or the client (#12) are constrained in the way and extent they can carry out, alone or with third parties, research or commercial activities concerning the same subject matter as the alliance. Moreover, another item in this group asks whether the R&D firm is subject to any other kind of restraint at all, like extensions of the non-compete requirement to a certain period after the expiration of the agreement, non-solicitation of employees, applying the research funding only for the principal purposes of the alliance, etc. (#13)

Another cluster of variables assesses the mechanisms that are used to reach decisions during the life of the agreement on broad classes of problems or on particular issues. First we ask whether decisions concerning organizational problems (that is, on specification of the tasks of participants beyond the basic roles outlined in the contract, on adjustments and reassignment of tasks) are to be selected by routines (that is, prescribed by the contract itself), by a centralized authority (like a

[60] For the purpose of this item, research and development activities were considered only those carried out at the discovery and pre-clinical stage. The segmentation imposed upon drug development activities by FDA regulations and by industry practices helps detecting them quite unambiguously within contracts.

joint-steering committee or a party vested with decision making power) or are left to the negotiation of the parties (# 14).[61] Next we asked whether the contract assigns decision rights on certain matters that are of particular concern in alliances in general and in technological alliances in particular. This is surely the case with the right to influence the timing of publications of the research findings, an issue that may put in conflict the academically-oriented biotechnology firm and pharmaceutical firms, which are more highly concerned with securing patent protection (# 15). Other relevant decisions concern the scope of the alliance, in particular whether the technologies under development can be expanded (# 16), whether the project can be extended (# 17) or whether one party or both can terminate the alliance without cause ('at will'), that is, without the insurgence of the typical causes for termination: bankruptcy, uncured payment default or uncured material breach (# 18).[62]

Items relating to coordination ask whether the contract mentions the use of budgetary control of the alliance activities (# 19) or institutes liaison roles with primary responsibility for communication between the parties (# 20).

As to monitoring, we assessed whether the contract grants the client the right to audit the counterparty's records of expenditures concerning research and development activities (# 21) and the right to inspect the scientific records or other records of process (# 22).[63]

Helm and Kloyer (2004) have argued that several provisions may institute hostages in alliances for R&D interfirm cooperation. One that can be assessed quite unambiguously from content analysis of contract documents is the requirement that the client makes significant payments upfront to the R&D firm or that it places firm orders of supplies (# 23). Another one is the agreement that one party makes a non-negligible equity investment in the other's capital (# 24).[64]

A final set of variables assesses certain dispute resolution provisions. First we ask whether the contract provides that one party has a final say in disputes concerning particular matters (e.g.: the

[61] We borrowed this item from Brousseau (1995) who measured, through questionnaire items, also the mechanisms adopted to select actions concerning problems at the strategic and the operational level. In the focal context we observed that alliance contracts almost never allowed changing the strategic decisions agreed in the contract. As to actions at the operational level, we assed that contracts were often too ambiguous on this point to enable reliable measurement.

[62] Items 15 to 18 have been inspired by Lerner and Merges (1998).

[63] As to auditing rights, the focus on those concerning project expenditures has been advised by the realization that the assignment of auditing rights of royalty accounting is a boilerplate provision in virtually all of the alliance contracts. As to the right to inspect scientific records, we distinguished it from prescriptions of periodical reporting and from generic duties to disclose information

[64] It could be argued that equity investment serves more the purpose of extending the control of the financier over the R&D firm, rather than that of handing over a hostage to the R&D firm. One reason why the equity investments observed in our sample are of little use for the purpose of control is that they are usually limited to minority shares, and often exclude the possibility for the financier to make further purchases of shares. Moreover, control is often limited by the fact that despite the equity investment, the financier does not obtains a seat on the partner's board (in our sample a seat is obtained in only 20% of alliances with equity investment). Finally, the value of the investment as a hostage is increased by the fact that as many biotechnology firms are unlisted startups, the possibility for the financier to dispose of the shares is severely constrained by their illiquidity, if not by explicit contractual covenants.

client may decide unilaterally in case of disagreement over sales promotion activities) (# 25). Then we observe whether there are particular problems for which decision-making authority is expressly assigned to outsiders, besides those disputes that are to be solved expressly through formal arbitration. A typical occurrence thereof is to entrust industry experts of the solution of disputes on the inventorship of inventions made under the research plan (# 26). Finally, we ask whether the contract allows the parties to settle their disputes through court litigation (# 27).[65]

A cursory glance at the table reveals that there is no variable to measure the governance element of one cell of our framework, namely, property rights. The reason is that two items devised for the purpose had very little variance. In particular, the provisions regulating the ownership of jointly-made and individually-made inventions almost invariably establish that the former shall be "jointly owned", while for the latter "each owns its own".

Although 27 items are a tiny fraction of the contractual characteristics of an alliance agreement that are theoretically salient, they are still too many to be modeled individually.[66] Thus the application of data reduction techniques is in order to identify fundamental, uncorrelated dimensions.

5. Multivariate analyses

The first problem in the construction of an empirically based taxonomy is the selection of the variables to be observed. The previous section has dealt with precisely with that issue. In principle, cluster groupings could be constructed directly from the original variables. However, our desire that the taxonomy be based on a rich description of the contractual features and, conversely, the limited size of our database, prevented the adoption of this research design and advised the use of data reduction techniques first.

Earlier studies have used factor analysis applied to matrixes of tetrachoric and polychoric correlations (Pearson 1901), multidimensional scaling (MDS – Kruskal and Wish, 1978) and multiple correspondence analysis (Benzecri, 1973). One problem with the first methodology is that the model assumptions are not always appropriate – for example, if the latent traits are truly discrete. Unfortunately this obtains very often with the measurement of the presence of certain provisions in a contract: there is no such thing as the intensity, say, of a non-compete clause in a contract. As to MDS, its normal application is to determine the perceived relative image of a set of objects (Hair et al., 1998). Researchers in a variety of fields ranging from psychology to marketing find it

[65] The reader may consider this as a matter of course in the case of formal contracts, which are stipulated precisely to secure legal protection in case things go sour. However, as a matter of facts, the parties often waive their right to bring issues to courts, and quite often opt for leaner means of dispute resolution, like mediation or arbitration. Ryall and Sampson (2003) found that this is a common practice also in the case of ICT alliance contracts.

[66] Suchman (1994) had based his content analysis of venture capital contracts on about 400 items.

convenient as it does not require the specification of variables to be used in comparing objects. However, quite opposite to these conditions, our research has determined inductively the variables that we intend to use for the comparison, while it does not have any obvious respondent whose perceptions we may be interested to map. Thus, the only way to apply MDS would be to construct synthetic indexes that summarize the similarity between objects – contracts – on each variable. Thus described this procedure already sounds like a quite convoluted way of comparing contracts: using a decompositional method for a compositional purpose. In addition, the simultaneous presence in our dataset of variables measured at the nominal ordinal and interval level would make the computation of a synthetic index of similarity not just practically complex but also theoretically problematic (Coppock and Mazlack, 2003).

These difficulties have been considerably alleviated by the fairly recent introduction of state-of-the-art computer programs implementing a special variety of principal component analysis that includes nonlinear optimal scaling transformation of the variables, that is, the optimal assignment of quantitative values to qualitative scales. Meulman et al. (2004), explain the essence of the optimal scaling process to the treatment of categorical data by referring to the linear regression model. In such model the researcher is interested in predicting a response variable from a number of predictors. "This objective is achieved by finding a particular linear combination of the predictor variables that correlates maximally with the response variable. Incorporating optimal scaling amounts to further maximization of this correlation, not only over the regression weights but also over admissible nonlinear functions of the predictor variables" (Meulman et al. 2004: 50).[67] One computer program that incorporates such features (the one that was used for the analyses in this study) is CATPCA (an acronym for Categorical Principal Components Analysis) that is available from SPSS 10.0 onward.

Multiple Correspondence Analysis (MCA) is another feasible procedure, quite similar to CATPCA, in the sense that it combines optimal scaling with principal components techniques. However, we preferred CATPCA over MCA since the latter assumes that all variables need to be scaled at the multiple nominal level, while the former allows for scaling of variables at single nominal, ordinal and numeric level.[68]

[67] "The optimal quantification for each scaled variable is obtained through an iterative method called alternating least squares in which, after the current quantifications are used to find a solution, the quantifications are updated using that solution. The updated quantifications are then used to find a new solution, which is used to update the quantifications, and so on, until some criterion is reached that signals the process to stop." (Meulman and Heiser, 2005: 1).

[68] With single-nominal quantification, you don't usually know the order of the categories but you want the analysis to impose one. If the order of the categories is known, you should try ordinal quantification. If the categories are unorderable, you might try multiple-nominal quantification (Meulman and Heiser, 2005: 4).

5.1. Categorical Principal Component Analysis

Principal components analysis requires the researcher to make a number of choices. One of these relates to the number of factors to be extracted from the larger set of variables. A number of rules of thumb are used in the social sciences (cfr Dunteman, 1989). Yet none of them is totally undisputed. In the last analysis it is important that the factors extracted are comprehensible, and comprehensibility tend to decay with the number of factors. A second important consideration in the choice of factors is to be given to the fact that the variance they explain is sufficiently high. While for uses of PCA like the validation of a scale of five or six items a researcher would try to extract variance in the neighborhood of 90%, in our setting where 27 items are involved we regard anything in excess of 50% are quite satisfactory. A floor on the variance explained sets an opposing requirement that factors are not too few. Since a 50% floor can be barely crossed by two-dimension CATPCA's we focused on three dimension solutions.

In preliminary runs of CATPCA, we observed that the transformation plot of the categorical variable 'Action selection mechanism' (#14) always resulted in a kinked curve where the quantified values of two categories were almost identical.[69] This showed that these categories did not differentiate between contracts, and suggested to rescale the variable in a two-component one. However, once recoded, the cases concentrated overwhelmingly in one of the two categories, so that we decided to drop the variable for insufficient variance. A second variable that had to be dropped is 'Allocation of continuous rewards' (#10). While CATPCA works even if the underlying data contain numerous missing values, when missing values are given a passive treatment (that is, objects with missing values on the selected variable do not contribute to the analysis) CATPCA cannot compute the variance explained. To circumvent this problem we had to opt for an active treatment, whereby all missing values are replaced with the same quantification of an extra category. Unfortunately, once that was effected, it turned out that both one of the original categories and the extra category of missing values had high quantifications. This fact blurred the interpretation of the factor loading and suggested dropping the variable from the analysis.

We carried out CATPCA on the remaining 25 variables and proceeded on by deleting in a single shot all the variables that explained 30% or less of the variance of all the factors. Then we fine tuned the solution by deleting other low-loading variables, while keeping an eye also on cross loadings. This process resulted in the solution that is displayed in Table 3. For ease of interpretation the variables are sorted so that those with the highest loading on a certain factor are placed next to

[69] Transformation plots display the original category number on the horizontal axes; the vertical axes give the optimal quantifications.

each other, and lines are drawn between sets of variables loading highly on different dimensions. This solution encompasses 13 of the original variables and explains 54.8% of total variance.

In CATPCA dimensions are to be interpreted in terms of the sign and dimensions of their loadings, which represent the correlation coefficients between the original variables and the factors. By looking at Table 3 we notice that d1 is highly correlated with longer contracts (# 1), with the assignment of monitoring rights (# 21), of bureaucratic control (# 19) and greater use of restraints (# 12). Although lower in absolute value than that of other dimensions, d1 also exhibits a positive and non-negligible correlation with a higher use of presentiation (# 4) and with open ended R&D activities (# 2). Thus, not surprisingly, contracts scoring high on d1 assign less frequently the right to extend the project or the alliance (# 17).[70] All this seems to describe a strategy centered on the use of formalization (# 1, 12, 4) and, in parallel, on the use of control (# 21, 17), that we shall label *bureaucratic intensity*. As setting up and operating a bureaucratic apparatus is costly, it is not entirely unexpected that its use better associates with ongoing, rather than with time-bounded activities (# 2).

As to d2, we must notice preliminarily that one of the variables that loads highly on it (# 5: 'Specification: task') had missing values, which had to be treated as an extra category, as explained above. By looking at the table of quantifications we notice that the categories having significant values are "High" (with negative sign) and the extra category (positive sign).[71] In turn most of the missing values owed to the variable being not applicable, inasmuch as the R&D firm was not requested to carry out pre-clinical R&D activities. In sum a high positive loading of variable 3 on d2 negates either a high specification of tasks or the fact that the R&D firm is requested to carry out a task at all in that particular area. The other loadings indicate that d2 correlates positively with open endedness of R&D activities (# 2), with sharing of project costs among the parties (# 8), and negatively with the use of contingency planning (# 4). Other non-negligible loadings indicate that d2 negatively associates with the use of explicit incentives in the form of milestone payments (# 9) and with the detailed specification of the human resources to be brought to the alliance (# 7). Overall, the sharing of the incidence of burdens (# 8), low-powered incentives to effort (# 9), a less conscious awareness of future contingencies (# 4), and an ongoing relationship (# 2) seem to be some of the describing feature of a 'community of fate'[72] and suggest the labeling of *associational intensity* for d2.

[70] This feature should not be emphasized, since the right to extend the project separates the three dimensions only by the intensity (not the sign) of its correlation.
[71] The vector coordinates of "Low", "High" and "Missing" for variable #3 on d2 are respectively 0.05, -0.63, 1.48. Case frequencies of those categories are respectively 30, 35 and 14.
[72] We owe this expression to C. A. Heimer (1985).

Finally, d3 is correlated positively with the use of contractual hostages (# 23) and explicit incentives (# 9) and negatively with the assignment of decision rights on specific matters (# 15) and with the specification of the quality of inputs (# 7) to be brought to the alliance. Such high reliance on incentives and the relative neglect of the process that leads to the desired outcome seems to be at the core of discrete transactions that are underpinned essentially by the self interest of the parties, as reflected in the promises exchanged (Macneil, 1974). These characteristics give good reason for labeling d3 as *market intensity*.

5.2. Cluster analysis

The output of the CATPCA has been analyzed to reveal groupings of contracts in our sample that would otherwise be not apparent. As it is well known, cluster analysis requires several methodological choices on the part of the researcher (Ketchen and Shook, 1996). Two important ones are the choice of the clustering algorithm and, relatedly, the choice of the number of clusters. To-date neither of these problems has received a definite answer and these issues are still subject to ongoing research. Extant theories about contracting for technology do not suggest very detailed typologies. Additionally, given the limited size of our sample it was unlikely we would be able to predict with high statistical accuracy memberships of solutions involving a large number of clusters. Thus, *a priory* considerations and sample characteristics indicated we should focus on solutions involving up to three or four clusters and compare them. In turn, this decision implies that a trial-and error exploration through k-means clustering is feasible, and allows us to avoid two main problems that are associated with the main available alternative: hierarchical clustering.[73] Partitioning methods like k-means have their own limitations, the most relevant of which is the fact that the number of clusters must be specified in advance.[74] Thus, following a solution advocated by many experts, we shall also compare the number of groupings suggested by a priori considerations with the number determined by one type of hierarchical clustering.[75]

The joint application of these criteria indicates that a three-cluster solution best suits our data.[76] As indicated by the final cluster centers in Table 1 in the Appendix, cluster 1 is defined by values of associational intensity and of market intensity respectively above and below the sample average.

73 K-means clustering is known to suffer less from the impact of outliers and to have greater stability when cases are dropped. Moreover, since it reaches a solution through multiple passes through the data, k-means clustering optimizes within-cluster homogeneity and maximizes between cluster heterogeneity (Ketchen and Shook 1996: 445-446).

74 Other limitations are the fact that k-means clustering may converge on local optima and that it is not suitable to discover clusters with non-convex shapes.

75 We shall use TwoStep Cluster, one method implemented by SPSS that integrates hierarchical with distance-based clustering.

76 An pseudo F test indicates that a 2 cluster k-means solution would be unsatisfactory, as just one dimension would account for the greatest separation between groupings. On that account both a 3-cluster and a 4-cluster one would be equally acceptable. However, we select the former as the TwoStep procedure also yields a 3 cluster solution.

Cluster 2 is described by high bureaucratic intensity and by low associational intensity. Finally, cluster 3 is characterized by above-average market intensity and by below-average bureaucratic control.[77] Thus the definition of each cluster involves high doses of one dimension and negates average, or above-average values of at least another one. Moreover, each dimension significantly associates with the definition of at least one cluster.

Cluster analysis is known to be very sensitive to the choice of the variables the analysis is conducted upon. In particular, the inclusion of irrelevant variables increases the chance that outliers will be created on these variables (Hair et al 1998: 482). On the other side, also the exclusion of relevant variables may result in suboptimal clustering (Dillon, Mulani and Frederick, 1989). In our case, basing on criteria of parsimony and interpretability we opted for a 3-variable solutions of CATPCA. However, we examined also what the impact on our cluster analysis would be if we based it on the output of a 4 dimensional CATPCA. When four dimensions are used as inputs to a 3-cluster k-means CA, the pseudo F-test highlights the fact that one variable contributes distinctively less than the other three to our cluster solution, though the number of cases in each cluster remains almost unchanged.[78] The coordinates of the final cluster centers along the first three dimensions differ only marginally from those obtained by clustering applied to three variables. A TwoStep procedure again generates a three cluster solution. However, in every grouping the fourth variable fails to reach critical value of significance in the pseudo t test assessing its difference from the average.[79] In sum, it appears that dropping from CATPCA the next factor with lower eigenvalue does not deprives the subsequent cluster analysis of valuable information.[80]

An additional concern with cluster analysis relates specifically to the k-means procedure, which can yield different final clusters depending on different initial partitions of the dataset. To tackle this concern we have run the clustering procedure 10 times, each time after sorting the cases in a different way. Indeed this results into slightly different assignments of cases to clusters and into different values for the cluster centers. While visual inspection may be sufficiently reassuring of sufficient reliability, we have also subjected our data to quantitative analysis. This problem resembles an assessment of inter-rater agreement between n-judges. In our case the 'judges' are the

[77] One output of the TwoStep procedure is a t test of equality of a variable's distribution within a cluster versus the variable's overall distribution. With the exception of bureaucratic intensity in cluster 2, all dimensions are significantly different from average at a 95% confidence level, with their size and direction in line with the values indicated by the cluster centers. Additionally, bureaucratic intensity in cluster 1 and associational intensity in cluster 3 are also significantly below the average of their overall distribution.

[78] We obtain a 26, 38, 15 cluster distribution versus 28, 34, 17 in the main-case analysis.

[79] Data available from the author.

[80] We have also tried to assess whether our solution is sensitive to outliers. For this purpose, we have plotted the distance of cases from their classification cluster center in a box & whiskers plot. Only one case, in cluster 2, lies more than 1.5 times the interquartile range away from the median. Filtering out such case does not significantly affect the resulting clustering solution. Data available from the author.

10 different cluster analyses while the 'subjects' are the cluster centers and the number of cases in each cluster. We conducted the reliability analysis on the cluster centers separately from that on the number of cases in each cluster. The former yields a Cronbach alpha of 0.973, the latter one of 0.908. We consider this as evidence that that our results are sufficiently robust to different initial partitioning of the dataset.

6. Discussion

This study adds flesh to Stinchcombe's (1985) contention that contracts are an organizational phenomenon, that is, social structures that can contain the same basic elements as unified governance forms. It also expands a line of reasoning first developed by Victor Goldberg (1976: 428) that contracts can be "constitutions". Continuity with Goldberg's lies in the acknowledgement that in certain contexts contracts shift from a detailed specification of the terms of the agreement to more complex, generally procedural, governance structures. Expansion lies in the recognition that the complexity of the contractual apparatus may exceed what is required for a simple "adjustment" of the agreement over time and may be motivated by the need to support also the discovery of suitable actions, and the adaptation, if not the discovery, of the goals of the relationship.

However, this study was designed particularly to highlight different *configurations* of mechanisms; hence, what differentiates dissimilar governance forms, rather than what they have in common. Thus, lest we forget, it is useful to remind some mechanisms that are important in technology alliances and yet do not show up in the multivariate solutions due to their uniformity across contracts. Some form of sharing of continuous monetary rewards, usually in the form of royalties on net sales or on net margins, is common to the vast majority of pharmaceutical biotechnology contracts. Similarly, alliance agreements in this field adopt a standardized solution concerning the incidence of foreground intellectual property, that is, inventions developed after the inception of the alliance. The solution is that each owns its own inventions and that jointly developed inventions are owned jointly. As to decision-making, the vast majority of contracts does not allow for changes at the strategic level of decision, but allows for post-contractual selection of actions through centralized and decentralized authority. Moreover, in about 70% of cases contracts assign one or both parties one particular decision right, that to terminate the alliance without cause. Yet this clause explains very little of the contractual heterogeneity in our sample.[81]

[81] In our coding scheme binary variables take values of 1 (corresponding to "No") or 2 (corresponding to "Yes"). Accordingly, one can interpret the mean of those variables minus 1 as the percentage of the agreements in the sample where a certain mechanism has been observed.

Other standardized contractual terms that do not even make the list of our initial 27 variables relate to dispute resolution through arbitration and the institution of a joint-steering committee of tied membership, which usually decides by unanimous consent.

Some contractual mechanisms were left out not on account of uniformity of adoption but because they show a low correlation with the main contractual dimensions. Among these we have all the dispute resolution mechanism listed in Table 2, which are adopted in 30% or less of cases. Another, such mechanism is equity investment in the partner's capital.

Our study finds results that corroborate the hypothesis advanced by Grandori (2005). It appears that one defining characteristic of technology alliances is the degree to which they establish a continuing association of resources "no matter what", which tends to vary inversely with the specification of tasks and with the planning of contingencies. We labeled this dimension "associational intensity". This result comes with some caveats that will be detailed in the conclusions.

Next we shall compare our findings concerning the contractual dimensions with those of prior studies. In Suchman's study dimension 1 was understood to measure the degree to which the contract delineates various rights and obligations of the parties and was reflected particularly in the protective covenants of the agreement.[82] That dimension has little or no correspondence with our dimensions. In my opinion this owes mainly to two reasons: first, to the fact that our research design does not emphasize the risk planning part of the contracts;[83] second, to the fact that the protection of interests through the assignment of specific rights must be particularly salient in a setting like venture capital financing, which binds together for a long time two or more organizations with very different knowledge bases. On the contrary, dimension 2 bears a certain resemblance with our "associational intensity". The former, labeled the *intensity of the relationship*, was based essentially on several decision rights that have the purpose of preserving the involvement of the financier. Continuity of commitment it certainly a definitional feature of an association and it is what makes possible the establishment of a communitarian regime on the incidence of costs – one of the defining traits of our dimension.

Some similarity can be established also between our dimensions and those in Brousseau (1995). In the latter study, factor 1, labeled "specificity" (in the sense of the extent to which the contract establishes a governance apparatus specialized to the particular relationship), is described by the intensity of use of centralized decision-making, monitoring, unilateral hostages and duration, with

[82] "Preferred as opposed to common stock (…) specific dividend, merger, mandatory conversion and anti-dilution provisions (…) covenants that might weaken investors' preferential rights" (Suchman 1994: 210).
[83] Risk planning is identified by asking whether the contract may likely go through a successful conclusion without what is being planned in a particular section of the contract having to be carried out. An affirmative answer identifies risk planning. A negative answer identifies performance planning (Macneil 1975: 640).

higher values of these mechanisms corresponding to higher degrees of specificity. These elements line up quite well with those defining the dimension we interpreted as "bureaucratic intensity". On the contrary, Brousseau's second factor – the degree of asymmetry – which measures the lopsidedness in the allocation of certain rights and obligations (hostages, monitoring, monetary rewards) does not find a parallel among our dimensions. Also in this case the design of our research (that was concerned more with the presence or absence of certain elements in the contracts than with the party to whom they were assigned) may be partially responsible for underplaying this factor. However, as illustrated by our previous remarks concerning decision-making structures and the assignment of intellectual property rights, biotechnology alliance contracts tend to exhibit a remarkably balanced allocation of rights and duties in several areas.

As to the clusters of contracts identified in our study, our results indicate that among pharmaceutical biotechnology alliances there are quite radically different governance models. Supposing that our dimension of bureaucratic intensity adequately represents the conceptual domain that Williamson (1991) meant by 'administrative' or 'hierarchical' intensity, our results indicate that a governance solution characterized by medium or low values of hierarchy is suitable in over 50% of the cases in our sample (clusters 1 and 3).

The governance configurations identified seem to be quite consistent with results established by organization theory for ongoing integrated structures. Market governance seems ill suited for organizations pursuing high involvement of members and continuity of association [citazioni?] (cluster 1). Bureaucratic governance, particularly in the sense of standardization and formalization, does not match well with a low specification of commitments, a low planning of contingencies and, presumably, with the joint decision making that attend to associational alliances (cluster 2). Finally, alliances with substantial reliance on incentives show also below-average dependence on instruments of conscious adaptations (cluster 3). These results indicate that in a stylized sense, 'hierarchy' is not just the opposite of 'market' but it is also at variance with governance by 'communities of fate'.

7. Conclusions

As it should be apparent for the foregoing review of literature, the field of the economic and organizational studies of contracting does not seem to have reached consensus about the fundamental dimensions of inter-firm agreements. As a result, "theory provides no unifying structure for the specification and testing of design hypotheses" (Masten and Saussier, 2002: 282). In a sense, the state of the field resembles that of the studies of work behavior at the beginning of

the sixties, when factorial studies were still rare (Pugh et al. 1963). By analyzing *in extenso* a medium-sized sample of agreements, in terms of variables obtained from the literature on contracting, this paper attempts to redress this problem and, limitedly to the formalized governance of technology alliances, it replicates the research strategy that the Aston studies had applied to working systems at large.

This study indicates that the intensity of 'hierarchy' is not the only dimension that discriminates among different inter-firm alliances. Further, it highlights that the 'type' of a governance structure is the resulting combination of a large number of contractual clauses often belonging to different substantive areas. This finding should inspire caution when analyzing contracts in a piecemeal way. Still more, our results indicate that the lopsidedness of rights allocation is not always a salient problem when contracting for technological information. If asymmetric allocation of rights is the efficient response to contractual incompleteness (see Hart, 1995) our results indicate that many technology agreements are, in a sense, "complete" yet, quite low on presentiation.

This study has also several limitations. First, by conscious design, this study has focused on the performance planning side of contracts to the neglect of the risk planning, that is, of provisions like representations, warranties, indemnities and insurance. This was motivated both by the perception that in biotechnology agreements these sections are generally dealt with by means of 'boilerplate', standardized provisions, as well as by the practical necessity to reduce the mind boggling complexity of the task of analyzing contracts. Our guess is that in particular settings, like venture capital financing, risk planning is a non-negligible part of the contract and should be accounted for in the analysis. A second limitation is related to the size of the sample. As principal component analysis requires the ratio between cases and variables exceeds a certain minimum level, we have been prevented from basing our analysis on an even wider set of contractual attributes. Accordingly, some relevant contractual characteristics may not be reflected in our dimensions. The limited number of the original variables entails that each CATPCA dimension is predicated only on five or six contract terms. While this may be enough to identify dimensions, like 'bureaucratic intensity', that are already well rooted in the tradition of organization theory, a larger number of indicators would be desirable for constructs, like 'associational intensity', that have been recently proposed to the attention of the scientific community.

Some avenues for future research are implicit in the aforementioned limitations. Additionally, one future development may consist in developing and testing hypotheses on the antecedents of different contract types. Other studies should replicate the analysis in settings other than contracting for R&D, to explore the extent to which the dimensions identified are context-specific or

characterize a wider class of alliances. Finally, still other studies may replicate the analysis beyond dyadic alliances and investigate which particular problems are posed by multiparty hybrid governance forms.

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Appendix

Table 1: Coding scheme

Level	Matter	Area
Contractual		
		Documents
		Duration
		Presentiation
Intra-contractual		
	Substantive	
		Monetary Rewards - Project
		Property rights
		Commitments (Task, Resources)
	Procedural	
		Decision making
		Selection of Actions
		Control Rights
		Restraints
		Enforcement
		Hostages
		Punishments
		Monitoring
		Coordination
		Dispute Resolution

Table 2: Value labels and descriptive statistics

Variable	Values	Valid cases	Min	Max	Mean	Std. Dev.
Contract-level characteristics						
1 Contract length (pages)		79	19	223	83.2	46.80
2 Project duration	1='Close ended', 2='Open ended'	79	1	2	1.4	0.50
Presentiation						
3 Contingent compensations	1='Contingent terms', 2='No contingent terms'	76	1	2	1.6	0.50
4 Cost allocation of 3rd party licenses	1='No', 2='Yes'	79	1	2	1.6	0.50
Specification of commitments						
5 Specification: task	1='Low', 2='High'	65	1	2	1.5	0.50
6 Specification: # of personnel	1='No', 2='Yes'	79	1	2	1.3	0.48
7 Specification: skills	1='No', 2='Yes'	79	1	2	1.4	0.48
Monetary rewards						
8 Project costs regime	1='Reimbursement', 2='Sharing'	79	1	2	1.4	0.48
9 Milestone payments	1='No', 2='Yes'	79	1	2	1.7	0.46
10 Allocation of continuous rewards	1='Revenues', 2='Profits and margins'	70	1	2	1.2	0.43
Restraints						
11 Non-compete restraint (on R&D firm)	1='No', 2='Yes'	79	1	2	1.6	0.50
12 Non-compete restraint (on client)	1='No', 2='Yes'	79	1	2	1.4	0.50
13 Other restraints (on R&D firm)	1='No', 2='Yes'	79	1	2	1.6	0.49
Decision making						
14 Action selection mechanism	1='Routines', 2='Centralized authority', 3='Decentralized authority'	79	1	3	2.1	0.56
15 Right to delay publications	1='No', 2='Yes'	79	1	2	1.6	0.48
16 Right to expand alliance	1='No', 2='Yes'	79	1	3	1.8	0.89
17 Right to extend alliance	1='No', 2='Yes'	79	1	2	1.6	0.50
18 Right to terminate alliance without cause	1='No', 2='Yes'	79	1	2	1.7	0.45
Coordination						
19 Budgets	1='No', 2='Yes'	79	1	2	1.5	0.50
20 Liaison roles	1='No', 2='Yes'	79	1	2	1.3	0.47
Monitoring						
21 Auditing rights	1='No', 2='Yes'	79	1	2	1.4	0.50
22 Inspection rights (of scientific records)	1='No', 2='Yes'	79	1	2	1.3	0.46
Hostages						
23 Upfront payments/ firm orders	1='No', 2='Yes'	79	1	2	1.6	0.50
24 Equity investment	1='No', 2='Yes'	79	1	2	1.5	0.50
Dispute resolution						
25 Unilateral decision rights	1='No', 2='Yes'	79	1	2	1.3	0.47
26 Authority to outsiders	1='No', 2='Yes'	73	1	2	1.2	0.43
27 Litigation	1='No', 2='Yes'	78	1	2	1.3	0.47

Table 3: Factor loadings

		Dimension		
Variable		*d1*	*d2*	*d3*
1	Contract length (pages)	0.82	0.04	0.08
21	Auditing rights	0.65	-0.32	-0.15
19	Budgets	0.63	-0.06	-0.06
17	Right to extend project/alliance	-0.57	-0.32	-0.26
12	Non-compete restraint (on client)	0.50	-0.03	-0.29
5	Specification: task	-0.03	0.75	0.08
2	Project duration	0.47	0.67	0.11
8	Project costs regime	0.30	0.64	-0.32
4	Cost allocation of 3rd party licenses	0.40	-0.63	0.04
23	Upfront payments/ firm orders	0.24	-0.18	0.73
9	Milestone payments	0.10	-0.48	0.68
15	Right to delay publications	0.29	-0.37	-0.53
7	Specification: skills	-0.04	-0.41	-0.52

Table 4: Final cluster centers

	Cluster		
	1	2	3
Bureau Object scores dimension 1	0	1	-1
Association Object scores dimension 2	1	-1	0
Market Object scores dimension 3	-1	0	1

Table 5: Cluster distribution

		N	% of Valid Cases
Cluster	1	17	22%
	2	34	43%
	3	28	35%
Valid		79	100%
Missing		0	

Planning for Risk or Planning for Performance? Managing Resource Requirements and Coordination Concerns in Technology Alliance Agreements

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ABSTRACT

Research on interfirm alliances typically analyzes the choice of alliance form as an efficient response to hazards of various kinds. In keeping with this hypothesis alliances are usually ranked along a continuum of 'hierarchical intensity'. However, recent research has emphasized that alliance governance form must also manage coordination requirements. This claim has been tested and corroborated at the level of the choice between major alternative forms, like contractual alliances, minority investments and equity joint ventures (Gulati and Singh 1998). We carry out a similar investigation at the level of the choice between alternative contractual alliances. In addition we allow for the possibility that contracts are multidimensional and differ 'in kind'. Our findings confirm that coordination concerns are an important predictor of the choice between alternative contracts. The distribution of resources has also a significant impact on that choice. The response of different contractual forms to certain predictors contradicts the one-dimensional representation of alliance forms, and implicitly supports the idea that contracts serve other purposes besides providing safeguards against hazards. Finally, the significance of resource-related explanatory variables indicates the need for a more systematic investigation of a resource-base view of contracts.

KEYWORDS: Governance, contracts, strategic alliances, biotechnology, joint R&D.

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1. Introduction

Research on contract choices in interfirm alliances has been mainly influenced by transaction cost economics (henceforth, TCE) (Gulati and Singh 1998). This perspective is primarily "concerned with the *identification, explication, and mitigation of all forms of contractual hazards*" (Williamson, 1996: 5, emphasis in the original). Accordingly, much TCE-inspired research explains the choice of governance forms with the presence of transaction-level hazards: "superior performance is realized by working out a farsighted but incomplete contracting setup in which the object is to use institutions as (cost-effective) instruments for hazard mitigation" (Williamson 1996: 14).

In the paradigm problem investigated by TCE – vertical integration – the main hazard is represented by the risk of expropriation of the rent associated with specific investments. However over time, TCE has identified several other types of hazards, which vary depending on the type of transactions involved. Despite this expansion of the concept TCE remains chiefly concerned with those contracting problems that would vanish but for the joint occurrence of opportunism and bounded rationality (Williamson 1996: 14).

While such problems may be paramount in transactions involving high potential conflict, at a minimum when the activities contemplated by the partners to an alliance are complex, the governance model adopted is likely to reflect also the concern that the pattern of coordination it helps establishing is suitable for the task at hand. Even more, when an alliance involves exploration activities, the parties ought to be concerned also about their capabilities and the resources they commit to the task (de Laat 1997; Grandori 2005). Borrowing from legal jargon, we can say that within contracts, the planning of *performance* is at least as fundamental as the planning of *risk* (Macneil 1975).

Based on a similar reasoning, Gulati and Singh (1998) advanced the hypothesis that the choice of the alliance form is driven not only by appropriation concerns but also by *coordination requirements.* While Gulati and Singh have found support for their hypothesis, the antecedents of formal alliance governance that could be inspired by classical organizational thinking or by the resource-based view have not been investigated systematically, and have yielded mixed evidence (see, for example, Sampson (2004) and Xia Wang (2005)).

This paper further expands on this line of thinking. In particular it decomposes coordination requirements in the various sources they owe to, and examines the power that different types of interdependence in predicting contractual forms. Such decomposition is made necessary by the realization that various forms interdependence can be qualitatively different (Grandori 2001). Further, we examine whether other traditional predictors of inter-firm coordination modes –

uncertainty and the distribution of resources – are useful when the explanandum is specifically the formal, enforceable, agreement.

Divergence on the predictors notwithstanding, both the tradition focusing on contractual hazards, and those contributions emphasizing antecedents inspired by organization theory or the resource-based view, have often been in practical agreement in treating alliances form as a one-dimensional construct varying along a continuum, usually labeled 'hierarchical intensity' (Oxley 1997, Gulati and Singh 1998) or 'integration intensity' (Xia Wang 2005). However, prior research (Alter and Hage, 1993; Suchman 1994, Brousseau 1995, Furlotti, 2007) has alerted us that one-dimensional characterizations of inter-firm alliances in general, and of alliance agreements in particular, are bound to leave a lot of the observed variance unexplained. This focus on low dimensional representations seems to be inspired more by analytical convenience than by theoretical reasons. For instance, in Williamson (1991) governance forms are argued to differ by incentive intensity, administrative intensity, adaptability properties and by the type of contract law. For Gulati and Singh (1998: 787; our emphasis) "each governance structure for alliances is typically associated with distinct *types* and levels of hierarchical control". Yet they end up analyzing "the choice across structures [as] one of choosing the appropriate *level* of hierarchical control".[84]

This state of things provides the occasion for a second purported contribution of this study: allowing for the possibility that different governance forms differ not just in degree but also *in kind*. Practically, this requires that contractual forms are not categorized simply by the presence or absence of equity investment (as a proxy of control) or by means of ready-made typologies ('second sourcing', 'licensing', 'technology sharing', etc.) but through an in-depth analysis of structure and process based on theoretically relevant categories. The creation of empirical taxonomies of organizational forms based on an analysis of their elementary building blocks is in the tradition of organizational theory (McKelvey 1982; McKelvey and Aldrich 1983). By carrying out such analysis at the level of formal alliance agreements, and by investigating the antecedents of contractual forms, we bring to bear such tradition on the economic and managerial understanding of inter-firm contracts. Obviously carrying out such task in its entirety exceeds the limits imposed by a single paper. Thus, we take advantage of the results of a prior analysis carried out in Furlotti (2007) and focus here on the predictors of contractual forms.

Our interest in the coordination capabilities of contracts, rather than in their agency features, requires that that the issue is investigated in a setting where coordination and capability

[84] While the cited passage reveals a contradiction, their econometric technique – multinomial logistic – does not assume that the dependent variable is ordinal. Thus the statistical analysis is compatible with a nominal measurement of the dependent variable.

requirements are not trivial and where inter-firm alliances are a common means of doing things. This led quite naturally to the choice of biotechnology alliances as the setting of our research.

The paper develops as follows. The next section introduces the results of a study that identified relevant contractual types and the dimensions that define them. Section 3 introduces antecedents inspired by classical organizational thinking. Section 4 develops hypotheses about the relationships between those predictors and different contractual types. Section 5 describes our empirical analyses and their findings. Section 6 discusses the results and concludes.

2. Contractual types

Empirical research on alliance forms has often distinguished alliances based on the presence or absence of shared equity investment (Hennart, 1988; Pisano, Russo, and Teece, 1988; Pisano, 1989; Teece, 1992; Osborn and Baughn 1990; Oxley 1999; Sampson 2004; Oxley and Sampson 2004). Shared equity is generally associated with stronger control and with better incentive alignment, thanks respectively to the administrative apparatus and to the hostage function played by each party's equity share. Other studies expand the types of alliances investigated (Oxley 1997, Gulati and Singh 1998), yet they assume that the types considered can be ranked in terms 'hierarchical control', with the equity joint ventures and simple contractual agreements usually situated at the opposite ends of the continuum. Representations along a single axis have been adopted also when the characterizing dimension was not the degree of control but 'organizational interdependence' (Contractor and Lorange 1988) the 'degree of vertical integration' (Lorange and Roos 1992), and 'integration intensity' (Xia Wang 2005)

While such representations may be justifiable, given the fact that most of the alliances have focused on agency problems, "the presence of equity sharing also masks difference across each type of structure" (Gulati and Singh 1998: 783) and the same applies to the other particular traits that have been singled out to characterize alliances. That one-dimensional representations are insufficient to describe the variety of interorganizational forms is perfectly clear to anyone who proposed a typology of such forms (Williamson 1991; Alter and Hage 1993; Grandori 1997; Ménard 2004). Additionally, principal component analyses and investigations carried out with equivalent techniques reveal that unless two or three dimensions are employed, only a modest fraction of alliance heterogeneity can be explained (Suchman 1994; Garrette and Dussauge 1995; Brousseau 1995; Furlotti 2007).

All these objections notwithstanding, the empirical support for hypotheses that predicate the choice between alliances with different degrees of 'hierarchical intensity' on various types of contractual hazards is fairly strong. Most of the above mentioned studies have been rather

successful under that respect.[85] Basing on such evidence, contrasting 'market-like' to 'hierarchical' alliances would be a useful heuristic, and it would be justifiable to think of forms that do not fall neatly into either type as 'hybrids'.

However, most of the contractual relations that have been investigated involved the supply of goods or services in exchange for payments (e.g. Joskow 1985, 1987; Masten and Crocker 1985; Crocker and Reynolds 1993; Saussier 2000). Even when the explanandum is specifically the type of alliance form (as opposed to particular contractual clauses) the alliances investigated involve more often transfers of rights (in the form of second sourcing, licensing, assembly and buyback, management or marketing service agreements, etc.) rather than genuine joint action collaborations. Thus, arguably, agency concerns are dominant, and the market-hierarchy characterization is satisfactory.

Is an agency framework sufficient also when joint-action alliances are involved? While joint activities are not an exclusive characteristic of R&D alliances, innovation often requires a combination of different competences and activities (Von Hippel 1998). These combinations, in turn, entail interdependence in various degrees. Further, the innovativeness of outcomes implies the uncertainty of tasks, which compounds with interdependence and renders coordination a non-trivial problem. Thus, R&D collaborations may reveal, better than 'plain-vanilla' alliances, whether a typology based on an agency perspective is adequate.

From a theoretical point of view, there are good reasons to argue that hierarchy cannot be expected to be a cure for all the situations where market fails. Authority is known to fail under conditions of high uncertainty (Radner 1997). The problem with uncertainty is that it makes difficult to specify what constitutes 'proper' behavior. Setting forth from that reflection, Grandori and Furlotti (2006) argue that under conditions of radical uncertainty a better strategy than full and detailed contractual specification of actions or the assignment of authority to a single party would be to shift the matter of contracting to something that is capable of generating actions: resource commitments. Obviously a commitment of resources to a joint enterprise would also call for allocations of property rights and for decision procedures on how to make use of pooled resources. Contractual relations defined by these criteria – a pooling of resources and allocations of property rights and decision rights – are certainly not market-like, but neither are they necessarily 'hierarchical'. Thus, the authors design them by a different label, as 'associational contracts'.[86]

[85] However, David and Han (2004) carried out a systematic investigation of 117 tests of the proposition that as asset specificity increases, hybrids and hierarchies become preferred over markets, and found that only 45% of tests were supported, while 8% of results were counter to the theory.

[86] Relations based on 'combinations' of resources and on procedural rules have been identified also by Coleman (1990) and by the constitutional paradigm (see Vanberg 1994).

Inspired by such considerations, Furlotti (2007) has carried out an empirical investigation of pharmaceutical biotechnology alliances, based on content analysis of their alliance agreements. The analysis grid was developed to gauge the dimensions traditionally identified by the transaction cost perspective, namely the incentive and administrative incentive of contracts. In addition, the measures assessed the extent of specification of task and resource commitments, the assignments of property rights, and the specifications of procedures form decision making. Through a principal component analysis of 27 original variables, three factors have been identified which, together, accounted for about 55% of total sample variance. The defining characteristics of each factor are summarized in Table 1. Basing on factor loadings it is possible to establish a reasonably close correspondence between the three factors and the conceptual dimensions identified above. The first factor seems to capture the intensity of use of formalization and standardization, the overall contractual specification, and the presence of a monitoring apparatus. This is pretty much in line with accounts of organizations developed from Weber's classical bureaucratic model (Hall 1962; Hage 1965; Pugh et al. 1963) which were rather in agreement on at least four dimensions: standardization (uniformity regarding procedures and material), formalization (how far procedures are written down and filed), specialization (number of functions performed by specialists) and centralization (the locus of authority to make decisions). Accordingly, our first factor has been labeled 'bureaucratic intensity'. The second dimension, labeled 'market intensity', measures the extent to which the contract relies on autonomous adaptation through explicit incentives, and de-emphasizes conscious coordination mechanisms. Finally, 'associational intensity' captures that extent to which the contract creates a continuous association of dedicated assets, rather than obliging the parties to the performance of specific behaviour. This is reflected in the choice of sharing as a way to allocate project costs, in the open endedness of the project itself, in the restrained specification of tasks, and in the limited use of contingency clauses as a means to effect adaptation.

Through a cluster analysis performed on the scores on these contractual dimensions, three contractual types have been identified. As indicated in Table 2, each contractual type scores high along one dimension, is significantly below sample average along a second, and is not significantly different from average along the third. This suggests interpreting the contractual types in terms of their 'dominant' dimension. Accordingly the three types will be indicated as 'associational', 'bureaucratic' and 'market-like' contracts. In the remainder of the paper we shall develop hypotheses on the predictors of these types and we shall test them empirically.

3. Predictors of formal alliance governance

What influences the choice of the contractual governance of alliances? As argued above, we are interested in the contractual governance of alliances with significant degrees of joint activity or pooling of resources. Accordingly we are looking for factors that are useful to capture particularly its coordination and integration aspects. The factors we consider here are external to the alliance or are intrinsic to the type of work being done, and have a tradition in organizational studies.

These factors shall be used to work out an explanation of efficient alliance types which conforms to Jon Elster's recommendation, that is, "organized around (partial) *mechanisms* rather than (general) *theories*" (Elster 1944, as cited by Williamson 1996: 5)

The factors we consider are referable to two fundamental ways of viewing organizations: the first focusing on the task dimensions, the second emphasizing resources.

From the all the variables that have been considered under the first perspective we single out uncertainty and interdependence. The first refers to the extent to which task processes have knowable outcomes (Alter and Hage 1993). This variable has been a factor in organizational theory for a long time (Burns and Stalker 1961, Thompson, 1967) but has not been used frequently as an antecedent of interorganizational configurations. Exceptions were Hladik (1988) and Grandori (1997). However, TCE has reinstated it as a fundamental explanatory variable also at the inter-firm level. The second, interdependence, is an intermediate and composite variable that is often used as a concise predictor of organizational solutions.

A keen concern for resources cannot by credited to a single theoretical perspective. Among the theories that examined organizations in terms of resources there are the resource-dependence theory (Pfeffer and Salancik 1978), the organization assessment perspective (Van de Ven and Ferry 1980) and the theory of negotiation (Grossman and Hart 1986; Hart and Moore 1990). Resources matter in many respects. For instance, in the study of many types of networks it is important to ascertain whether the network receives resources from a single source, like the government, or not. However, given the fact that we are concerned only with dyadic relations between private business organizations, many resource-related variables that have attracted investigation in the past are not relevant in our context. Thus we shall focus only on the extent to which two types of resources – knowledge and the financial resources – are contributed to an alliance by a single party or by both of them.

Below we examine more in detail all these variables, particularly in the context of inter-firm alliances.

Uncertainty

Contracting is supposed to require the specification of actions and/or of goals, particularly in a 'classical' contracting perspective (Macneil 1974).[87] In general uncertainty hinders meaningful specification, that is, the greater the uncertainty, the more detailed specification becomes dysfunctional. This is immediately apparent if the source of uncertainty is the difficulty of identifying all the relevant alternative scenarios or the variability of the factors that may affect the situation, that is, if uncertainty generates *computational complexity* for the decision maker (Simon, 1962, Galbraith 1974). However uncertainty may have other, different reasons. In particular, it may reflect a lack of knowledge of cause-effect relations. Analyzing the type of uncertainty surrounding a given transaction is relevant, as different governance forms are likely to prove effective in dealing with uncertainty of particular kinds. For instance, to the extent that the sources of uncertainty are of the former kind, letting the future unfold and adapting to it may suffice (Williamson 1975). However, to the extent that uncertainty is 'epistemic', the simple passing of time does not help: what is required is the construction of a valid model of what actions and alternatives are available and what consequences can be expected (Grandori, 2001).

Interdependence

Interdependence is one of the fundamental explanatory variables in organizational models. Originally interdependence has been investigated in an intra-organizational context (March and Simon, 1958; Thompson, 1967). Later, is has been applied as a predictor of efficient organizational configurations also in inter-organizational settings (e.g. Grandori, 1997). Nevertheless, interdependence is rarely found as a predictor in the literature on inter-firm contracting (Shelanski, Klein 1995; David, Han 2004; Boerner, Macher 2005; Furlotti 2007). Exceptions are Mayer and Bercovitz (2003) and Mayer and Nickerson (2005). Until the work of Gulati and Singh (1998) also the literature on strategic alliances has not used interdependence as an explanatory factor of governance structures frequently.

One reason for this state of things is that most of the contracts that have been investigated involved the supply of goods or services in exchange for payments (e.g. Joskow 1985, 1987; Masten and Crocker 1985; Crocker and Reynolds 1993; Saussier 2000). As a result, the situations they dealt with concerned relatively simple *do ut des* relationships, while interdependence presupposes the division of work and unified effort (March and Simon 1958). Moreover, the main contracting problem analyzed within these settings – the protection of relation-specific investment – can be modeled satisfactorily without resorting to interdependence (Williamson 1975, 1983). By contrast, the parties of an alliance are often requested to perform actions as part of a common effort, not just to supply widgets or commodities. Different competences need to be brought to bear on the

[87] The promise relates to something, not to everything (Macneil 1974: 715).

goal of the alliance, often with intensity and timing that are unknown ex-ante. In other words, alliances are frequently based on the division of work and require the diffusion of information and resources, that is, all the basic ingredients of interdependence.

The classical types of interdependence have been investigated mainly with reference to going concerns, focused on the exploitation of a given technology (Thompson 1967), and with reference to flows of tangible resources. By contrast, technological alliances focus on exploratory activities, are usually assigned a specific time bracket and rely largely on immaterial inputs. As a result the defining criteria of interdependence need to be adapted to a context where a smooth flowing of goods is not a particularly critical element for success and the basic patterns of interdependence need to be figured-out ex-ante, at the contracting stage, rather than being assessed from a retrospective look at past activities.

This complicates our task a little. Yet, we posit that depending on some initial conditions relating to the type of assets contributed, to the kind of output envisaged and to the actions undertaken, certain predictable patterns of interaction will ensue. Accordingly, the parties are likely to respond by providing for suitable coordination mechanisms. Not only, but since coordination costs are affected by the structure chosen (Thompson 1967), in principle interdependence might affect also the contractual allocation of decision, action and reward rights.

The task of spelling out particular types of interdependence is delegated to Section 4. However, one variable that we shall investigate under the rubric of interdependence – alliance scope – requires justification. In classical organization studies, 'scope' is an attribute of task, and is one dimension of technology (Van de Ven and Delbecq, 1974; Dewar and Hage 1978). Task scope is defined as "the degree to which tasks are variable and require a multidisciplinary and multidimensional approach" (Alter and Hage, 1993: 117). "It explains why there is a need for a variety of technologies and a given level of specialization in each of them" (Dewar and Hage 1978: 115). Thus, defined, task scope should be expected to produce effects quite similar to uncertainty, either in its computational or in its cognitive version. Different alliances are likely to entail tasks with different scope but we aver that such dimension would be quite difficult to measure in large samples, and particularly through documental analyses. Here we are concerned with 'scope' in a slightly different sense. In particular, we want to analyze whether the carrying out the commercial exploitation of the results of the R&D activity within the umbrella of the same alliance that generated them brings consequences for the choice of the alliance contractual governance. Manufacturing and sales activities clearly require different competences from those that are necessary for R&D. However, they are just instrumental to the overall task and do not increase the

"product mix", as sometimes task scope is called. Thus, we investigate scope in the precise sense of the range of functional activities. We shall argue later that when specified in this sense alliance scope samples more within the conceptual domain of interdependence than within the domain of complexity.

Distribution of resources

The concept of 'alliance' entails the notion of collaboration among parties that are peers, in some sense (Oxley and Silverman 2007). In terms of their contributions across the whole spectrum of resources, it is reasonable that the parties establish some form of reciprocity. However, with respect to particular classes of resources quite uneven contributions can be observed. We claim that the degree of concentration of certain resources is an important predictor of certain organizational features of technological alliances. In what follows we focus attention on financial contributions and on the scientific know-how, whether patented or not, brought by the parties to an alliance.

In other settings, it could be argued that the balance of resource contributions is, at least to some extent, endogenous to the relationship. For instance, the willingness of a party to commit capital may be conditional on how much influence the other party is willing to accept. However, managerial literature in general seems to be rather unanimous in treating the balance of resources as an antecedent of certain organizational variables. Additionally, the particular setting of pharmaceutical biotechnology alliances is likely to offer the parties quite few degrees of freedom with regards to choices concerning resources. Clearly, in knowledge intensive collaborations, often involving cutting-hedge technology, the balance of knowledge resources is largely dictated by the partners' respective capabilities. Similarly, cash-constrained technology start-ups with no products yet in the commercialization stage can hardly be expected to fund the bulk of R&D expenses in projects that often span over a decade or longer.[88]

4. Hypotheses development

4.1. Uncertainty and contractual type

4.1.1. Epistemic uncertainty

In the previous section we have argued that under conditions of epistemic uncertainty simple ex-post adaptation may not be a solution to contracting problems since what is required is rather the construction of a valid model of the world. We posit that at an organizational level, the construction of a valid model benefits from the application of intellectual resources that are sufficient by quantity

[88] According to the sources mentioned in Table 3 in the Appendix, the drug development process currently lasts on average about 14 years. Although late stage development could be carried out by a licensor, if R&D companies were to engage just in the discovery stage on a standalone basis, they should be prepared to fund activities for an average 5.5 years.

and relevant by epistemic domain. This is an almost self-evident proposition. As to both antecedents (quantity and relevance), it is well known that the search of analogue problems and the recognition and the matching of patterns are common heuristics that can help generating more accessible problems (Pólya, 1945). Clearly the application of any of these techniques is likely to be the more effective the greater the available repertoire of related problems and the greater the relevance of such repertoire to the focal problem. The first condition entails that the application of a greater amount of intellectual resources enhances the odds of coming up with a solution. The second one implies that relevant knowledge resources are less than perfectly substitutable. Obviously, imperfect substitutability does not follow only from general characteristics of problem solving, but also from known dimensions of knowledge, in particular from its tacitness (Polanyi 1966, Nonaka and Takeuchi 1995), its distributions among different actors (Weick 1979) and its situatedness (Nelson and Winter 1982: 105?).

From all these reasons we can argue that organizational structures that ensure the bonding of a certain amount of specialized resources to the mission of solving an epistemically complex problem should on average outperform alternative structures that provide for the application of a lower amount of resources and structures in which the resources are made available intermittently or are frequently diverted to competing goals.

While bound to some extent to the solution of the focal problem, the resources brought to bear on it cannot be overly constrained, lest they loose the possibility of creating those novel combinations of activities and resources upon which innovation is typically based (von Hippel, 1988). This is a classic proposition in the organizational theory (Burns and Stalker, 1961) that hardly needs further arguing. However, the foreclosure to resources of the opportunities to be applied outside the domain defined by the "problem", and the granting of freedom from specific forms of application, are, as we saw, the main defining traits of an associational contract. Accordingly we can we can advance the following proposition.

Proposition 1a: A high level of epistemic uncertainty will be associated with greater use of associational contracts.

As seen in Section 2, the bureaucratic model is characterized by standardization, formalization, specialization and centralization. While specialization need not be in contrast with efficient problem-solving, the remaining characteristics of bureaucracy are difficult to reconcile with the type of uncertainty that surrounds Schumpeterian innovation. Standardization is impracticable by definition when the problem to be solved requires the pursuit of not-previously attempted combinations of activities and resources. Likewise formalization, in the specific sense of

a detailed writing and filing of procedures, is unsuitable for handling the explorations that accompany innovative activities.[89] Finally, the concept of 'combination' (of activities and resources; see above) presumes different elements to start with. Typically, in the innovation process these elements correspond to different knowledge bases, which are the more difficult to master the more they are cognitively distant. In turn, this lack of mastery of the required knowledge is an antecedent that should cause centralized authority to fail (Grandori, 2001). These arguments are not only conceptually plausible, but have received ample support from empirical research that ranges from the seminal work of Burns and Stalker (1961) to the literature on the new organizational forms and network governance (Saxenian 1990, Miles et al. 1997, Jones et al. 1997). To the extent that contracts incorporate bureaucratic elements they are also likely to fail under conditions of epistemic uncertainty. These intuitions lead to the following proposition.

Proposition 1b: A high level of epistemic uncertainty will be associated with lower use of bureaucratic contracts.

What we have called market-like contracts base their governance properties mainly on the self-interest of the parties and on the reduction of the relative importance of conscious coordination mechanisms. More in detail, market-like contracts are characterized by a greater reliance on performance-based rewards rather than on the sharing of residual rewards or on fixed compensation. Further, through the use of hostages these contracts set the proper incentives for contractual performance and reduce the need for alternative administrative ways to safeguard the relationship, like monitoring (Jensen and Meckling 1976). To the extent that the pursuit of individual interest can be reconciled with collective interest by means of output evaluation and rewards, market-like contracts are also relieved from the need to control the process by which the desired outcome is generated, and from the need to specify input requirements. Further, to the extent that they do not require specific commitments of resources, market like contracts are scarcely concerned with the assignment of rights to make decisions over pooled resources, and with the establishment of a centralized authority to prescribe the actions to be taken in the interest of the collaboration.

As argued above, uncertainty hampers the setting of standards. This, in turn, weakens the possibility of measuring performance, which is a precondition for an effective use of incentives (Milgrom and Roberts 1992).

Moreover, as seen before, epistemic uncertainty favors the pooling of knowledge resources, which in turn poses the problem of assigning rights to take decisions concerning their use and the

[89] However, a different type of formalization, that fixes the outward form, structure, relationship of elements rather than their content, may be very useful for handling complex problems. One can think for instance of the importance of formal logic or of mathematics for the development of science.

withdrawal from the pool (Vanberg 1994). All this hinders the adoption of market-like governance and suggests the following proposition:

> *Proposition 1c: A high level of epistemic uncertainty will be associated with lower use of market-like contracts.*

4.1.2. Computational complexity: devices vs. abstract knowledge

Biotechnology alliances sometimes concern the development of a device, like a DNA microarray reader, or a needle-free injection system for administering a new drug. In an intuitive sense, the development of a device is even further removed from basic research than the early stages of the drug discovery process. Thus it should involve on average less radical uncertainty. However, ceteris paribus, projects for the development of devices are different from projects based exclusively on chemistry or molecular biology also in another respect: the latter are based mainly on abstract knowledge, whereas the knowledge deployed in projects of the first kind ends up being 'reified' into artifacts. We posit that dealing with devices poses different contracting problems from dealing with abstract knowledge. First, in comparison with drugs and chemicals in general devices will be cognitively simpler. This means that device producing firms will be under a stronger pressure to resort to alternative means of protecting the competitive advantage, like lead time compression and a quick move down the learning curve. In turn, this implies that in projects for the production of devices efficiency and time management will be more salient concerns. Another difference is that while in the limit a new drug may have at its core just one patent covering a new molecule, devices usually require the integration of several bits of heterogeneous knowledge and overall success may depend heavily on architectural capabilities, above and beyond the individual technologies (Brusoni, Prencipe and Pavitt 2001). This fact coupled with the trend for devices to embody an increasing number of functions, implies that the governance chosen for the development of devices must be equipped to deal with unpredictable variability arising from a high number of elements to be considered, or from a high number of exceptions, that is, with *computational complexity*. The typical organizational response to this type of uncertainty is codification and formalization of information, and ad-hoc residual hierarchical coordination among units (Galbraith 1977, Grandori 1997). With their reliance on the specification of tasks and on the formalization of procedures for control, bureaucratic contracts seem well equipped to deal with this type of uncertainty.

How suitable are the other contractual types in the case of the collaborations for the development of devices is less clear. Typically one response to the difficulty to contracting technological information is to bundle it either within less peculiar commodities or within a

relationship (Zeckhauser 1996). Thus, the fact that a device realizes such bundling within a physical artifact subtracts from the need to bundle technological information within a relationship. This should favor market contracting and should render associational contracting unnecessary. On the other hand, bringing together the different bits of knowledge that are necessary for the development of a device may be facilitated by an association for one specific order of reasons. In general technological information suffers from problems of counting and valuation (Arrow 1996: 120), which explains why a typical practice for its transmission is barter-like exchange (Zeckhauser 1996). However, an association that is based on the pooling of different technological resources in fact realizes barter and economizes on transaction costs. Yet in turbulent environments the benefits of integration are frequently outweighed by its costs, so that modular architectures often prove superior (Langlois 2007). These considerations may counterbalance each other. In sum, we advance the following propositions:

Proposition 2a: biotechnology alliances for the production of devices will be more frequently associated with the use of bureaucratic contracts.

Proposition 2b: biotechnology alliances for the production of devices will not be significantly associated with the use of market-like and associational contracts.

4.2. Interdependence

4.2.1. Interdependence defined on types of asset usage: exchange-based vs. activity-based

One definitional trait of alliances is that each participant firm brings assets and capabilities to it. Assets and capabilities can be understood as 'resources', that is, as 'sets of potential services [that] can, in large part, be defined independently of their use' (Penrose, 1959: 25). The parties to an alliance may take advantage of this independence from specific use and employ the asset for at least two qualitatively different purposes. One use is the extraction from an asset of its typical services. Thus a piece of technical equipment may be exploited for the production of the physical goods for which it has been conceived. In this case the asset becomes a factor of production. A different function would be to use an asset as a currency, that is, as a medium of exchange (Pfeffer and Salancik 1978; Allee, 2004). Financial resources are typically used for that purpose, but other assets, like intellectual property or land, could also serve as currencies.

Technology collaborations use at least one party's capabilities for the extraction of its characteristic services. It is not infrequent that the other party's knowledge is leveraged in functions like regulatory development, manufacturing or commercialization. However, with concern to the technological research and development task, one party is often little more than a financier and a bystander. Even as such, that party may be involved in the governance of the project, to determine

budgets, supervise progress of activities and take strategic decisions on facts that affect its interests. However, we posit that participation of both parties as contributors of activities to the R&D project entails a different level of involvement.[90] Even in the case where both parties' actions are totally disjoint, the fact that they converge to a common output requires at a minimum a decision about a technical interface and a verification of the compatibility of the activities undertaken. In other cases, the need for coordination will require also agreement on a schedule for intermediate activities and on (possibly flexible) specifications of each other's deliverables. In extreme cases, joint action requires mutual adjustments based on real time information that arises from the execution of the tasks. We call these types as 'activity-based interdependence' and the case where assets of one party are used just as currencies as 'exchange-based interdependence'.

The participation of both parties as contributors of activities to the R&D project should have significant organizational consequences. First of all, we expect that action-based interdependence strengthens the need for procedural coordination. Second, the contribution of assets to be employed for their services, rather than as currencies, increases the incommensurability of the parties' resources. This should deemphasize the measurement of both inputs and outcomes, and favor sharing over specific allocation, as a means to distribute the results of the collaboration (Fiske 1992). Finally, the information exchange that accompanies procedural coordination may lessen informational asymmetries between the parties and reduce the need to elicit performance through monetary incentives.

As to our contractual forms, we aver that the sharing of project costs that characterizes associational contracts should be easier to implement where the parties are allowed observe the partner's activities frequently and from close up, rather than where they remain at arms' length. However, such insight into the partner's activities is gained rather naturally when the coordination requirements cause the parties to engage in frequent, 'high-bandwidth' information exchange.

By contrast, market-like contracts rely mainly on autonomous coordination and fail to assign even basic decision rights. Overall, this should make them better suited to regulate a flow of goods and services between the parties, carried out within the framework of the contractual 'programme', rather than to manage the solution of complex problems that impinge on each other's performance.

As to bureaucratic contracts the relations they may have with action-based interdependence is rather ambiguous. On one hand being endowed with a rich control apparatus, they seem to be well equipped to deal with non-trivial degrees of interdependence. On the other hand, such

[90] One article that describes and characterizes the content of a business relationship in terms of linking activities is Dubois and Håkansson (1997). According to these authors, links can be characterized in terms of different types, and they give rise to interdependencies.

apparatus centers on vertical and horizontal and specification of tasks and centralized ad hoc problem solving, which should be prone to failure to govern certain types of joint action interdependence. Thus, activity-based interdependence is unlikely to be a good predictor of bureaucratic contracts. For all these reasons we advance the following propositions.

Proposition 3a: activity-based interdependence will be associated with greater use of associational contracts.

Proposition 3b: activity-based interdependence will have no significant association with the use of bureaucratic contracts.

Proposition 3c: activity-based interdependence will be associated with lower use of market-like contracts.

4.2.2. Interdependence defined on technology structure: team production vs. decomposable production

Operationalizing the types of interdependence considered in classical organization theory requires a modicum of understanding of the work flows among the activities involved. At the stage of planning an interfirm technological collaboration even such limited understanding may be lacking for several reasons. First, the relevant activities may take place only several years down the road and the persons that shall be involved may not even be on board for an analyst to ask them. Second, to the extent that the collaboration involves genuine exploration, some activities cannot be meaningfully anticipated. For instance, exploratory biotechnology research is often initiated without clear foresight of specific therapeutic applications (Fumero 2003). As research uncovers promises for a specific disease area the activities that are to be accomplished afterwards get progressively defined. Third, even though the patterns of interdependence can be partially envisaged, they may change during the course the alliance.

Nonetheless, even a cursory reading of alliance agreements reveals that the parties possess at least a rudimentary understanding of whether the characteristics of the output envisaged and their respective knowledge bases are such that the production process is neatly decomposable or not. For instance, the contract for a 1998 alliance between Biosearch Italia S.p.A. and Versicor Inc. of California, reveals that the respective specialization of the parties allowed them to envisage a collaboration for the performance of a neatly separable task. Biosearch, which had expertise in natural products discovery and in vivo evaluation capabilities, was to contribute natural product antibiotic lead compounds. Then Vicuron would apply its skills in combinatorial chemistry/library

synthesis and in in-vitro assessment of activity, toxicity and pharmacokinetic properties to optimize those leads. Finally, upon detection by Vicuron of promising improved analogues, Biosearch would step in and perform in vivo studies of efficacy. Each stage would end with a rather clearly identifiable intermediate output (Grandori and Furlotti 2007). Would knowing as much bear implications for an efficient organizational configuration? We claim that it does, and that it helps predicting the efficient contractual form.

A production process where the activities are not technically separable and cannot be carried out in isolation from each other without loss of efficiency is called team production (Alchian and Demsetz 1972). Obviously, in the context of an inter-firm relationship what matters is that the activities involving team production are those that require contributions from both parties, not simply by different organizational units of the same actor.

Team production gives rise to a metering problem, in the sense that it becomes difficult to establish the proportions in which the output is attributable to each factor. Ambiguity of performance, in turn, makes it difficult to rely on individual incentive rewards and hinders the specific attribution of costs as well. To the extent that each actor is not solely in charge of its own subtask, we aver that team production requires also the specification of procedures for decision making (Vanberg, 1994). Furthermore, for the same reason, it is likely that the parties will find it more difficult to estimate the time required for completion reliably, and shall envisage the possibility of extending the duration of the alliance. All these features seem to negate as many defining elements of the main dimension market-like contracts are based upon.

To be sure, team production is partly unfavorable also to some aspects of bureaucratic contracts. For instance, to the extent that the partner's actions are a source of variability the counterparty's task becomes less specifiable ex ante, at least at an operational level. However, Mayer and Bercovitz (2003) observed greater formalization as a means to compensate for a greater expected uncertainty under conditions of task interdependence. However, this implication seems only of second-order importance, in comparison with the metering problem.

Likewise, we are not persuaded that team production poses enough reasons for associational contracts, although some of the implications of the metering problem are in tune with associational characteristics. While a 'community of fate' may have some advantages when it is difficult to measure each other's contributions, if the input each factor are rather easily substitutable the parties

may count on the threat of dismissal to elicit sufficient performance and may refrain from entertaining too exclusive a relationship.[91]

All these intuitions lead to the following propositions.

Proposition 4a: team production will not be significantly associated with the use of associational contracts.

Proposition 4b: team production will not be significantly associated with the use of bureaucratic contracts.

Proposition 4c: team production will be associated with lower use of market-like contracts.

4.2.3. Interdependence defined on deliverables attributes: existing knowledge vs. knowledge to be created

Contracting for information is challenging, as information is an unusual commodity in several ways (Arrow 1996; Zeckhauser 1996). One of the characteristic that most seriously hinders contracting on information is an asymmetric knowledge of value between the buyer and the seller. However, if we focus on that particular bunch of information and knowledge that is technology, we notice that the degree of asymmetry is likely to vary greatly depending on how close a technology is to the stage of practical application. This is rather clearly illustrated precisely by the case of pharmaceutical technologies. When a compound or a protein is in its early stages of development, it has undergone little or no examinations by the regulatory authorities. Similarly, some of the technologies it is based on have not been patented yet. Things like efficacy and long term side effects are understood only partially. Further, the prospects to employ it in the treatment of additional applications are uncertain. From a commercial point of view, it is hard to establish how great an improvement it will represent over competing products. By contrast, as the technology progresses through the development stages not only are valid models of reality built and refined, but knowledge undergoes a massive process of codification.[92] The point is that such codification not only is a reflection of lower uncertainty, but it reduces the asymmetry of information as well. In the limit, a large pharmaceutical company with global distribution may be better positioned to assess the commercial opportunities of a drug in late clinical trials than the specialized biotechnology firm that developed it. In turn, a reduction of asymmetry facilitates contracting and exchanges (Akerlof 1970). Thus we expect that ongoing research and existing research results give rise to quite different

[91] This corresponds to the case of a team without a central organizing agent discussed by Alchian and Demsetz at page 781 of their 1972 article.

[92] The documents that are necessary to obtain FDA approval for a new drug usually reaches a volume of several cubic meters and are composed of millions of pages (Fumero 2003: 155).

contracting problems. In general the latter will offer a more objective basis for the measurement of commercial value, whereas the former requires a bet on the capabilities of the contracting party, on its luck and on its behavioral attitude. The less evaluation becomes problematic the more effective is governance through incentives (Milgrom and Roberts, 1992). Further, codification reduces the need to secure the partner's tacit knowledge to bring the project to completion. Thus, resources need not be firmly locked in. Additionally, the reduction of the hazards of asymmetric information should also, to some extent, dispense from the monitoring apparatus of bureaucratic contracts. To be sure, contracts for the transfer of existing technology often require the selling party to provide assistance and ancillary services, so that at a first analysis they may appear rather similar to contracts for the development of new knowledge.[93] However, if our previous arguments are correct, it would be unwise to pool together in the same contract a transfer of existing research results and a project for the creation of new knowledge. Thus, if any 'projects' are attached to the transfer, they are likely to be of secondary importance, and they should not impact heavily on the governance architecture. All this leads to the following propositions.

Proposition 5a: the transfer of existing technology will be associated with lower use of associational contracts.

Proposition 5b: the transfer of existing technology will be associated with lower use of bureaucratic contracts

Proposition 5c: the transfer of existing technology will be associated with greater use of market-like contracts.

4.2.4. Interdependence defined on the scope of activities

Alliance scope, in the sense made explicit in Section 3, has been used as a predictor of governance structure by Pisano (1989) and Oxley (1997), among else. These authors underscore that a wider alliance scope associates with a greater difficulty in specifying contractual terms, hence with higher contractual hazards. However, it must be noticed that these studies the comparison is drawn between alliances that focus just on production and marketing and those that carry out also R&D activities. Here we reverse the terms of the comparison, and we ask what difference may ensue from expanding the scope of the activities from just R&D to include also the later stages of the value chain. Thus, we compare 'pure R&D' alliances with 'mixed activity' alliances.

[93] A well known example is provided by the Bessemer process for the conversion of crude iron to steel. After licensing the rights on his invention to several manufacturers, Bessemer was forced to refund license fees, due to the inability of the licensees to set up a workable process. Afterwards Bessemer started his own steel works and perfected what turned out to be the most important technique for steel making in the 19th century (Misa, 1995), thus demonstrating both the validity and the incompleteness of the licensed codified knowledge.

The addition of manufacturing and sales is not likely to raise the uncertainty of the task substantially. Neither is it going to pose major challenges to the specification of contractual rights and duties. We posit that the main channel through which a wider functional scope (as we defined it) can influence organizational structure is by creating additional and different coordination requirements. For instance, as manufacturing is put under the umbrella of the alliance, things like the timing of the orders, the compliance of the deliverables with quality specifications, and the continuity of supplies become salient. These conditions can be described concisely as configuring conditions of 'sequential' interdependence (Thompson 1967). As a result of sequential interdependence, we expect a greater use of programming (Thompson 1967).

A wider functional scope is likely to compound interdependence with a greater potential for conflict of interests. In fact, activities related to the supply of mass-produced products or to sales promotion are likely to have a clearer zero-sum characteristic than R&D. That this must be the case can be easily understood by considering two facts. First a change in product specifications required at the mass-production stage affects more units of input than changes requested when a product is still at the prototype stage. Second, the move from R&D to production is often a move from concepts to artifacts. Thus contingencies arising at the production stage may require changes of materials, which have lower plasticity than concepts, drawings and computer programs.

When the game gets more distributive, the parties will have a stronger incentive to explicitly declaring admissible dimensions for adjustment and setting procedures about it (Williamson 1979). Additionally, we expect that in routine activities like manufacturing or sales promotion, declaring such dimensions is cognitively less difficult than for R&D activities. All this should translate into greater use of presentiation, or explicit planning of adaptation. Moreover, the lower cognitive uncertainty of downstream activities means that cost control and time savings become primary ways to add value. As efficiency becomes of greater concern and administrative control better feasible, we expect a greater resort to standardization and more intense monitoring.

All the factors mentioned above seem to indicate that a wider functional span will lead to alliances with more bureaucratic contracts. As to the other alternative contractual forms, we notice first of all a more articulated coordination apparatus and a greater reliance on control negate the essence of market-like contracting. Second, we expect that the resources that are necessary to the performance of downstream activities like manufacturing and sales are more substitutable than those that are required by R&D. This implies that the addition of downstream activities does not translate in stronger incentives to the creation of a long-lasting pooling of resources through

associational contracts. Thus we do not expect a significant association of a wider scope with this contractual type. Overall, this discussion allows us to advance the following proposition.

Proposition 6a: mixed activities alliances will no be significantly associated with the use of associational contracts.

Proposition 6b: mixed activities alliances will be associated with greater use of bureaucratic contracts.

Proposition 6c: mixed activities alliances will be associated with lower use of market-like contracts.

4.3. Distribution of financial resources

Resource dependence theory, argues that exclusive control of a resource, coupled with asymmetry in a relation, is a source of power for the less dependent organization (Pfeffer and Salancik, 1978: 50-4). This applies generically to all types of resources. With regards to specifically to financial resources, managerial studies of strategic alliances, have repeatedly found that "equity share is a predictor of the overall control held by the partners of international joint ventures" (Child 2002: 784).[94] Theories rooted in economics have also taken a keen interest in the contributions of financial resources as an antecedent of organizational configuration. For instance, Hart and Moore (1990) predict owners' identity basing on the criticality of the investments.

On these premises, we argue that in technology alliances, a dominant or exclusive contribution of financial resources by one party should be associated with agreements that assign higher levels of control to that party. Accordingly a dominant contribution of financial resources should associate with a lopsided distribution of decision rights and with an administrative apparatus favoring one party. This seems definitely to favor the adoption of bureaucratic contracts. While this could also be argued to run counter to market-like contracting, we have some reservations on this point. In fact, to the extent that knowledge is distributed, and that control is clearly assigned to one party, the relationship may still benefit from the use of performance incentives and the contract may de-emphasize the assignment of particular decision rights. In other words we do not see a clear association between a concentrated contribution of financial resources and the use of market-like contracts, and neither have we envisaged one with the choice of associational contracts.

[94] Obviously an equity share can be acquired also thanks to contribution of resources of different kind, though financial resources are likely to represent the typical form of contribution.

Proposition 7a: in technology alliances, a highly concentrated distribution of the financial resources contributed to the collaboration, will be associated with greater use of bureaucratic contracts.

Proposition 7b: in technology alliances, a highly concentrated distribution of the financial resources contributed to the collaboration, will not be significantly associated with use of market-like and of associational contracts.

4.4. Distribution of knowledge

A similar relationship between distribution of resources and efficient organizational structures can be argued to exist when concentration involves knowledge resources. The argument of the resource dependence theory also applies here straightforwardly.

Contingency theory is another stream of literature that sees a relationship between the control of resources and organizational power. In such framework the basis of power is the control of strategic contingencies, which in turn is a latent construct capturing the joint occurrence of several different conditions.[95] The control of resources is likely to confer power through the positive influence it exerts on some of the 'formative indicators' of the latter, notably the effectiveness in coping with contingencies and the centrality of the actor holding the resources (Hickson et al. 1971).

While this is still an application of the logic of bargaining power, other approaches have addressed the issue from the point of view of the effectiveness of knowledge management. One early example in such stream is Burns and Stalker (1961). In their model, when the environment is turbulent firms have to rely on the (decentralized) knowledge of their workers, rather than on know-how embodied in rules and procedures, and the accompanying organizational structure needs to be characterized by intense horizontal relationships, rather than by hierarchy, and by low levels of formalization. In more recent times, the literature on network governance (Jones, Hesterley and Borgatti, 1997) and on the new organizational forms (Miles et al., 1997) has expressed a similar viewpoint: when the requisite knowledge is distributed, the organizational structure decentralizes and decisions tend to be co-located with knowledge.

These hypotheses have been confirmed also at the level of small groups. The performance of groups that have pockets of unique knowledge distributed across different group members is facilitated by flat networks, with minimal hierarchy, that provide opportunities for task related

[95] In an intraorganizational context "a contingency is a requirement of the activities of one unit which is affected by the activities of another unit" (Hickson et al 1971: 222).

communication and information exchange (Albretcht and Ropp 1984; Rulke and Galaskiewicz, 2000).

Finally, the idea that hierarchy, as a centralized system of decision-making, fails under conditions of distributed knowledge has drawn support also from some economists (Radner 1997).

These arguments lead us to think that distributed knowledge should run counter to the adoption of a centralized, bureaucratic model. As to associational contracts, knowledge concentration renders the holder rather self-sufficient and should lessen the need to forge a stable tie-up with complementary knowledge. Thus, we can argue *a contrario* that distributed knowledge favors such association. Finally, we fail to see a significant influence of knowledge distribution on market-like contracts. In sum, all the preceding discussion can be condensed in the following propositions:

Proposition 8a: in technology alliances, distributed knowledge resources will be associated with a higher use of associational contracts.

Proposition 8b: in technology alliances, distributed knowledge resources will be associated with a lower use of bureaucratic contracts.

Proposition 8c: in technology alliances, distributed knowledge resources will not be significantly associated with the use of market-like contracts.

For the reader's convenience Table 5 in the Appendix summarizes the hypotheses developed so far.

5. Empirical analysis

5.1. Sample and dependent variable

We tested the implications of the arguments above with data that were obtained mainly from the coding of actual pharmaceutical biotechnology agreements. The contracts have been provided by Recombinant Capital (Recap), a San Francisco Bay Area-based consulting firm that manages some of the largest and most detailed biotech business intelligence databases in the world. As of October 23, 2006 Recap's databases contain 23,687 high-level summaries of biotech alliances commenced since 1973. In order to take advantage of additional information that Recap collects from the business press, companies' presentations, and various additional sources, as well as to cross-check our coding of variables with that accomplished by professional contract analysts, we focused on those alliances that have been analyzed in detail by Recap. [96]

[96] As of Nov 11, 2005 they were about 1700.

Our sampling criteria excluded first of all those alliances where one of the parties was a non-business organization, in the belief that that might introduce excessive heterogeneity in the sample. Second, being interested primarily to technology cooperation we excluded those alliances that did not include any element of R&D, and focused exclusively on the granting of licenses, production, marketing, the setting of standards, the assignment of assets or options, etc. The selection was based on the value of a measure of contract type coded by Recap's analysts. We excluded also alliances where both parties were pharmaceutical companies. While it might be interesting to investigate whether industry membership made a difference in terms of alliance governance, these alliances were numerically too few to expect statistical significance.

At the next step, we assessed that we would like to have both 'early stage' and 'late stage' alliances equally represented in our sample. By 'early' and 'late', we mean an alliance entered before or after a lead molecule has been discovered. Then through random choice we selected a total 280 alliances stratified in such way that each class encompassed 50% of the alliances. At this stage we noticed that Recap's database offered us a coarse but convenient means to bias the sample toward successful alliances. In fact, it contains a flag to identify those alliances that were terminated ahead of time. While not necessarily the result of governance inadequacy, early termination may be an indication of some unforeseen trouble in the relationship. This allowed us to exclude an additional 40 alliances. Finally, through random selection we picked the 79 alliance contracts that compose our sample, again with a constraint of approximately equal representation of early stage and late stage alliances. A team of two raters analyzed the contracts during the period from December 2005 to August 2006.

For our sample of pharmaceutical biotechnology alliances the dependent variable (FORM) takes on one of three values, as discussed above

FORM = 1 for associational agreements

FORM = 2 for bureaucratic agreements

FORM = 3 for market-like contracts

Although different forms are represented by different natural numbers, we do not treat FORM as an ordinal variable.

5.2. Independent variables

Epistemic uncertainty. Epistemic uncertainty is a construct that describes primarily the difficulty of constructing valid models of cause-effect relationships, but it may also include other related sources of incomplete knowledge, notably lack of clarity of preferences and difficulty of observability. We claim that in biotechnology research the lack of valid knowledge concerning

cause-effect relationships is the more severe, the farther is the drug discovery process from the commercial release. To support our claim we can look at simple statistics of the 'attrition rate' (the number molecules that are discarded during the process) in Table 3 in the Appendix. At the discovery stage, biotechnology firms begin with a hunch about molecules (or proteins, or monoclonal antibodies) that may be effective vis-à-vis a certain target. As knowledge of actual cause-effect relationship is very vague, the search has to encompass thousands of molecules. As the research progresses through successive stages, many molecules are rules out. Moreover, researchers begin to characterize progressively better those that are left and establish properties like pharmacological potency, toxicity, the pharmacokinetic and pharmacodynamic profiles, etc. As suggested by Table 3, this reduction in uncertainty has a monotonic development that parallels the progression of the development process through the stages that have been codified by regulatory authorities and industry practice. Thus we can think of the stage of research at the time of signing an alliance agreement as a meaningful proxy of uncertainty. The measure we rely upon is the 'stage at signing' as measured by Recombinant Capital (Recap). A detailed description of the measure is contained in Table 4. Given the profile of the attrition rate, we assume that the identification of a lead candidate implies a dramatic reduction in uncertainty. Thus for our initial analysis we recode Recap's original measure into a three categories variable (STAGE), where the stage of Discovery is treated as a class of its own and is assigned a value of 1, and the remaining stages are evenly subdivided in two classes with value 2 and 3 respectively.

Computational complexity: abstract knowledge vs. devices. This variable measures whether purpose of the alliance was for the development of abstract knowledge or for the production of knowledge reified into artifacts. This variable was operationalized by asking whether the alliance was for the production of a device (e.g. a DNA microarray reader, or a needle-free injection system) or just a therapeutic agent (a molecule, a protein, or a monoclonal antibody). Although the end product for the development of a drug often includes formulations of a drug substance, if the 'reification' does not go any further we assessed that the project is for the production of abstract knowledge. On the contrary, when physical and spatial organization of chemical compounds is an important feature of the product, we classify the knowledge developed as reified.[97]

Whether the product is a device or not is usually made explicit in the Definitions section of biotechnology agreement, which normally defines the product in a distinct clause. A typical clause defining a therapeutic agent reads as follows:

[97] This is the case, when the object of the alliance is the supply of compound libraries, that is, samples of structurally related chemical compounds arranged in a format such as a microtiter screening plate, with evenly spaced wells containing compounds in specified amounts.

> 1.2 "COLLABORATION PRODUCT" shall mean any product incorporating or derived from any peptide or antibody compound, and the sequence contained therein, discovered by DYAX using the DYAX TECHNOLOGY during the COLLABORATION TERM, and that binds to an HGS TARGET.[98]

In the case of alliances for the production of devices the corresponding clause reads as follows:

> 2.22 "Products" shall mean the HP System, HP Software, MTX Chips, MTX Software and Necessary Reagents.[99]

The variable, called DEVICE, was coded as follows:

- 1: immaterial deliverables
- 2: technology devices.

Interdependence defined on type of asset usage: exchange-based vs. activity-based. This variable measures whether the contribution of assets to the R&D project by either party is purely financial or whether both contribute to the project with their own capabilities, thus becoming actively engaged in the project.[100] The former type of asset contribution defines an exchange-based interdependence, while the latter is the defining criterion of activity-based interdependence. Sometimes for confidentiality reasons specific sections of are excised from the contracts made available by the SEC to the public. As a result, occasionally the extent of the involvement of a party in R&D activities is somewhat ambiguous. Thus, for practical reasons, it is easier to assess engagement in action from the observation of monetary provisions, that reveal whether a given party bears project-related costs (independently of whether they are later reimbursed or not). The monetary arrangements of each alliance are also explicitly analyzed by Recap's analysts, who triangulate contractual content with information acquired by press conferences, company presentations, annual reports, etc. If not self-evident from task descriptions, active involvement of one party in R&D action was presumed by the observation that that party bears project-related costs.[101] As a result the variable, called ACTIVITY, was coded as follows:

- 1: exchange-based interdependence
- 2: activity based-interdependence

Interdependence defined on technology structure: team production vs. decomposable production. This variable measures whether the overall R&D objective of the alliance is neatly decomposable into subgoals that can be pursued by each party in relative isolation; or, conversely, whether the performance by the parties of their respective tasks, requires an extent of collaboration that prevents the possibility of specific, individual attribution of the results of the R&D activities.

[98] Collaboration and license agreement between Human Genome Sciences, Inc. and Dyax Corp., dated March 17th, 2000.
[99] Collaboration agreement between Hewlett-Packard Company and Affymetrix, Inc., dated Novembre 11, 1994.
[100] In principle a party might contribute also assets other than knowledge and finance. In practice, contributions of technical equipment or buildings or similar is never a salient aspect of the contracts in our sample.
[101] Project costs were considered distinctly from costs relating to continuous activities like manufacturing or sales promotion.

Since what we are concerned with are the typical expected outcomes of the R&D project, the problem can be reformulated as one of observing whether the alliance may give rise to joint inventions or not. Thus stated, the underlying concept becomes easily observable, as it closely correspond to one of the dominant issues in technology contracting: that of establishing the ownership of foreground intellectual property rights (IPRs). While the particular assignment of rights is a governance variable, the possibility that in a certain alliance the parties give rise to joint inventions or not is something that depends essentially on the distribution of the requisite capabilities and, relatedly, on the structure of the R&D process. For instance, in the above-mentioned example of the Biosearch Italia-Vicuron alliance, the process envisaged was one of a neat separation of tasks, to be carried out sequentially on the opposite sides of the Atlantic. All this made the possibility of joint inventions quite unlikely. Indeed the alliance agreement did not envisage any joint invention.[102] Owing to the salience of inventorship and invention ownership Recap's analysis grid has a specific item for that. This allowed us to cross check our assessment with that of Recap's analysts. In sum, the variable called TEAM was coded as follows:

- 1: decomposable production (no joint inventions envisaged)
- 2: team production (joint inventions envisaged)

Interdependence defined on deliverables attributes: existing knowledge vs. knowledge to be created. This variable measures whether the contract stipulates a transfer or rights on existing technology or not, by means of a license or an option to license.[103] The transfer of existing technology we are concerned about is that for commercial exploitation outside the collaboration. Thus any licensing of rights to develop technology in accordance with a jointly agreed development plan (so called 'background rights') is not considered a transfer of rights on existing technology. Whenever such transfer is missing we assume that the main purpose of the alliance is to create new knowledge.[104] The variable, called EXIST, was coded as follows:

- 1: knowledge to be created
- 2: transfer of existing knowledge

Interdependence defined on the range of functional activities. This variable measures whether an alliance is specifically dedicated to R&D or whether in encompasses also sales and distribution activities. While observing such a fundamental characteristic in a generic alliance

[102] In that agreement the term "joint inventions" is used to indicate inventions to be put to use in the geographic territory that has been reserved for joint commercial exploitation. Thus, it is not related with the originator of an invention.
[103] We did not observe any outright assignment of existing technology.
[104] Such assumption is warranted by the criteria of sample construction that excluded those alliances that did not include any element of R&D, and focused exclusively on the granting of licenses, production, marketing, the setting of standards, the assignment of assets or options, etc.

should pose no problem, in the particular case of pharmaceutical biotechnology agreements this is more complex than it appears.

Biopharmaceutical alliance agreements almost invariably regulate the issue of the future stream of continuous rewards associated with the sales of the final product.[105] This holds true also for alliances entered at the discovery stage, for which commercialization is, on average, 14 years away from the signing of contract (PhRMA 2006). Indeed, most contracts contain provisions to the effect that manufacturing rights are assigned and royalty payment obligations are imposed. Since such obligations usually terminate with the later of the expiration of the last valid claim on licensed patents or a predetermined number of years since the start of commercialization (usually 10 or 15), the natural termination date of biopharmaceutical alliance agreements is many years after R&D activities have been completed. However, maintaining that the scope of biotechnology alliances normally extends to downstream activities would be an overstatement. Quite often, after a period of four or five years when actual R&D is carried out, only one party – usually the client – become entrusted with all the action rights, and the other becomes a passive receiver of royalty payments, if any. Therefore, our requirements for assessing that an alliance has a functional scope that extends to downstream activities is that a certain sales activity is a stated goal of the collaboration and, in order to be accomplished, it requires coordination between the parties (or with a joint entity), above and beyond the passive receival of monetary considerations and the performance of activities that are instrumental to that exchange (e.g.: royalty auditing). By applying these criteria to the analysis of contract content we measured the variable SCOPE, coded as follows:

- 1: pure R&D
- 2: mixed activities (R&D and sales)[106]

Distribution of financial resources. This variable measures the relative contribution of financial resources that arises as a consequence of the explicit financial commitments of the parties and of the tasks they are required to accomplish within the framework of the collaboration and. For the measurement of this variable it is not sufficient to look at the first component, since it is not infrequent the case of one party (or both) undertaking obligations to perform costly activities for which no corresponding compensation is established. For instance, in the above mentioned alliance between Biosearch Italia and Vicuron, the agreement did not provide any monetary compensation for Vicuron's compound optimization activities nor for the in-vivo studies to be conducted by

[105] At least, this is the case in almost 90% of the alliances in our sample. The alternative case, of no envision of continuous rewards, is much rarer (8%) and the case where the client settles the issue with a one-off payment to the R&D firm is almost exceptional (1 observation).

[106] In order to carry out robustness analyses we tried also alternative coding of SCOPE. In one version 'mixed activities' were defined as 'R&D and manufacturing'; in another, SCOPE was defined as a summated scale of indicators of sales and manufacturing.

Biosearch Italia. A case like this was coded "approximately equal contributions". An opposite case is represented by the alliance established in September 1989 between Immulogic and Merck, centered on recombinant DNA technologies for the treatment of autoimmune diseases. Here Merck reserved for itself all the tasks from preclinical research until mass production and commercial exploitation, and agreed to fully compensate Immulogic for the performance of research at the discovery stage. This case was coded "Client makes exclusive contribution". Besides these polar situations we observed cases where the client made a dominant, yet not exclusive contribution, either because reimbursement of project costs to the R&D firm was partial or because the R&D firm was allowed to participate with a junior position in downstream functional activities, like sales promotion, at its own cost.[107] However, as excessive dispersion of cases would violate conditions for application of chi-square tests, we classified dominant contributions together with cases of exclusive contribution. Only two cases in which the financial contributions of the R&D firm exceed those of the client were observed. These cases stand out also for several other unusual contractual characteristics. Thus, although they have been initially treated as cases of about equal financial contributions, we also controlled whether treating them as outliers would significantly impact on results. In sum, observations concerning the distribution of financial resources are captured by a variable called BALANCEFIN that is coded as follows:

- 1: About equal contributions (or no significant contribution by client)
- 2: Client dominant or exclusive

Distribution of knowledge resources. This variable measures the relative contribution of knowledge resources by the parties to the alliance's R&D project. Contribution of effort and capabilities to regulatory development, manufacturing and sales where not considered. In extreme cases the client is purely a financier and does not take active part in R&D. This situation is best exemplified by the alliance dated 20 March 1989 between Sumitomo Chemical Company and Regeneron, in which Sumitomo undertook to sponsor Regeneron's general research and development efforts in exchange for a first right of refusal to obtain an exclusive license to products in Japan. In other cases, as in the above mentioned alliance between Biosearch Italia and Vicuron, both parties contribute distinct know how that allows them to be involved in substantial portions of the overall R&D project. Cases like this are coded "about equal contributions". The same assessment has been done of alliances in which one party has a lesser involvement in R&D activities but contributes most or all the licenses under the intellectual property and know how that

[107] Given the salience of cost allocations within alliance agreements, Recap's analysis grid has an item called "Reimbursement basis" that usually distinguishes partial from total reimbursements and helped us cross checking our own assessment.

are necessary for the conduct of the R&D project.[108] Intermediate cases (e.g.: where client's involvement in R&D has been quantitatively marginal or has been confined to tasks which had a clear lower complexity) have been lumped together with those where the R&D firm makes an exclusive contribution".[109] As these assessments involve an element of subjectivity we cross checked them with the companies' own representations to the public, as reflected in the press releases collected by Recap. Only one case was observed where the client's contribution was assessed to be more important than the R&D firm's contribution. This case has been initially included in the category "about equal contributions", based on the presumption that it would sort the same consequences. However it has also been circled for alternative treatment as an outlier.[110] In sum, observations concerning the distribution of knowledge resources are captured by a variable called BALANCEKW that is coded as follows:

- 1: About equal contributions (or no significant contribution by R&D firm)
- 2: R&D dominant or exclusive

Table 6 in the Appendix contains value labels and descriptive statistics for all variables.

5.3. Statistical Methodology

The fact that our dependent variable is categorical, severely limits the types of statistical methods that can be adopted to test our hypotheses. Discriminant analysis and logistic regression are the appropriate statistic techniques for the prediction of the category in which an object is located. However the former is not able to accommodate categorical predictors. The alternative methodology, logistic regression, is quite popular in studies focusing on the choice of alternative governance forms. However, unlike OLS regression, logistic regression derives parameters through maximum likelihood estimation. As MLE relies on large sample asymptotic normality, when observations are few compared to the number of independent variables one may get high standard errors. Our case, where sample size is 79 and the total number of independent variables and control variables is ten, does not attain the minimum advisable ratio observations / parameter (Peduzzi et al. 1996). Therefore we opt to analyze our dataset through cross tabulations and related statistics of association. In particular, we shall assess whether a pair of variables are independent through Pearson's chi-square statistics. Since our dependent variable has no meaningful ordering, we must use a measure of nominal association. Among several available alternatives we opt for the

[108] In all the alliances the licensed background rights are explicitly listed in an appendix to the contract.
[109] An example of engagement in lower complexity activities is given by the alliance dated Nov 1997 between Signal Pharmaceuticals and Serono, where the R&D firm was entrusted with target identification and validation, high throughput screening and lead optimization, while the client was assigned more routine pre-clinical and clinical development.
[110] This case coincides with one of the two outlier candidates discussed with the variable BALANCEFIN.

Uncertainty Coefficient (Theil 1972) which expresses the percent reduction in error in accounting for the variance in the dependent variable. Chi-square only tells us whether there is a significant association overall between the two variables investigated while the Uncertainty Coefficient provides us a measure of the strength of the association. However, to test our hypotheses we must be able to tell whether the observed frequency in *particular* cells is significantly different from the expected frequency, and which is the sign of the difference between the two values. One suitable test is given by the Adjusted Standardized Residual, which is defined as follows:

Adjusted Standardized Residual =

[(Observed Cell Count - Expected Value) / √ (Expected Value)] / estimated Standard Error

Adjusted Standardized Residuals (henceforth: adj. res.) are distributed according to a Standard Normal distribution (Haberman 1978), thus values above 1.96 or below -1.96 indicate significant differences at the 0.05 level.

5.4. Crosstabulation analyses

The results of our crosstabulation analyses are summarized in Table 7. We notice, first of all, that STAGE has a significant association with the choice of governance form (p= 0.067) level and helps reducing the error in the prediction of FORM by 5.7%. No significant association is found with associational contracts (hypothesis 1a not supported). On the contrary, partially in contrast to propositions 1b and 1c, we observe a significant increase of bureaucratic contracts and a significant drop of market-like ones in intermediate stages of the R&D process (adj. res. are 2.6 and -2.6 respectively). These are not easily explainable results. From the results of further tabulations (available from the author), it appears that the 'Discovery' stage is a class in its own, which witnesses a certain dominance of market-like contracts (44.7%). Most of these alliances (71.1%) are of the research-for-fee type, where just one party contributes to research results. If we analyze the other two stages separately, we notice that the results significantly support the proposition that greater uncertainty reduces market-like contracting. Greater uncertainty also increases bureaucratic contracting.

DEVICE is significantly associated with contractual form at the 0.01 level. However the cross tabulation of DEVICE violates the condition that fewer than 25% of cells have a minimum expected count lower than 5. Moreover, the fact that the minimum expected frequency has a rather extreme value of 2.8 discourages even the use of more robust tests like the likelihood-ratio. Together with the size of the whole sample, a particularly uneven split of the variable (83.5% Immaterial deliverables, 16.5% Technology devices) is also jointly responsible for this situation. Thus we assess that our sample does not justify discussing the results of the cross tabulation.

ACTIVITY has a significant association with contractual type. Knowing whether the type of asset usage defines an exchange-based interdependence or an activity based interdependence helps reducing the error in accounting for the variance in the dependent variable by 10.5%. By looking at the cross tabulation we observe that activity-based interdependence is associated with a substantial decrease of market-like contracting, while it causes a sharp rise in the use of bureaucratic contracts and not in associational contracts, as it was expected. These differences are significant (adj. res. = -3.5 and 3.8 respectively). This provides clear support for proposition 3c but not for 3a. Evidence is counter to proposition 3b.

TEAM turns out to be another useful predictor of contractual form. Knowing whether technology is decomposable or not helps reducing the error in variance by almost 10%. In particular team production associates with use of market like contracts significantly below sample average (adj. res: -3.1), and with greater resort to bureaucratic governance (adj. res: 3.6). The first finding provides support for proposition 4c, and is counter to 4b, that predicted no significant influence. Consistent with proposition 4a, associational contracts do not vary significantly with technology structure.

EXIST shows no significant association with the contractual type. Thus the fact a R&D collaboration agreement also stipulates a transfer or rights on existing technology or not, is not a significant predictor of the type of contractual governance adopted. Propositions 5a, 5b and 5c are not supported. Conceptually, whether an alliance is created for the purpose of developing new knowledge or just to transfer rights on research results should be a fundamental difference, with the potential to impact on the contractual form. The fact that we failed to find support for that hypothesis may indicate that the simultaneous presence within an agreement of both types of transaction does not pose particular problems: the governance apparatus established to manage the development of new knowledge can effectively manage also an exchange of existing one. In turn, this could indicate either that it is possible to design contracts in a modular way, or that the contractual relation that is established to develop new knowledge is enough of a hostage for the exchange transaction, and provides sufficient safeguard despite suboptimal governance. A stronger test of hypotheses 5a, 5b and 5c would require including both 'pure' license agreements and pure collaboration agreements in the sample, but we have ruled that out by conscious design.

SCOPE significantly affects contractual form, and shows an uncertainty coefficient of 0.078. As proposed by proposition 6b, R&D alliances that encompass sales activities adopt bureaucratic contracts significantly more often than sample average (adj. res.: 2.3; Proposition 6b supported). The idea that a wider functional scope also decreases market-like governance (Proposition 6c) finds

strong support in our data, (adj. res.: -3.5), while associational contract are invariant to functional scope (Proposition 6a not supported). These findings are fairly robust to alternative operationalizations of SCOPE. The sign of the relationship with market-like and bureaucratic contracts does not change when a wider functional scope is defined as encompassing both manufacturing and sales, in addition to R&D, although the effect on bureaucratic governance is significant at a level slightly lower than 0.05 (adj. res. 1.8).[111] In other words, manufacturing seems to dilute the predictive power of SCOPE. One possible explanation for this result could be that even 'pure R&D' alliances very often have to manage manufacturing for use in clinical trials (not measured). Thus, to some extent they are already equipped to deal with manufacturing in general, so that the shift from clinical trial to large scale manufacturing does not make a radical impact on governance forms.

BALANCEFIN is significant at the 0.001 level and helps improving prediction of the dependent variable by 8.3%. Counter to proposition 7a, greater concentration of financial resources does not lead to a significant increase of bureaucratic contracts. On the contrary, it has a significant effect of market-like and associational contracts; the former increase, and the latter decrease when financial contributions are more unbalanced (Proposition 7b not supported). These results are not significantly altered by the exclusion of two potential outliers mentioned in Section 5.2.[112]

BALANCEKW is significant at the 0.001 level and helps reducing the error in accounting for FORM by 8.4%. The use of bureaucratic contracts does not associate significantly with the distribution of knowledge (Proposition 8b not supported), while the use of associational contracts does (adj res. -3.9; proposition 8a supported): associational contracts are more likely to be observed under conditions of distributed knowledge. Finally, market-like contracts are not significantly affected by this variable (Proposition 8c supported). These results are not significantly altered by the exclusion of one potential outlier mentioned in Section 5.2.[113]

5.5. Logistic regression

As discussed in Section 5.3, data limitations have prevented the application of logistic regression to the testing of our hypotheses. However, this technique can further extend our understanding of the antecedents of contractual forms if we turn to an exploratory mode. The findings of the previous analyses help fulfilling the data requirements of logistic regressions in two ways. First they screen out two measures of interdependence – EXIST and DEVICE – that have no

[111] In the alternative specification SCOPE has been constructed as a summated scale of the indicator for 'manufacturing' and the indicator for 'sales'. This gives rise to a three-category variable.
[112] Data available from the author.
[113] Data available from the author.

explanatory power or suffer from other limitations. Second, they indicate that market-like contracts are somewhat easier to predict than the other two contractual forms. Thus, rather then undertaking the quite ambitious task of predicting three different contractual forms, we can focus on discovering which variables help predicting the use of forms alternative to market-like contracting. This halves the number of parameters to be estimated and eases data requirements considerably. Accordingly we recode FORM into the binary variable FORM2. Since our purpose is exploratory, we can use a stepwise logistic regression with forward selection of variables based on the likelihood ratio test. Table 8 reports the results of this exercise. The chi-square for the model is significant, which indicates that the fit is satisfactory. The model predicts actual contractual form in 81.1% of cases, which represents a 16.5% increase in accuracy over assigning all the contracts to the non market-like category (64.6%). To interpret the results it must be borne in mind that for the purpose of the analysis the independent variables have been recoded, so that regression results are contrasted to the lower original values of ACTIVITY, TEAM and SCOPE, and to the final values of STAGE, BALANCEFIN, and BALANCEKW. Thus the estimated parameters reflect the change in the probability of observing nonmarket-like contracts associated with higher levels of interdependence and uncertainty, and with more evenly balanced distributions of resources. The four variables selected by the stepwise process (ACTIVITY, TEAM, SCOPE and BALANCEFIN) are all significant at the 0.05 level. The positive signs of the coefficient indicate that the odds of choosing a nonmarket-like contract increase with higher levels of interdependence and with a more balanced distribution of financial resources. Thus most of the variables that had been found significant in crosstabulation analyses retain predictive power also in the logistic regression. Moreover, the direction of all the relations is coherent with those that were found in crosstabulation. Thus, for instance, predictors of market contracts confirmed as significant in crosstabulations turn out to be – with reversed sing – logistic regression predictors of nonmarket-like. Judging on the size of the odd rations (column 'Exp(B)' in Table 8), the distribution of resources contributes the most to explaining the probability of non-market contracts, followed by the structure of the technology.

Two variables, the proxies for uncertainty and for the distribution of knowledge lose explanatory power when other predictors are controlled for. With reference to the latter we observe that if BALANCEFIN is removed from the analysis, BALANCEKW becomes significant ($p<0.05$) and its coefficient retains the same sign and approximately the same size of the coefficient for BALANCEFIN.[114] This is an indication that the two variables behave pretty much in the same way. Indeed a cross tabulation of the two variables reveals a significant association between them, with a concentrated contribution of knowledge corresponding to a concentrated contribution of financial

[114] Data available from the author.

resources (see Table 9). Indeed, as a look at Table 9 also reveals, almost three fourths of the alliances in our sample can be described as research-for-fee alliances, since in these cases the concentration of knowledge resources is the mirror image of financial resources.

With regards to STAGE, we observe from Table 8 that while as a whole its effect on the dependent variable is not significant, the second category of STAGE has a positive significant coefficient ($p<0.10$), while the first category does not. This indicates that in comparison with late stages, the increase in uncertainty associated with intermediate stages raises the probability of observing non-market contracting, while a move to the discovery stage does not, as already observed in crosstabulation analysis. Since the possibility that very late stage alliances have the same effect on non-market contracting as discovery stage ones is conceptually quite disturbing, we investigated whether any variable may shade the impact of uncertainty, as observed with the distribution of resources. A cross tabulation of STAGE with the other variables, reveals that STAGE is significantly associated with SCOPE. In other words, 'Discovery' alliances are predominantly also 'pure R&D' alliances, while 'Late stage' ones are also 'Mixed activities' alliances. If we repeat the stepwise logistic regression while omitting SCOPE, STAGE fails again to make it among the significant variable, though by a narrow margin ($p = .12$). However, both of its categories become significant at the .10 level and with the expected sign.[115]

6. Discussion and conclusions

This study has investigated the antecedents of alternative contractual types, not treated as points along a continuum of hierarchical intensity but as qualitatively different forms. The investigation has been carried out in a context where presumably coordination requirements are a central concern.

Indeed, our findings confirm that the variables that measure different types and levels of interdependence are, for the most part, important predictors of contractual form. Our measures of interdependence explain the choice between market-like and bureaucratic contracts. This result is perfectly aligned with the findings of Gulati and Singh (1998) and with those of Mayer and Bercovitz (2003) and Mayer and Nickerson (2005), though the latter two studies interpreted interdependence as one particular form of contractual hazard, rather than as a source of coordination requirements. Uncertainty also turned out to have some explanatory power. This is broadly in like with the predictions of TCE. However, the impact we found is not linear: a higher uncertainty favors initially bureaucratic contracts but at higher levels the choice reverts to market like contracting. While this effect needs to be investigated more in detail, it is possible that at very high

[115] Data available from the author.

levels of uncertainty client firms give up their attempts to control the alliance through bureaucratic means, and consider the alliance as a simple purchase of an option on research results, possibly trusting other means, like the differentiation of their alliance portfolio, to safeguard against risks. This is remindful of the finding by Poppo and Zenger (2002) who argued their data suggested that managers may lose confidence in complex contracts as uncertainty becomes very severe.

Our findings also confirm that variables emphasized by negotiation theory, the resource dependence theory and the knowledge-based view – distributions of resources – do matter, and have the strongest predictive power among those investigated in this paper. In particular, the need to combine complementary resources impacts heavily on the choice to forge associations, that is, on the choice to commit resources firmly, while loosely specifying particular behaviour. This finding is supportive of a resource-based view of contracts.

Vis-à-vis several predictors, market-like and bureaucratic contracts behave in a specular way and associational contracts behave as hybrids, in the sense that they are rather insensitive to contingencies that cause bureaucratic contracts to move in one direction and market-like contracts to move in the opposite one. This is indirect evidence of the face validity of our labeling of the contractual forms. Moreover, this indicates that for many practical purposes characterizing contractual forms as points along a continuum is not terribly off the mark. However, vis-à-vis the distribution of resources associational contracts behave in a distinctly different way from the other two contractual forms, and this vindicates our choice to treat governance forms as qualitatively different.

This study has limitations. First and foremost, the limited dimension of the sample reduced the power of the tests and did not allow estimating more complex specifications of the model. Second, we emphasized coordination requirements as a predictor of contractual form. However, we did not test any measure of contractual hazard. Future studies may investigate whether the inclusion of appropriation concerns affects the choice of contractual forms in general, and of associational contracts in particular. One puzzling findings of our study is that associational contracts are observed at all levels of task uncertainty. As this type of contracts seems to arise mainly in response to the need of combining resources, this indicates that tight combinations of resources may be an efficient governance form even at moderate levels of epistemic uncertainty. While transaction cost economists may immediately think of contractual hazards as a possible explanation, this fact would not square well with the loose specification of actions and with the lean control apparatus of associational contracts. Indeed, this is a puzzle that awaits further investigation.

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Appendix

Table 1 – Contractual dimensions

Bureaucratic intensity	Detailed contract specification Monitoring rights Bureaucratic control through budgets Behavioral vetoes High use of contingency clauses
Associational intensity	Open endedness Low task specification Sharing of costs Low use of contingency clauses
Market intensity	High use of explicit incentives High use of contractual hostages Low resort to cost sharing Close ended projects Low assignment of decision rights Low specification of resources

Table 2 Contractual types

	Contractual type		
	1	*2*	*3*
Bureaucratic intensity	0	1	-1
Associational intensity	1	-1	0
Market intensity	-1	0	1

Notice: '1' and '-1' indicate values of the corresponding variable that are respectively significantly above and below the sample average. '0' indicates values that are not significantly different from sample average. By construction it is not possible that all cluster score high or low along a single dimension

Table 3- The drug discovery process: length, costs and attrition rates

Molecules entering the phase	**Phase**		**PhRMA 2004 expenditures (bln USD)**	**Length (years)**
5000-10000	Drug discovery		9.6	5.5
250	Pre-Clinical			1
5	Clinical	Phase I	15.9	1.5
		Phase II		2.0
		Phase III		2.5
	FDA Review		3.4	1.5
1	Large-scale manufacturing			

Adapted from PhRMA 2006, www.bio.org, and Fumero (2003)

Table 4 - Definition of alliance stage

	Stage	Definition
1	Discovery	No lead product candidate identified
2	Lead Molecule	Lead product candidate identified but no animal testing yet undertaken
3	Pre-Clinical	Data from animal models obtained, but human trials not yet started
4	Formulation	Research on a vehicle or agent for the administration of a therapeutic agent
5	Phase I	Human testing focused on safety begun
6	Phase II	Small-scale human testing focused on efficacy begun
7	Phase III	Large-scale human testing focused on efficacy begun
8	BLA/NDA filed	Biological License Application or New Drug Application filed with the FDA
9	Approved	Drug approved for commercialization

Table 5 - Summary of hypotheses

Hypothesis	Independent construct	Sign of association	Contractual form
1a	*Epistemic uncertainty*	+	*A*
1b		-	*B*
1c		-	*M*
2a	*Computational complexity*	+	*B*
2b		NS	*M/A*
3a	*Activity-based interdependence*	+	*A*
3b		-	*B*
3c		-	*M*
4a	*Team production*	NS	*A*
4b		NS	*B*
4c		-	*M*
5a	*Transfer of existing technology*	-	*A*
5b		-	*B*
5c		+	*M*
6a	*Wider functional scope*	NS	*A*
6b		+	*B*
6c		-	*M*
7a	*Concentration of financial resources*	+	*B*
7b		NS	*M/A*
8a	*Distribution of knowledge*	+	*A*
8b		-	*B*
8c		NS	*M*

NS: not significant association; “A”: associational; “B”: bureaucratic; “M”: market-like

Table 6 – Value labels and descriptive statistics

Variable	*Value*	*Label*	*N*	*Min*	*Max*	*Mean*	*Std. Dev.*
Dependent variables							
FORM	1	"Associational"	79	1	3	2.1	0.75
	2	"Bureaucratic"					
	3	"Market-like"					
FORM2	0	"Market-like"	79	0	1	0.2	0.41
	1	"Nonmarket-like"					
Independent variables							
STAGE	1	"Discovery"	79	1	2	1.5	0.50
	2	"Lead molecule to Phase I"					
	3	"Late stage"					
DEVICE	1	"Immaterial deliverables"	79	1	2	1.2	0.37
	2	"Technology devices"					
ACTIVITY	1	"Exchange-based interdependence"	79	1	2	1.6	0.48
	2	"Activity based interdependence"					
TEAM	1	"Decomposable production"	77	1	2	1.8	0.42
	2	"Team production"					
EXIST	1	"Knowledge to be created"	77	1	2	1.2	0.43
	2	"Transfer of existing knowledge"					
SCOPE	1	"Pure R&D"	79	1	2	1.4	0.50
	2	"Mixed activities"					
BALANCEFIN	1	"Equal"	77	1	2	1.8	0.40
	2	"Client dominant"					
BALANCEKW	1	"Equal"	77	1	2	1.8	0.43
	2	"R&D firm dominant"					

Table 7 – Cross tabulations, chi-squares and measures of nominal association

			FORM			Tot.	χ^2	Asymp. Sig.	Expected count < 5	Uncert. Coeff.	Asymp. Sig.
			Associational	Bureaucratic	Market-intensive						
STAGE	1	%	41.2%	41.2%	60.7%	48.1%	8.78	0.07	2 cells (22.2%)	0.057	0.034
		Adj. Res.	-0.6	-1.1	1.7						
	2	%	23.5%	38.2% *	7.1% *	24.1%					
		Adj. Res.	-0.1	2.6	-2.6						
	3	%	35.3%	20.6%	32.1%	27.8%					
		Adj. Res.	0.8	-1.3	0.6						
Total		Count	17	34	28	79					
DEVICE	1	%	64.7%	97.1%	78.6%	83.5%	9.41	0.01	2 cells (33.3%)	0.062	0.034
		Adj. Res.	-2.4	2.8	-0.9						
	2	%	35.3%	2.9%	21.4%	16.5%					
		Adj. Res.	2.4	-2.8	0.9						
Total		Count	17	34	28	79					
ACTIVITY	1	%	41.2%	11.8% *	60.7% *	35.4%	16.39	0.00	0 cells (.0%)	0.105	0.046
		Adj. Res.	0.6	-3.8	3.5						
	2	%	58.8%	88.2% *	39.3% *	64.6%					
		Adj. Res.	-0.6	3.8	-3.5						
Total		Count	17	34	28	79					
TEAM	1	%	29.4%	2.9% *	42.3% *	22.1%	13.95	0.00	1 cells (16.7%)	0.099	0.042
		Adj. Res.	0.8	-3.6	3.1						
	2	%	70.6%	97.1% *	57.7% *	77.9%					
		Adj. Res.	-0.8	3.6	-3.1						
Total		Count	17	34	26	77					
EXIST	1	%	76.5%	84.4%	64.3%	75.3%	3.26	0.20	1 cells (16.7%)	0.02	0.022
		Adj. Res.	0.1	1.6	-1.7						
	2	%	23.5%	15.6%	35.7%	24.7%					
		Adj. Res.	-0.1	-1.6	1.7						
Total		Count	17	32	28	77					
SCOPE	1	%	41.2%	41.2% *	82.1% *	55.7%	12.29	0.00	0 cells (.0%)	0.078	0.04
		Adj. Res.	-1.4	-2.3	3.5						
	2	%	58.8%	58.8% *	17.9% *	44.3%					
		Adj. Res.	1.4	2.3	-3.5						
Total		Count	17	34	28	79					
BALANCE-FIN	1	%	50% *	17.6%	3.7% *	19.5%	13.86	0.00	1 cells (16.7%)	0.083	0.042
		Adj. Res.	3.5	-0.4	-2.6						
	2	%	50% *	82.4%	96.3% *	80.5%					
		Adj. Res.	-3.5	0.4	2.6						
Total		Count	16	34	27	77					
BALANCE-KW	1	%	58.8% *	15.2%	11.1%	23.4%	15.44	0.00	1 cells (16.7%)	0.084	0.045
		Adj. Res.	3.9	-1.5	-1.9						
	2	%	41.2% *	84.8%	88.9%	76.6%					
		Adj. Res.	-3.9	1.5	1.9						
Total		Count	17	33	27	77					

Notes: dependent variable: FORM; *: significant at the 0.05 level or better

Table 8 – Logistic regression – Results of forward selection

Variables in the equation

Variable	B	S.E.	Wald	df	Sig.	Exp(B)
ACTIVITY	1.36	0.64	4.51	1	0.03	3.89
TEAM	2.41	1.13	4.58	1	0.03	11.12
SCOPE	1.36	0.68	4.04	1	0.04	3.90
BALANCEFIN	3.40	1.50	5.11	1	0.02	29.95
Constant	-3.01	1.12	7.15	1	0.01	0.05
-2 log likelihood	63.19					
Chi-square	31.47				0.00	
% correct	81.1%					

Dependent variable: FORM2

ACTIVITY entered on step 1; SCOPE, on step 2; BALANCEFIN2, on step 3; TEAM, on step 4.

Variables not in the Equation

Variable	Score	df	Sig.
STAGE2	2.97	2	.226
STAGE2(1)	1.39	1	.239
STAGE2(2)	2.95	1	.086
BALANCEKW	1.11	1	.293
Overall Statistics	4.07	3	0.254

Table 9 – BALANCEKW * BALANCEFIN Crosstabulation

			BALANCEFIN		
			1 Equal	2 Client dominant	Total
BALANCEKW	1 Equal	Count	11	6	17
		%	73.3	9.8	22.4
	2 R&D firm dominant	Count	4	55	59
		%	26.7	90.2	77.6
Total		Count	15	61	76
		%	100	100	100

Chi-square: 27.95 ($p < 0.01$); Cramer's V: 0.61 ($p < 0.01$).