Università Ca' Foscari – Venezia

L'ORGANIZZAZIONE FA LA DIFFERENZA?

IX Workshop dei Docenti e dei Ricercatori di Organizzazione Aziendale

7 – 8 Febbraio 2008

Track: Modelli organizzativi per l'innovazione e per il trasferimento tecnologico

KNOWLEDGE DISTRIBUTION, COORDINATION REQUIREMENTS AND CONTRACTUAL CHOICE IN TECHNOLOGY COLLABORATION

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ABSTRACT

The choice of efficient contractual form is often framed as the selection of a degree of hierarchical intensity suitably matching the level of contractual hazards. We posit that technology collaboration contracts are also responsive to the configuration of resources and to coordination concerns and that contractual solutions may be multidimensional and differ 'in kind'. A sample of joint R&D biotechnology agreements provides broad support for propositions concerning the antecedents. Moreover, we find that the way certain contracts are chosen in response to various contingencies, challenges the idea that they can be usefully characterized as 'intermediate' between polar forms of governance.

INTRODUCTION

Research on contract choices in interfirm alliances has been mainly influenced by transaction cost economics (henceforth, TCE). Despite expanding its concepts over time, 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 conflict potential, when the activities contemplated by the partners to an alliance are complex, the governance model adopted is likely to reflect also the coordination requirements of the task at hand and the resources the parties need to bring to the alliance. In other words, we can say that within certain contracts, the planning of *performance* is at least as fundamental as the planning of *risk* (Macneil 1975).

This paper further expands on this line of thinking that was started by Gulati and Singh (1998), and analyzes whether traditional predictors of intra- and inter-organizational coordination modes are useful when the explanandum is specifically the formal, enforceable, agreement.

Allowing for the possibility that different governance forms differ not just in degree but also *in kind* represents a second purported contribution of this study. In particular we shall argue that the choice between arm's length and hierarchical contracts is too stark an alternative, and that certain problems of inter-firm collaboration under conditions of radical uncertainty call for an additional, 'associational' governance model that can hardly be described as an intermediate form. We investigate the issue in the biopharmaceutical industry.

CONTRACTUAL TYPES

TCE argues that under conditions of information complexity coupled with the potential of conflict of interests the control provided for by hierarchical governance is to be preferred to market-based forms. However, if the word 'hierarchy' is taken at face value, as indicating decision-making

structures based on centralized authority, it is dubious that hierarchical governance structures can be comparatively efficient even in highly uncertain contexts (e.g.: Burns & Stalker 1961). Truly, in many studies inspired by TCE, 'hierarchical intensity' is just a convenient label for a bundle of heterogeneous governance mechanisms. Thus we need to specify more accurately what the constituent elements of hierarchy are and to consider which of them can adequately serve the goals that are asked of the contractual governance of R&D collaborations. A brief review of some representative studies in the strategic alliance literature (cfr. Appendix A) reveals that the mechanisms that are said to ensure hierarchical control are quite heterogeneous and that several of them have little applicability to joint R&D collaboration agreements, particularly in the biotechnology sector.

What remains of 'hierarchical' governance, once multiple mechanisms have been ruled out on various accounts, are resource commitments, coupled with arrangements to lock them in for a suitably long period.[1] Before being a safeguard against the risk of opportunism, from a cognitive viewpoint commitments of resources may be the only feasible contracting strategy under conditions of uncertainty. On one side, it is easier to specify ex ante a capability to deal effectively with a certain situation than an action to mechanically cope with it (Knight, 1921: 298). On the other side, resources are characterized by high flexibility and width of possible services and applications (Penrose 1959). Such flexibility largely relieves from the need to ensure adaptability through the specification of many contractual contingencies, which, in turn, eases the burden of verification and makes the contract more enforceable. Enforceable resource commitments have also the potential to align the parties' interests: to the extent that a party has pledged a resource to the exclusive service of a certain relationship, that party's threat point with regard to that resource is zero.

An agreement to pool resources also needs to be complemented by rules about the sharing of the surplus, decision-making and the termination of the relationship (Vanberg 1994). While alternative solutions may be viable, to the extent that the resources that are pledged to the relationship are different, complementary capabilities from the two parties, allowing both parties to take decisions in their respective domains of expertise and to bear the wealth effects of their decisions serves the purpose of efficiency (Fama & Jensen 1983). Accordingly we would expect that polyarchic decision making and shared residual claimancy would be typically observed in such agreements.

Locating the contracting model just described on the market-hierarchy continuum is rather difficult. We suggest that such model is more conveniently treated as differing 'in kind' from the other two archetypes, and we follow Grandori (2001 and 2005) in designating it as 'associational contracting'.

[1] This section draws several ideas from Grandori (2001, 2005) and Grandori and Furlotti (2007).

Although associational contracts can be argued to possess certain advantages under conditions of radical uncertainty, they also entail costs. Thus, for simple transactions market-like contracts may be the preferred alternative. Further, when just one party provides valuable specific knowledge inputs, efficient decision management may require delegating the initiation and implementation of decision to that party, and assigning control to the other, to assuage agency concerns. In this case a more hierarchical and bureaucratic governance structure may be advisable (Fama & Jensen 1983).

A close correspondence with the associational archetype has been observed in venture capital financing contracts (Kaplan & Strömberg 2003). Four mini-cases described in Grandori and Furlotti (2007) illustrate how biopharmaceutical alliance contracts also resemble the three contractual models we have just outlined.

PREDICTORS OF FORMAL ALLIANCE GOVERNANCE

What influences the choice of the contractual governance of alliances? The factors we consider are referable to two fundamental ways of viewing organizations: the first focusing on the task dimensions, the second emphasizing resources.

Uncertainty and contractual type

Task uncertainty is often used as a predictor in empirical studies investigating contractual design. In general, there seems to be convergence of results supporting the proposition that greater uncertainty favors the adoption of less detailed contractual clauses (e.g. Crocker & Reynolds 1993) and of less complex contracts (i.e., shorter, with fewer provisions) (Saussier 2000). In terms of our typology, this is unfavorable to the adoption of bureaucratic contracts.

From classical organizational theory we know that the generic bureaucratic model is characterized by standardization, formalization, specialization and centralization (Pugh, et al. 1963). Standardization and formalization (in the specific sense of a detailed writing and filing of procedures), are at a disadvantage when the problem to be solved requires the pursuit of not previously attempted combinations of actions and resources (Burns & Stalker 1961). As to centralization, it may fail for cognitive reasons (Radner 1997) but it may also be useful to prevent shirking and multitasking (Holmström & Milgrom 1991) and to safeguard against knowledge spillovers (Oxley 1997). Therefore, upon carefully balancing its various mechanisms, the bureaucratic model may not be wholly unsuitable for managing technological alliances.

Further we can argue that under conditions of radical, non-probabilistic uncertainty simple ex-post adaptation achieved by means of bureaucratic governance may not be enough of a solution to contracting problems since what is required is rather the construction of a valid model of the world

(Grandori 2001). We maintain also that the knowledge resources that are relevant to problem-solving and discovery are often less than perfectly substitutable (Polanyi 1966; Nelson & Winter 1982: 105). For 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 where resources are insufficient, not specialized, and easily 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 lose the possibility of creating those novel combinations of activities and resources upon which innovation is typically based (von Hippel, 1988). 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. Finally, it is also well known that conditions of radical uncertainty hinder the use of high powered incentives (Milgrom & Roberts 1992) and the specification of performance (McNeil 1978) that are typical of market contracting. Bringing these arguments together we can argue what follows:

Hypothesis 1: Associational contracts will be chosen over bureaucratic contracts, and these over market-like contracts, for transactions involving higher levels of uncertainty.

Interdependence

Interdependence defined on types of asset usage

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, "sets of potential services [that] can, in large part, be defined independently of their use" (Penrose, 1959: 25). Owing to this property, an asset could be employed for its typical services, or, alternatively, as a currency, a medium of exchange (Pfeffer & Salancik 1978). In technology collaborations at least one party's capabilities are used for its characteristic services. We posit that participation of *both* parties as contributors of activities to the R&D project entails a different level of involvement and of coordination requirements. We call these coordination requirements as 'activity-based interdependence' and the case where assets of one party are used just as currencies as 'exchange-based interdependence'.

The rich control apparatus with which bureaucratic contracts are endowed makes them well equipped to deal with non-trivial degrees of interdependence. By contrast, market-like contracts, which rely mainly on autonomous coordination, should be better suited to regulate a flow of goods and services between the parties. The case for associational contracts is less clear. For all these reasons we advance the following proposition:

Hypothesis 2: Bureaucratic contracts will be chosen for transactions involving higher levels of activity-based interdependence.

Interdependence defined on technology structure

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. Would knowing as much bear implications for an efficient organizational configuration? 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 & Demsetz 1972). Team production gives rise to a metering problem, makes it difficult to rely on individual incentive rewards and hinders the specific attribution of costs. 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). 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 but they appear of less fundamental importance. Indeed, Mayer and Bercovitz (2003) observed greater contractual formalization under conditions of task interdependence. All these intuitions lead to the following proposition.

Hypothesis 3: Bureaucratic contracts will be chosen for transactions involving team production.

While a 'community of fate' may have some advantages when it is difficult to measure each other's contributions, cheaper mechanisms for the control of motivational problems ought to be available. Thus, we treat the comparative assessment of associational and market-like contracting under team production as an empirical question.

Interdependence defined on the scope of activities

Alliance scope, in the sense of whether an alliance encompasses just R&D or also manufacturing and distribution, can affect the level of contractual hazards (contractibility, spill over), and call for safeguards in the form of greater hierarchical intensity. However we posit that the main channel through which a wider functional scope 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. As a result of these conditions 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, which calls for the formalization of procedures for adjustment (Williamson 1979).[2] Moreover, the lower cognitive uncertainty of downstream activities means that cost control and time savings become primary ways to add value, adding the pressure to increase standardization and monitoring. All the factors mentioned above seem to indicate that a wider functional span will lead to alliances with more bureaucratic contracts.

The type of interdependence that we have just described vastly exceeds the information processing capability of market-like coordination (Thompson 1967). Moreover, the resources that are necessary to the performance of downstream activities are likely to be more substitutable than those that are required by R&D. Therefore the addition of downstream activities should not increase the need for a lasting pooling of resources through associational contracts. Thus we do not expect a significant association of a wider scope with this contractual type. Overall, we advance the following hypothesis:

Hypothesis 4: Bureaucratic contracts will be chosen for transactions involving a wider functional scope

Distribution of knowledge

The knowledge that is necessary to accomplish an R&D project can be distributed between the two parties of an alliance, or it can be concentrated and, in the limit, contributed by just one of them. When one party can contribute R&D competencies and the other has manufacturing and commercialization capabilities, it can also be argued that their knowledge bases are quite differentiated.

Several studies have stressed the distribution of the requisite knowledge, and the differentiation of the knowledge bases of the actors, as possible predictors of organizational configurations from the point of view of the effectiveness at problem solving. Burns and Stalker (1961) claimed that 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. For their part, Lawrence and Lorsch (1967: 72) found that influence is more effective at resolving interdepartmental conflict and promoting organizational performance, if it concentrated at the managerial level where knowledge to make decisions is available. In more

[2] 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. Moreover, the move from R&D to production is often a move from concepts to artifacts, which certainly have lower plasticity.

recent times, the literature on network governance and on the new organizational forms has expressed a similar viewpoint.

Studies of organizational learning and organizational knowledge have argued that as knowledge differentiation increases so does the diversity in languages, perceptions, practices. This is expected to reduce the capacity to utilize the knowledge of others (Cohen & Levinthal, 1990) and to call for increasingly more powerful knowledge integration mechanisms. However, in the limit the combination of different knowledge bases becomes no longer possible and the parties can exchange "the output of the application of knowledge, but not have access to the source" (Grandori, 2001: 391).

In the specific field of R&D biopharmaceutical alliances, when the biotechnology firm possesses all the know-how that is relevant for the 'upstream' research activities, no real transfer of the core technology is possible. The counterparty must be satisfied with receiving the results of the discovery activities. We argue that a rather autonomous, disconnected pattern of decision making, supported by market-like contracting is a suitable model of interaction in the case of concentrated knowledge and, *a contrario*, that this is not the case with distributed knowledge.

When both parties contribute their capabilities to the R&D *project*, some degree of integration of their knowledge bases cannot be dispensed with and the intense coordination that is required to blend different knowledge bases into an innovative output needs to be sustained by the sharing of risk, responsibilities and benefits as well as by an intense communitarian interaction (Grandori & Neri 1998). Associational contracts provide precisely for all these elements. Combining these arguments we advance the following proposition:

Hypothesis 5: Associational contracts will be chosen over bureaucratic contracts, and these over market-like contracts, for transactions involving an equal distribution of knowledge resources.

EMPIRICAL ANALYSES

Sample and dependent variable

We tested the implications of the arguments above with data obtained from the content analysis of US pharmaceutical biotechnology agreements. The contracts have been provided by Recombinant Capital (Recap), a San Francisco Bay area-based consulting firm. Our sampling criteria excluded those alliances where one of the parties was a non-business organization and those that did not include any element of R&D. We also left out agreements terminated ahead of time, as a means to bias the sample toward successful alliances. Finally, through random selection we picked 79

alliance contracts with a constraint of approximately equal representation of early stage and late stage alliances. The contracts in our sample date from 1989 until 2005.

Our dependent variable (FORM) takes on one of three values, which correspond to the three contractual types that were identified through a preliminary taxonomical analysis. Details of the process that led to the identification of these types are provided in Appendix B.

FORM = 1 for associational agreements

FORM = 2 for bureaucratic agreements

FORM = 3 for market-like contracts

Independent variables

Uncertainty. We claim that in biotechnology research the lack of valid knowledge concerning cause-effect relationships is the more severe, the farther the drug discovery process is from the commercial release. To support our claim we can look at the 'attrition rate' statistics (the number molecules discarded during the process) in Table 1.

Insert Table 1 about here

Thus the stage of research at the time of signing an alliance agreement is our proxy for uncertainty.[3] For our initial analysis we recode Recap's original measure into a three categories variable (STAGE), where the stage of Discovery is assigned a value of 1, and the remaining stages are evenly subdivided in two classes with value 2 and 3 respectively.[4]

Interdependence defined on type of asset usage. This variable measures whether the contribution of assets to the R&D project by either party is purely financial or whether both are actively engaged in the project. The former type of asset contribution defines an exchange-based interdependence, while the latter is the defining criterion of activity-based interdependence. This variable, called ACTIVITY, was coded as follows:

- 0: one side performs R&D activities
- 1: both sides perform R&D activities

Interdependence defined on technology structure. The variable called TEAM measures 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. Since what we are concerned with are the typical expected outcomes of the R&D project, the problem can be

[3] A detailed description of the measure is provided in Appendix C.
[4] To check for robustness of findings, alternative codifications have also being used.

reformulated as one of observing whether the alliance may give rise to joint inventions or not. In sum, TEAM was coded as follows:

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

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. This variable, called SCOPE, is coded as follows:

- 0: pure R&D
- 1: mixed activities (R&D and sales)[5]

Distribution of knowledge resources. Observations concerning the distribution of knowledge resources in the R&D project, as reflected by contributions of intellectual property and the performance of R&D tasks, are captured by a variable called BALANCEKW that is coded as follows:[6]

- 0: About equal contributions
- 1: R&D firm makes dominant or exclusive contribution

Control variables

In addition to the independent variables featured in the hypotheses we also included some control variables that may impact on the contractual choice. The indicator variable EXIST measures whether the contract stipulates, on top of the R&D collaboration, a transfer or rights on existing technology for commercial exploitation outside the collaboration. The reason for being concerned with this variable is that an external observer may think the alliance is a genuine collaborative effort, while in reality it could be little more than a licensing agreement, accompanied by ancillary activities.

Another dummy (VERTICAL) was included to indicate whether the alliance was horizontal (established between biotechnology firms) or vertical (established between a biotechnology and a pharmaceutical firm). This variable can be understood as a crude measure of the difference in the financial strength of the alliance partners. A third dummy variable (INTERNATL) indicates whether one partner in the alliance is from a country other than the US, thus entailing possibly different preferences as to the contractual type, or greater contractual hazards due to monitoring difficulties and a lower understanding of each other's expectations.

[5] In order to carry out robustness analyses we tried also alternative coding of SCOPE and obtained similar results.
[6] Contribution of effort and capabilities to downstream processes where not considered

Statistical Methodology

We assessed the probability of the choice between the three contractual types with a multinomial logistic regression model and Huber-White sandwich estimators of variance. Table 2 presents descriptive statistics and correlation coefficients.

Insert Table 2 about here

Table 3 presents the results of our analyses. Each model estimates coefficients indicating how covariates affect the choice of associational and bureaucratic contracts relative to the choice of market-like agreements. In all the models after the first, also coefficients for the choice of associational versus bureaucratic contracts are presented. Overall, our hypotheses find good support in the data, but some are rejected.

Insert Table 3 about here

We discuss only the results of the full model (Model 3). The addition of the full set of the variables of interest results into a considerable improvement of the predictive power of the model, as reflected in the chi-square test on the observed log likelihoods. The negative and significant intercepts of equations A and B indicate that in correspondence of zeros of our covariates market-like contracts have higher probabilities of being chosen. All the indicators of higher levels of interdependence (ACTIVITY, TEAM, and SCOPE) are significantly associated with greater use of bureaucratic contracts, in line with our hypotheses 2, 3 and 4. The configuration of the knowledge resources contributed to the alliance (BALANCEKW) also turns out to be an important predictor of contractual choice: where knowledge is more distributed the parties are more likely to favor associational contracts. However, conditions of distributed knowledge do not significantly affect the choice between bureaucratic and market-like contracts. The proxies for uncertainty, that had some explanatory power in Model 2, loose statistical significance altogether in the full model.

We have also analyzed the substantive significance of our results by comparing the discrete changes in the predicted probabilities of the different contractual alternatives for unit changes in our independent variables. Each of the five covariates that were found significant turned out to have a considerable impact on the average predicted probability of the three contractual types, with BALANCEKW displaying the largest impact of all.

One final analysis involved the comparison of odds ratios (Figure 1). The reason for taking an interest in odd ratios is that they help clarifying whether associational contracts can be considered ‘intermediate’ between the other two contractual types or not. If the ‘intermediate’ interpretation were justified we would expect that for any given change in contextual variables, the degree to which associational contracts would be found better-matched to a different environment, and thus

chosen with greater odds, would be intermediate to the corresponding degrees of the other two archetypical categories as, by definition, intermediate governance forms possess, to a lesser extent, the same adaptation mechanisms of more fundamental ones (Williamson 1991). In Figure 1 we see that an intermediate-like behavior can be seen in the response to activity-based interdependence and team production while this is not true for changes of SCOPE and BALANCEKW. In the latter case the odds ratios of associational contracts lie outside the range defined by the odds ratios of the other contractual forms.

DISCUSSION AND CONCLUSIONS

Our findings confirm that the different types of interdependence are important predictors of contractual form and explain the choice between market-like and bureaucratic contracts. This result echoes the findings of Gulati and Singh (1998) and those of Mayer and Bercovitz (2003).

Our findings also confirm that the configuration of knowledge resources matters, that it has the strongest predictive power among the variables we have investigated, and that it impacts heavily on the choice to forge associations. Uncertainty was not found significant in the full model, possibly due to the limited size of the dataset.

Vis-à-vis certain predictors, associational contracts behave as intermediate forms between market-like and bureaucratic contracts. Thus for some practical purposes characterizing contractual forms as points along a continuum is a useful heuristic. However, the behavior of associational contracts vis-à-vis other variables vindicates our choice to treat this governance form as qualitatively different.

Despite several limitations, this study has demonstrated that using conceptually-defined contractual types in empirical research is possible and that it can disclose aspects of the governance of interfirm relationships not easily revealed by the use of taxonomies borrowed from practice.

REFERENCES

Alchian, A. A., & Demsetz, H. 1972. Production, information costs, and economic organization. *American Economic Review*, 62(5): 777-795.

Burns, T., & Stalker, G. M. 1961. *The management of innovation*. London: Tavistock Publications.

Cohen, W. M., & Levinthal, D. A. 1990. Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 35(1): 128-152.

Crocker, K. J., & Reynolds, K. J. 1993. The efficiency of incomplete contracts: An empirical analysis of air force engine procurement. *RAND Journal of Economics*, 24(1): 126-146.

Fama, E. F., & Jensen, M. C. 1983. Separation of ownership and control. *Journal of Law and Economics*, 26(2): 301-25.

Grandori, A. 2001. *Organization and economic behavior*. Routledge: London and New York.

Grandori, A. 2005. Firm-like contracts: From task contingencies to resource commitments. *Crora Working Paper n. 10*. Milano: Bocconi University.

Grandori, A., & Furlotti, M. 2007. *Facio ut facias: Associational contracts and innovation*. International Studies of Management and Organization (forthcoming).

Grandori, A. and M. Neri: 1998, "The Fairness Properties of Networks", in A. Grandori (ed.), *Inter-Firm Networks: Organization and Industrial Competitiveness*. London: Routledge.

Gulati, R., & Singh, H. 1998. The architecture of cooperation: Managing coordination costs and appropriation concerns in strategic alliances. *Administrative Science Quarterly*, 43(4): 781.

Holmström, B., & Milgrom, P. 1991. Multitask principal-agent analyses: Incentive contracts, asset ownership, and job design. *Journal of Law, Economics & Organization*, 7(2): 24.

Kaplan, S. N., & Strömberg, P. 2003. Financial contracting theory meets the real world: An empirical analysis of venture capital contracts. *Review of Economic Studies*, 70(245): 281-315.

Knight, F. H. 1957. *Risk, uncertainty and profit*. New York: Kelley and Millman, Inc.

Lawrence, P. R., & Lorsch, J. W. 1967. *Organization and environment: Managing differentiation and integration*. Boston, MA: Harvard Business School Press.

Macneil, I. R. 1974. The many futures of contracts. *Southern California Law Review*, 47: 691-816.

Macneil, I. R. 1975. A primer on contract planning. *Southern California Law Review*, 48: 627-704.

Mayer, K. J., & Bercovitz, J. E. L. 2003. The influence of relationships, learning and inertia on contract design: The extent of contingency planning in information technology services contracts. *University of Southern California working paper*.

Milgrom, P., & Roberts, J. 1992. *Economics, organization and management*. Englewood Cliffs, N.J.: Prentice Hall.

Nelson, R. R., & Winter, S. G. 1982. *An evolutionary theory of economic change*. Cambridge: Harvard University Press.

Oxley, J. E. 1997. Appropriability hazards and governance in strategic alliances: A transaction cost approach. *Journal of Law Economics & Organization*, 13(2): 387-409.

Penrose, E. 1995. *The theory of the growth of the firm*. Oxford & New York: Oxford University Press.

Pfeffer, J., & Salancik, G. R. 1978. *The external control of organizations: A resource dependence perspective*. New York, NY: Harper and Row.

Pharmaceutical Research and Manufacturers of America (Phrma). 2006. *Pharmaceutical industry profile 2006*. Washington, DC: PhRMA.

Pisano, G. P. 1989. Using equity participation to support exchange: Evidence from the biotechnology industry. *Journal of Law, Economics & Organization*, 5(1): 109.

Polanyi, M. 1966. *The tacit dimension*. Garden City, NY: Doubleday.

Pugh, D. S. et al. 1963. A conceptual scheme for organizational analysis. *Administrative Science Quarterly*, 8(3): 289.

Radner, R. 1997. Bounded rationality, indeterminacy, and the managerial theory of the firm. In Z. Shapira (Ed.), *Organizational decision making*. Cambridge: Cambridge University Press.

Saussier, S. 2000. Transaction costs and contractual incompleteness: The case of Electricité de France. *Journal of Economic Behavior and Organization*, 42(2): 189-206.

Thompson, J. 1967. *Organizations in action*. New York: McGraw-Hill.

Vanberg, V. J. 1994. Organizations as constitutional systems. In V. J. Vanberg (Ed.), *Rules and choice in economics*. London & New York: Routledge.

von Hippel, E. 1988. *The sources of innovation*New York; Oxford; Toronto and Melbourne:; Oxford University Press.

Williamson, O. E. 1979. Transaction-cost economics: The governance of contractual relations. *Journal of Law & Economics*, 22(2): 233-261.

Williamson, O. E. 1991. Comparative economic organization: The analysis of discrete structural alternatives. *Administrative Science Quarterly*, 36(2): 269-296.

Williamson, O. E. 1996. The mechanisms of governance. In O. E. Williamson (Ed.), *The mechanisms of governance*: New York & Oxford: Oxford University Press.

APPENDIX A

A summary of how various studies spell out the constituting elements of 'hierarchy'

Reference	Elements	Comments
Hennart (1988)	Equity investment	The sharing of profits aligns interests. However, the pricing of intermediate goods which do not have clear arm's length prices determines how profits are divided between the JV's parent companies, thus often becoming a source of contractual difficulties.
Pisano (1989)	Equity investment, restrictions on rights to sell positions off	Equity entails better monitoring opportunities through representation on the partner's board. Agreements on relative contributions are said to be enforceable.
Oxley (1997)	Monitoring, decision and veto rights, sharing of profits, hostages	'Bilateral adaptation', also mentioned, (quantity adjustments, formulaic price adjustments, contingent clauses).
Gulati & Singh (1998)	Monitoring, decision rights, sharing of profits, standard operating procedures, non-market pricing, dispute resolution mechanisms, plans and rules	Emphasis shifted from reward systems to authority ('fiat', 'command structures' and 'hierarchical control')
Santoro & McGill (2005)	Hostages, contractual contingencies and ownership	Characterization of hierarchical intensity not seen as being particularly problematic

APPENDIX B

Construction of the dependent variable

The dependent variable FORM is the result of a classificatory study carried out on 79 agreements. Each agreement was coded on 27 items of contractual structure. Measured items included: a) substantive issues, such as arrangements on monetary rewards, property rights and commitments on tasks and resources; b) procedural issues, such as rules for decision making, mechanisms for enforcement, monitoring, coordination, dispute resolution; c) contract-level characteristics, as the length of the contractual document, its duration and the use of state contingent covenants.

Through a principal component analysis of the original variables, three factors loading on 13 items have been identified which, together, accounted for about 55% of total sample variance. Factor loadings suggested the following labeling and interpretation of the three dimensions:

- *Bureaucratic intensity*: extent to which the contract is articulated, contingencies are explicitly spelled out; control mechanisms and constraints are specified.
- *Associational intensity*: extent of use of cost sharing (as opposed to specific incidence), open ended relationships, low task specification
- *Market intensity*: extent of use of performance incentives and hostages

Through a k-means cluster analysis performed on the scores on these contractual dimensions, three contractual types have been identified. An alternative clustering procedure yielded the same number of number of groupings suggested by a priori considerations. As shown in the left-hand table below, each contractual type scored high along one dimension (1), was significantly below sample average along a second (-1), and was not significantly different from average along the third (0). Accordingly we interpreted the contractual types in terms of their 'dominant' dimension and labeled them respectively 'associational', 'bureaucratic' and 'market-like'. Item-by-item characterization of clusters corroborated the interpretation based on cluster centers. Cluster memberships provided the three values of the variable FORM.

FINAL CLUSTER CENTERS

	Cluster		
	1	2	3
Bureaucratic intensity	0	1	-1
Associational intensity	1	-1	0
Market intensity	-1	0	1

CLUSTER DISTRIBUTION

Cluster	N	% Cases
1 – Associational	17	22%
2 – Bureaucratic	34	43%
3 – Market-like	28	35%
Valid	79	100%

APPENDIX C

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 drug
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 1
The drug discovery process: length, costs and attrition rates

Molecules entering the phase	Phase		PhRMA 2004 expenditures*	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. * Figures in bln USD.

Table 2
Polychoric correlations and descriptive statistics

		1	2	3	4	5	6	7	8	9
1	FORM	1								
2	STAGE	0.13	1							
3	ACTIVITY	-0.28	0.23	1						
4	TEAM	-0.22	-0.04	0.27	1					
5	SCOPE	-0.43	-0.55	0.16	0.50	1				
6	BALANCEKW	-0.54	0.30	0.17	-0.40	-0.02	1			
7	EXIST	0.14	-0.04	-0.44	-0.18	-0.53	-0.53	1		
8	VERTICAL	0.13	-0.05	-0.13	0.12	0.13	-0.44	0.05	1	
9	INTERNATL	0.30	-0.02	-0.22	0.07	0.04	-0.39	0.00	0.68	1
	Obs	79	79	79	77	79	77	77	79	79
	Mean	2.14	2.20	0.65	0.78	0.44	0.23	0.25	0.56	0.39
	Std.Dev.	0.75	0.85	0.48	0.42	0.50	0.43	0.43	0.50	0.49
	Min	1	1	0	0	0	0	0	0	0
	Max	3	3	1	1	1	1	1	1	1

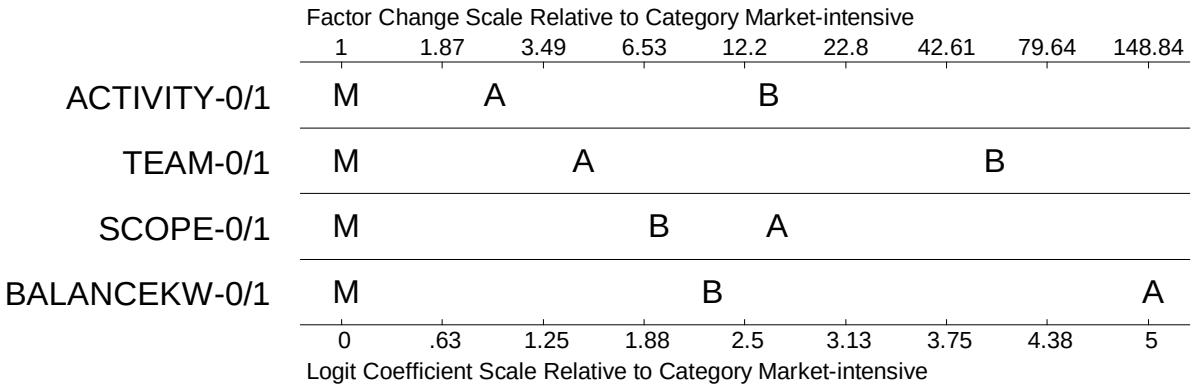
Table 3
Contractual form: multinomial logit models

	Model (1)		Model (2)			Model (3)		
	A	**B**	**A**	**B**	**A(B)**	**A**	**B**	**A(B)**
STAGE1			0.54	-0.21	0.75	1.59	-0.26	1.82
			(0.74)	(0.67)	(0.79)	(1.27)	(0.77)	(1.31)
STAGE2			1.44	1.74*	-0.30	2.06	2.16	-0.10
			(0.99)	(0.88)	(0.74)	(2.14)	(2.20)	(1.07)
ACTIVITY						0.92	2.62**	-1.70*
						(0.97)	(1.04)	(0.93)
TEAM						1.47	4.02***	-2.55**
						(1.09)	(1.42)	(1.04)
SCOPE						2.67***	1.94**	0.73
						(1.01)	(0.98)	(0.92)
BALANCEKW						5.00***	2.27	2.73**
						(1.64)	(1.46)	(1.09)
EXIST	-0.47	-0.95	-0.52	-1.02	0.50	2.19**	0.32	1.87*
	(0.72)	(0.65)	(0.76)	(0.69)	(0.74)	(1.09)	(0.94)	(1.01)
VERTICAL	0.00	0.76	-0.14	0.56	-0.70	0.62	1.17	-0.55
	(0.68)	(0.68)	(0.67)	(0.71)	(0.69)	(0.91)	(0.83)	(0.81)
INTERNATL	-1.27*	-0.76	-1.17*	-0.58	-0.59	-1.29	-0.45	-0.84
	(0.70)	(0.68)	(0.66)	(0.70)	(0.71)	(0.90)	(0.82)	(0.79)
Intercept	0.21	0.34	-0.14	0.11	-0.25	-5.81**	-6.90***	1.09
	(0.48)	(0.47)	(0.61)	(0.51)	(0.59)	(2.32)	(2.46)	(1.75)
N	73		73			73		
Log-likelihood	-74.39		-71.03			-47.35		
Chi-square	7.08		19.62			47.21		
P	0.313		0.033			0.000		

Dependent variable is FORM. Base outcome: Market-like. In last column of Models 2 and 3 base outcome is Bureaucratic. Outcomes: A: "Associational"; B: "Bureaucratic"; A(B): "Associational" (compared with "Bureaucratic"). Positive coefficients indicate increased probability that firms select the specified contractual type.

Figure 1

Plot of odds ratios



Odd ratios (a.k.a. “factor change coefficients”): upper scale. A: "Associational"; B: "Bureaucratic"; M: “Market-like”