

Cooperation via contract: An analysis of research and development agreements

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Abstract

We examine research and development (R&D) agreements between government agencies and other organizations. Consistent with theories of contractual “hold up,” contracts are longer and more complete when the parties envision a joint product as opposed to when they merely plan to share information. Contracts are less complete when the parties have an ongoing business relationship, suggesting an interaction between reputation and explicit contracting. While our experiment cannot dismiss the possibility that these empirical regularities simply reflect the nature of the parties’ joint investment, the findings are consistent with arguments that theories of contracting for tangible inputs also pertain to R&D. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

Prior empirical applications of contracting have focused mainly on the make-or-buy decision or long-term contracts for tangible products. But little empirical work

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has been done on the contracting for less tangible inputs, such as research and development (R&D). This may be largely due to the proprietary nature of R&D type contracts. As Coase (1992) notes “... The main obstacle faced by researchers in industrial organization is the lack of available data on contracts and activities of firms.” To fill this empirical void in the literature, we obtain and analyze a sample of 107 cooperative research and development agreements (CRDAs) between federal agencies and other entities. Our access to the sample permits us to test whether theories of contract design developed and tested in the context of tangible products also apply to less tangible inputs such as R&D.

Studying the nature of R&D agreements is of interest as firms often rely on these relationships instead of using outsourcing or direct acquisition. Chan et al. (1997) document that joint R&D agreements create value. The authors also observe that the majority of these relationships are purely contractual and do not involve an exchange of equity. Jensen and Meckling (1991) use the term “network organization” to refer to the entity established by the joint R&D agreement. The network organization is a hybrid form that exists between outright ownership and outsourcing.

We observe that CRDAs have different purposes ranging from sharing information to the development of a joint product. We find several significant empirical regularities in the design of the contracts. CRDAs with joint product purposes tend to be longer, and have more enforcement mechanisms relative to agreements that envision only information sharing. Since information sharing should be simpler and involve fewer interactions than planning for a joint product, these findings reflect the nature of the joint investment and have a straightforward explanation. But, at the same time, the results are also consistent with the theories of contractual “hold up” (Klein et al., 1978; Williamson, 1979, 1983a).

While complete agreements offer the parties increased protection, they also reduce flexibility and increase contracting costs. From an administrative perspective, parties who have not done business before may have the need to enter into more detailed contracts than those who have had extensive prior dealings. As parties become more familiar with one another, these contracting “start up” costs may abate. In addition, Williamson (1993) suggests that when the parties have had extensive prior contractual relationships, they can take more “calculated risks” in the current agreement. Klein (1980) posits that the major contract enforcement mechanism for parties who expect continued business dealings is implicit, namely the concern for their reputation. Consistent with all of the above arguments, CRDAs are less complete when the parties have ongoing business dealings outside of the agreement as opposed to when the CRDA is an isolated contractual relationship.

The paper proceeds as follows: Section 2 introduces the data and provides descriptive statistics for the sample of CRDAs to assess the prevalence of various types of provisions. Section 3 investigates the cross-sectional variation amongst CRDAs. Section 4 examines the relationship between explicit contracting and

reputation. Section 5 describes some caveats. Section 6 summarizes and offers conclusions.

2. Data

2.1. Data source

CRDAs are contracts to share resources for a specified period of time and for an articulated purpose. Based on The Stevenson–Wydlar Technology Innovation Act of 1980 and Executive Order 12591, *Facilitating Access to Science and Technology*, April 10, 1987, CRDAs came into being with the intent of permitting federal agencies to share personnel, intangible property, and tangible property with other public and private sector entities.

We recognize that using public sector entities to study contracting issues should be done with caution. Public sector agencies may have little incentive to negotiate efficient agreements. In this paper, we assume that our sample of contracts involving both public and private sector agencies represents a reasonable empirical proxy for the study of contractual governance issues. This reliance is based on the conditions that have driven the federal agencies in the sample to negotiate efficient agreements. Over the past decade, most of the defense agencies in this sample have had steadily decreasing real levels of federal appropriations. To overcome the shrinking appropriations, these federal agencies are finding alternative sources of revenue to improve their chances for survival. As a result, they are more business oriented than ever before. Efforts to “reinvent” government have also meant increased competition for public entities from the private sector.

Individual government agencies often supplement the federal law on technology transfer with their own guidelines for CRDAs under various regulations or instructions. An example is Air Force Instruction 61-302: Cooperative Research and Development Agreements. This instruction provides guidance to Air Force agencies. For example, equity participation is not permitted in CRDAs; the parties must rely on contracting to specify their rights and obligations. The instruction also specifies the basic approval authority, and provides an outline of the areas, such as the nature of the transfer, financial obligations, articulated benefits, and tasks (work plan), that must be covered in a CRDA contract.

CRDAs provide a useful data source for empirical study because the contracts tend to follow the framework specified by these instructions. CRDAs average about 35 pages in length and tend to be relatively uniform in design. This standardization has several benefits from a research perspective. For example, it allows the “scoring” of various provisions to be done on a more consistent basis than could be accomplished with a sample of private industry contracts. Given the variations in the sample CRDAs, however, it is also apparent that the parties have freedom to negotiate key terms.

The sample consists of 107 CRDAs entered into by Air Force agencies over the period from 1988 through 1995. These CRDAs were located by searching the repositories of the Office of Technology Transfer of the Secretary of the Air Force. Air Force contracts were used because of the familiarity of the authors with Air Force operations, and due to the accessibility of these contracts. CRDAs are publicly available, but continual reorganizations within the government make finding their repository location a challenging proposition.¹

2.2. Development of the sample data

We dissect each agreement into sections for the purposes of analysis. These sections are as follows: (1) the parties, (2) the contract purpose, (3) nature of the shared assets (basis of the bargain), and (4) the enforcement provisions. Within each section, all variables of interest are scored as dummy variables, taking the value of one if the parameter is contained in the agreement, zero otherwise. Similar to the approach taken by Gompers and Lerner (1996), we focus the study on provisions within each section that are neither “boilerplate” (common to virtually all contracts) nor isolated (in less than 5% of the agreements). As a result, the data set is not an exhaustive list of CRDA provisions but a tractable sample useful for understanding cross-sectional variations.

Similar to Pisano (1989), we assume that the negotiation of joint R&D agreements usually focuses first on the purposes for the relationship.² Motivation for entering into a CRDA springs from the partners’ recognition of possible asset sharing synergies. In a typical agreement, the detailed enforcement provisions are negotiated after the purpose is established. This ordering provides a useful basis to analyze whether the enforcement provisions are driven by the underlying purposes for the agreement.

2.2.1. Contract parties

There are a variety of government (Air Force) agencies in the sample. Table 1 (Panel A) provides a summary of the types of agencies. The most common agency is the Air Force laboratory, such as Phillips or Wright Lab. There are also a large number of operational testing agencies like the Air Force Flight Test Center that are partners in CRDAs. Beyond the laboratories and test organizations, there are educational institutions, such as the Air Force Institute of Technology, logistics centers, such as Warner Robins, and medical organizations, such as Wilford Hall.

¹ We believe that our data source was the single largest repository for CRDAs at the time the sample was gathered.

² In practice, government agencies are very concerned about the scope of the activities undertaken by those under their control.

Table 1

Agencies and partners

CRDAs involve federal government (Air Force) entities and other types of partners. Panel A shows the number of CRDAs (out of a sample of 107 over the period from 1988 through 1995) that involve the type of Air Force agency shown. Panel B shows the number of CRDAs with the types of partners shown. Also given is the percentage of the 107 agreements that are with each type of partner.

	Number of CRDAs	% of total
<i>Panel A: Type of Air Force agency</i>		
1. Laboratory	44/107	41
2. Operational testing	32/107	30
3. Educational	17/107	16
4. Logistics	10/107	9
5. Medical	4/107	4
<i>Panel B: Type of partner</i>		
1. Large, for-profit defense company ^a	34/107	32
2. Small, for-profit company	39/107	36
3. Not-for-profit educational institution	28/107	26
4. Other not-for-profit organizations	6/107	6

^aLarge means one of the top 10 defense contractors in the United States as of 1995.

The government agencies in the sample have a variety of CRDA relationships. Table 1 (Panel B) provides a summary of the frequency of each type of CRDA partner. The breakout of CRDA partners is (1) large (top 10 in defense sales as of 1995), for-profit defense contractors, such as Raytheon or General Electric; (2) small, for-profit contractors, such as Clinical Instruments; (3) not-for-profit educational institutions or universities, such as Virginia Tech; (4) other not-for-profit organizations, such as the Rome City School District in New York.

This table shows the wide variety of CRDA relationships. CRDAs with for-profit contractors make up the majority of the agreements. There are about the same number of CRDAs with large defense contractors as with smaller, for-profit contractors. But the sample also includes a number of agreements with not-for-profits, the majority being educational institutions. Altogether, these descriptive results show that CRDA relationships exist with a number of different types of partners.

For purposes of analysis, the large (top 10) defense contractors and the government agency are considered to have an extensive ongoing business relationship outside of the CRDA. In the case of the other parties, the CRDA is a much more isolated business contract. Most of the not-for-profit educational institutions and the universities have at least some prior business contact with the government agency. But it is far below the scale and scope of the dealings with the large defense contractors. Most of the small, for-profit contractors in the CRDA sample have had virtually no prior business dealings with the government agencies.

2.2.2. *Contract purposes*

As their name implies, all CRDAs have the objective of R&D. Pisano (1989) separates contract purposes into categories called R&D and “R&D plus.” “R&D plus” alliances combine R&D with other functions. Oxley (1997) identifies alliances that combine R&D with other functions as “mixed.” We take a similar approach, identifying three possibilities in the CRDA sample. The purposes are: (1) simple R&D — sharing information, (2) R&D plus production — conducting R&D with the ultimate goal of producing a good or service, or (3) R&D plus patent — conducting R&D with the goal of obtaining a patent or an exclusive license on a product or service. For ease of exposition, we will refer to purpose of the simple R&D agreements as “information sharing.” We refer to the purpose of the R&D plus Patent and R&D plus Production Agreements as “developing a joint product.”

An example of each purpose illustrates the differences. An agreement aimed at information sharing is one between Evans and Sutherland and Armstrong Labs. This CRDA focuses on joint efforts to develop a better understanding of technology used to integrate aircraft simulation environments. An example of a CRDA that envisions R&D plus actual production is one between Night Vision and Wright Aeronautical Lab. The goal is to develop, produce, and market a commercially acceptable, finger-mounted laser spotlight. Lastly, an agreement that has the goal of R&D plus patent is one between Grumman and Rome Lab. The goal of this agreement is to create and patent software technologies that make high-performance computers easier to use.

2.2.3. *Shared assets*

The shared assets section of CRDAs focuses on the nature of the resources that form the basis for the agreement. Chan et al. (1997) suggest that the costs of transfer can be very high when organizations share competitively sensitive information and capability. Klein et al. (1978) suggest that asset specificity increases the risks of opportunistic behavior by the parties to long-term contracts. To examine any linkages between the nature of shared assets, risks of opportunistic behavior, and contractual design, we classify the shared resources as (1) technical individual expertise, (2) tangible assets, or (3) intangible assets. An agreement can have more than one basis. For the purposes of this section, we do not focus on the role of management and administrative personnel. They are assumed to be universal to the sample.

When the basis of the agreement is the exchange of technical individual expertise, the CRDA specifically names individuals or groups. For these CRDAs, the variable ‘individual’ takes the value of one. An example of a CRDA emphasizing the sharing of individual expertise is one that arranges for government engineers at Oklahoma City Logistics Depot to provide technical support to a consortium of manufacturing firms in the surrounding region. Tangible assets, such as facilities or equipment, can also form the basis for the agreement. For

these CRDAs, the variable “facility” takes the value of one. An example of such a CRDA is one between Clark City Health and the Air Force Flight Test Center. In this agreement, the parties exchange the use of flight and air quality sampling equipment. The assets exchanged can also be intangible, normally data or software. When an exchange of intangible assets occurs, we assign that CRDA a “data” variable with a value of one. For example, the CRDA between E-Systems and the Air Force Intelligence Agency provides for the sharing of simulation data.

2.2.4. *Enforcement mechanisms*

Gompers and Lerner (1996) argue that enforcement provisions are included in contracts when the benefits of those restrictions outweigh their costs. As proxies for enforcement mechanisms in CRDAs, we use four provisions that have been theoretically and empirically evaluated in prior research. Based on the predictions of Klein et al. (1978) and Williamson (1979; 1983a) and the empirical research on tangible inputs by Joskow (1987) and Crocker and Masten (1988), we examine contract duration. We convert contract duration to a dummy variable by assigning the “long 12” variable a score of “one” if the contract length is in excess of 1 year and zero otherwise. We choose this dummy variable characterization to reflect the added complexity that multi-year relationships bring to the planning-intensive government, defense contractor, and non-profit organizations in the sample.³

Second, we study benefit sharing. Pisano (1989) asserts that dividing the potential benefits of cooperative R&D ventures contractually is so difficult that joint equity ownership is often the best approach. We therefore observe whether there is a defined benefit share ratio in the CRDA. If there is, the variable “share” takes value one. Without such a defined provision, the potential for contractual hold-up may be significantly greater. At the same time, specifying a share ratio up front can be a costly bonding provision because the parties must commit to an allocation in advance of information about the success of the venture and their relative inputs. An example of an agreement where a share ratio for benefits is specified is a CRDA between the International Education Foundation and the Air Force Academy. This agreement is for the development and marketing of Internet products used for the instruction of foreign languages. The CRDA calls for 25% of the net royalties to be paid to the Academy.

The third and fourth enforcement provisions involve the up-front exchange of cash or property. Alchian and Woodward (1988) and Parkhe (1993) argue that these exchanges act as a security deposit or bond between contracting parties. These enforcement provisions differ from the others studied in the sense that they

³ Regardless of multi-year planning issues, the selection of 1 year is arbitrary. We also experiment with different dummy classifications of the duration variable. In particular, another classification gives the variable a value of one if the CRDA is longer than the median duration for the sample.

may be “bilateral” as opposed to “unilateral.” For example, one party may transfer property to the other as opposed to both parties being subject to an agreed upon contract duration. Nevertheless, the transfer serves to bind both parties. One party has physical possession of the property; the other has the explicit contractual provision indicating that the transfer has been made. Accordingly, we determine whether cash and/or property are exchanged up front in CRDAs. If there is an up-front cash payment, the variable “cash” takes the value of one. If there is an up-front exchange of property, the variable “property” takes value of one.⁴

As examples, cash is exchanged up front in the CRDA between the Ohio Aerospace Institute and the Air Force Institute of Technology (AFIT), where Ohio Aerospace agreed to pay AFIT for the services of its faculty. Property is exchanged in the CRDA between W.L. Gore and Keesler Medical Center, where Keesler provided Gore with test material with the goal of testing expanded vascular graft techniques.

CRDAs can have multiple enforcement mechanisms. Following the approach of Gompers and Lerner (1996) in their analysis of venture capital agreements, we assume that the enforcement provisions have a cumulative effect. That is, CRDAs with more enforcement provisions are assumed to be more costly and restrictive.

2.3. Descriptive summary of the CRDA sample

Table 2 summarizes the sample with regards to purpose, the nature of the shared assets, and the enforcement mechanisms. The table shows how many agreements have the stated provisions and the associated percentage of the total sample. Information sharing is the most common articulated purpose, contained in about 60% of the sample. But CRDAs aimed at developing a joint product are not uncommon. Thirty-nine percent of the CRDAs in the sample envision the development of a joint product, meaning that they have the R&D plus patent or the R&D plus production purposes. Included in this total are five CRDAs that have both objectives. Table 2 illustrates the wide range of goals that CRDA contracting appears to address.

Regarding the nature of shared assets; the three types examined include individual expertise, facilities/equipment, and data/software. Each of these categories appears in about 40% of the sample. About one-fourth of all CRDAs are based on more than one type of asset sharing. In sum, CRDAs appear to have the potential to allow sharing of various organizational resources on more than an isolated but less than a permanent basis.

⁴ We also experiment with a different characterization of these security deposits. We collapse them into one variable, which takes the value one if there is either a cash or property exchange up front. CRDA regulations generally prohibit the Air Force agency from contributing cash up-front. So CRDA partners usually make the up-front cash payments, if there are any.

Table 2

Description of agreements

Panel A of this table shows the prevalence of the provisions that comprise CRDAs. Given are the number and percentage of the 107 CRDAs in the sample that have the respective provisions. Panel B gives the descriptive duration statistics (in months) for the sample.

Panel A: Provisions

Provision	Number	% of total
<i>Articulated purposes</i>		
Information sharing	65/107	61
Development of joint product	42/107	39
R&D plus patent	13/107	22
R&D plus production	24/107	12
R&D plus patent/production	5/107	5
<i>Nature of shared assets</i>		
Individual expertise	43/107	40
Facilities/equipment	45/107	42
Data or intangibles	45/107	42
<i>Methods of enforcement</i>		
Duration greater than 12 months	71/107	66
Exchange of cash	37/107	35
Exchange of property	29/107	27
Specified share ratio	60/107	56

Panel B: Duration (months)

Mean	Median	Maximum	Minimum
30.1	24.0	84.0	4.0

As for enforcement mechanisms, about two-thirds of the sample are agreements longer than 1 year. The average duration is about 30 months; the median is 24 months. The shortest CRDA is for 4 months, the longest for 7 years. Security deposits, such as the exchange of cash or property, are common in CRDAs, with each appearing in about one-third of the contracts. Benefit share ratios are present in more than half the CRDAs in the sample. In sum, these provisions suggest a contractual relationship with more enforcement potential than a typical outsourcing agreement. At the same time, the commitments are short of the hierarchy that would occur given a merger between the two organizations.

3. Cross-sectional variation of CRDAs

3.1. Theoretical development

The differing purposes of CRDAs may influence the contract design and drive cross-sectional variations across the sample. Klein et al. (1978) and Williamson

(1979; 1983a) argue that when an exchange involves more significant investments in relationship-specific capital, quasi-rents are created. Repeated bargaining is unattractive due to the threat of “hold up” or opportunism. Joskow (1987) and Crocker and Masten (1988) find that the size of these quasi-rents affects the length of agreements in the context of tangible inputs. Oxley (1997) finds more hierarchy in organizations combining R&D with other functions. Pisano (1989) suggests that collaborations where there is joint R&D and production involve greater transactional complications than R&D-only joint ventures. As joint equity ownership is not a viable option in our study, as in the sample of Pisano (1989), the CRDAs themselves must reflect the increased risks of expropriation attendant with the agreements that envision a joint product. CRDAs that contemplate a joint product should thus be longer than those with the information-sharing purposes.

Contract design extends beyond contract duration. Our data set includes four different enforcement provisions, including length, share ratio, and up front exchanges of cash or property. These enforcement mechanisms should be more prevalent when the risks of ex post expropriation are higher. In sum, to balance the increased potential benefits of agreements where a specialized joint product is envisioned, there must be larger contracting costs. Similar to Gompers and Lerner (1996), these costs may take the form of the number of specific enforcement provisions in the aggregate.

3.2. An empirical examination of CRDA purposes and contract design

Table 3 shows that CRDAs that envision a joint product tend to be longer in duration than those that involve only information sharing. The average length of agreements with the information-sharing purpose is 24.83 months, which is significantly less than that for joint product CRDAs as a whole (38.17 months).

Table 3

Duration of agreements

This table shows the average duration (in months) for the CRDAs with various articulated purposes. Develop joint product includes all of the R&D plus patent, R&D plus production, and the five CRDAs that have both of the R&D plus purposes. *N* is the number of agreements with each purpose. *P*-values are based on a two-tailed *t*-test for difference in means.

Purpose (<i>N</i>)	Mean duration of contract (months)	<i>P</i> -value for difference
1. Information sharing (65)	24.83	vs. 2 (0.00) vs. 3 (0.00) vs. 4 (0.03)
2. Develop joint product (42)	38.17	vs. 1 (0.00)
3. R&D plus patent (13)	47.69	vs. 1 (0.00)
4. R&D plus production (24)	35.21	vs. 1 (0.03)

Information sharing CRDAs are also significantly shorter than either of the subclasses of the joint product CRDAs, namely those with R&D plus production or R&D plus patent purposes (35.21 and 47.69 months, respectively).

Chan et al. (1997) observe that the average length of alliances/joint ventures in recent research is about 5–7 years. CRDAs with joint product motives average nearly 4 years in length, but other CRDAs tend to be noticeably shorter than these corporate alliances in duration. This comparison is especially apparent with regard to CRDAs with information sharing motives. Their average length is just over 2 years.

Table 3 findings are consistent with the theoretical arguments of Klein et al. (1978) and Williamson (1979; 1983a) relating to the design of contracts to address opportunistic behavior. In this case, CRDAs with joint product purposes involve more transaction specific investments and subject the parties to added hold-up risk. The findings are also in line with earlier empirical work by Joskow (1987) and Crocker and Masten (1988) on tangible products. In these cases, where sellers had made technological production choices aimed at serving particular customers' needs, their supply contracts tended to be longer in duration. In the less tangible input case of R&D, the analogy is similar. The commitment of mutual investment to develop a joint product is potentially of large benefit, but the agreement subjects the contract partners to large hold-up risks. Such risks are lower when the parties have merely agreed to share information with no defined product goal. Consistent with the changing purposes, CRDA length reflects the tradeoffs in ex ante costs and ex post risks that are considerations in contract design.

Besides being longer, joint product CRDAs tend to have more enforcement mechanisms in the aggregate than information sharing CRDAs. Table 4 shows that the average number of enforcement provisions in joint product CRDAs (2.24) is higher than that for those envisioning only information sharing (1.58). The R&D

Table 4

Number of enforcement provisions

This table shows the average number of enforcement provisions (including the up-front exchange of cash or property, whether the agreement is longer than 1 year, and whether there is a specified share ratio for benefits) for the CRDAs with various articulated purposes. *N* is the number of agreements with each purpose. *P*-values are based on a two-tailed *t*-test for difference in means.

Purpose (<i>N</i>)	Mean number of enforcement provisions	<i>P</i> -value for difference
1. Information sharing (65)	1.58	vs. 2 (0.00) vs. 3 (0.01) vs. 4 (0.00)
2. Develop joint product (42)	2.24	vs. 1 (0.00)
3. R&D plus patent (13)	2.29	vs. 1 (0.01)
4. R&D plus production (24)	2.08	vs. 1 (0.00)

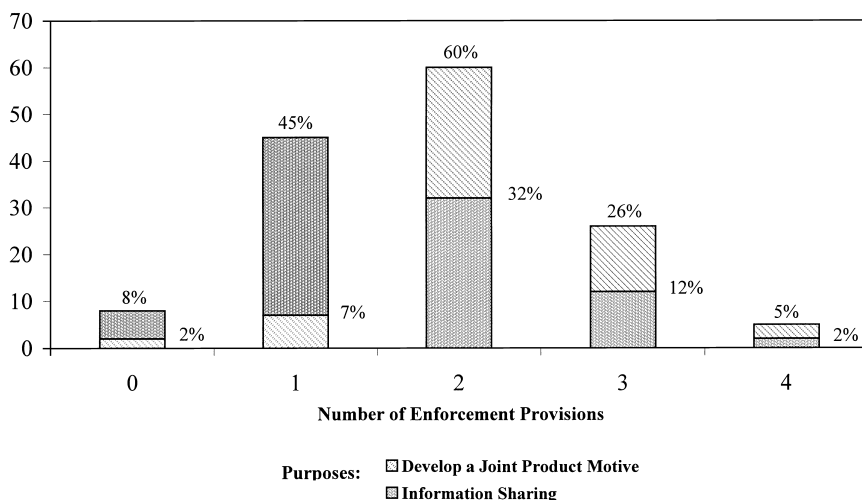


Fig. 1. Distribution of enforcement provisions. This figure illustrates percentages of CRDAs with information sharing or joint-product purposes that have the total number of enforcement provisions shown. Enforcement provisions include (1) CRDA longer than 1 year, (2) defined share ratio for benefits, (3) up-front exchange of cash and (4) up-front exchange of property.

plus production and R&D plus patent agreements also individually have a significantly higher average number of enforcement provisions than the information sharing agreements.⁵

Fig. 1 illustrates the percentages of agreements with the information sharing and joint product development purposes over the range of the possible number of enforcement provisions. Consistent with the results in Table 4, Fig. 1 shows that joint product CRDAs tend to have more enforcement provisions than their information sharing counterparts. Crocker and Reynolds (1993) argue that more complete contracting reduces flexibility and is costly, but may be necessary to offset the greater risks of opportunistic behavior in tangible input contracts. Similar arguments appear to apply to the case of less tangible inputs such as R&D. More complete agreements are likely as the potential benefits of the

⁵ As shown, the total number of enforcement provisions includes the duration dummy, which takes value one if the CRDA is longer than 12 months. This could obscure the impact of the other enforcement provisions. But removing duration entirely from the computation does not change the result that there are a significantly higher total number of enforcement provisions in the joint product CRDAs. The result is also robust to changes in the definition of the duration and security deposit variables. For example, the findings remain if the duration dummy has value one if the CRDA is greater than the median for the sample. The findings are also robust to the aggregation of the "property" and "cash" variables into one security deposit variable that takes value one if either (or both) transfers occur.

agreement (as well as the risks) reflect the motivation of joint product development as opposed to information sharing.

Table 5 compares the breakdown of enforcement provisions across the various purposes. This table highlights some of the differences in the subclasses of the joint product development CRDAs. For example, over three-fourths of R&D plus patent CRDAs involve up-front cash payments, but less than one-fourth have defined share ratios for benefits. In contrast, nearly 80% of R&D plus production CRDAs have defined share provisions. While both R&D plus patent and R&D plus production CRDAs envision a joint product, the production CRDAs may be more oriented to revenue creation than their patent counterparts. Share provisions

Table 5

Comparison of enforcement provisions

This table shows the percentages of CRDAs that have the enforcement provisions indicated. The table compares CRDAs with information sharing purposes with those that envision the development of a joint product. There are 65 information-sharing agreements. Panel A compares those 65 with the 42 joint product agreements. Panels B and C show the results when the joint product agreements are divided into two subclasses, those that envision R&D plus patent, and those that envision R&D plus production. Panels B and C, respectively, compare the 65 information-sharing CRDAs with the 13 that have patent, and the 24 that have production purposes. The *Cash* and *Property* variables indicate whether a cash payment or property exchange has occurred at the beginning of the CRDA. *Long 12* is whether the agreement is longer than 12 months in duration. *Share* is whether there is a specified share ratio for benefits in the agreement. *P*-values are given for the difference in proportions.

CRDA purpose			
Panel A			
Enforcement provision	Information sharing (%)	Develop joint product (%)	<i>P</i> -value
Cash	29.2	42.9	0.17
Property	24.6	31.0	0.52
Long 12	53.8	85.7	0.00
Share	50.8	64.3	0.17
Panel B			
Enforcement provision	Information sharing (%)	R&D plus patent (%)	<i>P</i> -value
Cash	29.2	76.9	0.00
Property	24.6	15.4	0.55
Long 12	53.8	92.3	0.01
Share	50.8	23.1	0.07
Panel C			
Enforcement provision	Information sharing (%)	R&D plus production (%)	<i>P</i> -value
Cash	29.2	25.0	0.73
Property	24.6	41.7	0.15
Long 12	53.8	83.3	0.01
Share	50.8	79.2	0.02

allow the up-front allocation of benefits. While negotiating this provision *ex ante* has some risks, the parties to production-oriented CRDAs appear to believe that the benefits of having a specified share provision outweigh the risks that the provision may turn out to be disadvantageous.

The parties do have the alternative of negotiating contractual enforcement terms, such as the share provisions, *ex post*. This raises the issue of whether negotiating these terms when they are not pre-specified is less costly than renegotiating established provisions.⁶ One argument favoring *ex ante* provisions is that they provide the parties with defined levels of bargaining power in renegotiations. Absent some assurance of the level of future benefits, the parties may limit their inputs or choose not to enter the venture at all. Hart and Moore (1990) argue that parties to an agreement may under-invest if they perceive that the benefits from their investment will be “dissipated in future bargaining.”⁷

Hart (1989) argues that the residual rights of control impact the *ex post* bargaining power of contracting parties and the division of surplus. Grossman and Hart (1986) define ownership as the “purchase of the residual rights of control.”⁸ Since equity participation in CRDAs is not possible, the parties cannot rely on this control mechanism. As such, they must rely on a contractual statement of rights and obligations. This factor favors the *ex ante* negotiation of provisions.

In sum, the results show a clear connection between the purposes of CRDAs and their enforcement mechanisms. As CRDAs span the purposes from information sharing to joint product development, the potential benefits of the CRDA increase, but the contracting costs associated with the agreement appear to be rising as well.

4. The effect of the parties' prior dealings and reputation on contract design

4.1. Theoretical development

Williamson (1983b) argues that the existence of mutual hostages from prior contracts reduces the need for future hostages. Similarly, Williamson (1993) suggests that extensive prior dealings allow the parties to rely on reasonable behavior in the future, permitting them to take calculated risks in new contracts. Klein (1980) argues that the major enforcement mechanism placed on parties who expect future business is the implicit threat to their reputation as opposed to explicit contractual restraints. In the case of franchising, where the contract

⁶ We thank the referee for raising this issue, and contributing significantly to its discussion.

⁷ See Hart and Moore (1990, p. 1151). Interestingly, Section 4 shows that the parties are willing to enter a more incomplete agreement when they have other business dealings.

⁸ See Grossman and Hart (1986, p. 716).

relationship between the franchiser and franchisee may be an isolated one, Klein (1980) and Hadfield (1990) observe that explicit contractual supports are needed. In sum, this research suggests that reputation mechanisms interact with explicit contracting.

For the purposes of our study, we cannot determine whether reputation effects are due to mutual trust from past relationships or the threat of punishment in future contracts. We do not have specific data on contract histories, so these two explanations are observationally equivalent. Given this confounding, we bundle these two explanations as a reputation argument.

Despite the longstanding theoretical predictions, empirical tests of how reputation and explicit contracting mechanisms interact are rare. Parkhe (1993) finds some empirical evidence of reduced contractual safeguards in a survey of partners in repeat alliance agreements. But Parkhe (1993) and Chan et al. (1997) agree that measuring the effectiveness of various enforcement provisions while considering reputation effects is difficult.

In the context of CRDAs, reputation considerations could impact contract design by reducing the number of enforcement provisions in the aggregate or in one of the enforcement classes. Klein et al. (1978) and Williamson (1979; 1983a) argue that increases in contract duration deter hold-up. Reputation could act to reduce contract length because there would be less need to deter hold-up in the context of the current agreement. Alchian and Woodward (1988) and Parkhe (1993) suggest that transfer of assets up-front acts as a security deposit and reduces the opportunity for opportunism. Reputation could reduce the need for these security deposits. Arrow (1974) and Pisano (1989) argue that the value of the commodity being exchanged in joint R&D agreements is difficult to assess. Explicit provisions dictating the allocation of benefits are critical to reduce the concerns for opportunism when values become more certain. Reputation could thus reduce the need for explicit sharing provisions.

4.2. Empirical examination of prior dealings and reputation on contract design

Table 6 divides the sample into two groups of government CRDA partners. The “ongoing partners” are the large defense contractors while the “isolated partners” are the small defense contractors and the non-profit organizations. This classification proxies for the existence of an extensive ongoing business relationship outside of the CRDA.⁹ These descriptive findings show that there are no significant differences between groups in terms of the percentages of agreements with information sharing and joint product development purposes. These results suggest that the lack of prior dealings does not seriously deter the parties’ ability to enter

⁹ To the extent that our classification proxies are measured with error, we are less likely to find any meaningful differences in our reputation categories.

Table 6

Agreements and reputation

This table shows the percentages of CRDAs that have the specified provisions. The basis of comparison is whether the CRDA is between partners that have an extensive, and ongoing business relationship (the ongoing partners) or between partners that have no prior business dealings (the isolated partners). Ongoing partners are top 10 defense contractors as of 1995. Isolated partners are small, for-profit contractors and other not-for-profit entities. There are a total of 34 agreements between ongoing business partners and 73 agreements between isolated partners. The table provides *P*-values for tests of significant differences between the proportions of agreements having the particular provision.

Provision	Ongoing partners (%)	Isolated partners (%)	<i>P</i> -value
<i>Purpose of agreement</i>			
Information sharing	67.6	57.5	0.33
Develop joint product	32.4	42.5	0.33
R&D plus patent	11.8	12.3	0.96
R&D plus production	20.6	23.3	0.79
<i>Basis of bargain</i>			
Individual expertise	23.5	47.9	0.02
Tangible assets (facility)	29.4	47.9	0.07
Intangible assets (data)	61.8	32.9	0.01
<i>Methods of enforcement</i>			
Up-front exchange of cash	29.4	37.0	0.47
Up-front exchange of property	32.4	24.7	0.46
Agreement longer than 1 year	67.6	65.8	0.86
Specified share ratio for benefits	35.3	65.8	0.00

into CRDAs with joint product purposes. The issue of whether the contract design of these CRDAs differs across these groups remains to be addressed.

Table 6 clearly shows that the ongoing partners group tends to share intangible resources with the government agency, while the isolated partners group shares individual expertise or tangibles. This is an intuitive result. Small for-profit contractors or non-profit partners are likely to be capital constrained. They would likely benefit from the access to the government agencies' technical personnel or tangible assets. This isolated partners group cannot afford the large-scale acquisition of equipment/property or the full-time hiring of expensive technical personnel. The government agencies, on the other hand, may have idle personnel or capacity due to the shrinking demand for their traditional defense-related services and product. This CRDA sharing allows them to better use existing capacity. In sum, the patterns of resource sharing are consistent with findings by Chan et al. (1997) that joint R&D activities are value enhancing.

The government's ongoing partners, on the other hand, are large defense contractors with massive tangible infrastructure and large numbers of technical personnel. Despite the fact that both these contractors and the federal government

agencies are very large, proprietary data or software could be very time consuming or expensive to internally develop or buy. The advantage of the CRDA is the timely and relatively low-cost access to proprietary intangibles. At the same time, the sharing of intangibles such as data or software could present the greatest opportunity for expropriation. It is unlikely for example, that the CRDA partner could successfully steal and use the government's facility or personnel. But the benefits from sensitive data or software are more easily expropriated. What may allow this exchange is the ongoing business relationship of the parties to the CRDA. Although we cannot determine if the exchange of intangibles is based on trust or enforced by fear of retaliation, both of these explanations are consistent with a reputation effect.

Table 6 also shows the patterns of enforcement provisions in the ongoing vs. isolated partners' CRDAs. There are no significant differences in the tendency to have up-front exchanges of cash or property. Nor are there differences in the proportions of contracts longer than 1 year. But CRDAs between isolated partners have nearly twice the proportion (65.8% vs. 35.3%) of specific share provisions as CRDAs between ongoing partners. This difference is statistically significant. This result suggests that there could be differences in explicit contractual enforcement based on the relationship of the parties.

Table 6 does not allow the direct assessment of the impact of an ongoing business relationship on contractual enforcement because it does not control for other variables, such as CRDA purpose. To make this assessment, Table 7 provides logistic regressions that examine whether there are interactions between explicit contract restrictions and implicit enforcement mechanisms based on reputation. The dependent variable in the regressions is a proxy for contractual enforcement. We use two dependent variables. In regressions (1) through (3), the dependent variable is a dummy that takes value one if the total number of enforcement provisions in the CRDA is two or more. In regressions (4) through (6), the dependent variable is a dummy that takes value one if the CRDA has a defined share provision.¹⁰ The independent variables include the reputation dummy, as well as dummy variables for contract motive, whether the party is for-profit, and the types of asset sharing.¹¹ Regressions (1) and (4) use the joint product purpose characterization of motive. To check whether the results are sensitive to the characterization of the product motive, regressions (2) and (5) use the R&D plus patent definition, and (3) and (6) use the R&D plus production definition.

¹⁰ Regressions using the existence of other enforcement provisions (besides the defined share ratio) as dependent variables gave insignificant results so they are not shown.

¹¹ We include a dummy indicating the for-profit status of the government's CRDA partner. This is due to the increased likelihood of the use of share provisions if the partner has this status.

Table 7

Logistic regression of enforcement provisions

This table shows regressions using two dependent dummy variables. Panel A has a dependent dummy variable for the number of enforcement provisions in the CRDA. If the number of enforcement provisions is one or less, the dummy has value zero. The dummy has value one otherwise. Panel B has a dependent dummy variable that takes value one if the CRDA has a specified share ratio for benefits. These contract enforcement dummies are upon other contract dummy variables. The joint product purpose dummy takes value one if the purpose is the creation of joint product (in regressions 1 and 4), or R&D plus patent (in regressions 2 and 5), or R&D plus production (in regressions 3 and 6). Other independent variables include the reputation dummy, which takes value one if the parties have an ongoing business relationship. These ongoing partners are the top 10 defense contractors as of the end of 1995. There is also a dummy if the CRDA partner is a for-profit enterprise. Lastly, there are dummy variables representing the three classes of possible asset sharing that form the basis for the CRDA. *P*-values are given in parentheses.

Regression	Independent dummy variables						Constant	Adjusted R^2 (P -value)
	Joint product purpose	Ongoing business relation	For-profit CRDA partner	Intangible resource sharing	Tangible resource sharing	Individual resource sharing		
<i>Panel A: Dependent variable is the dummy for number of enforcement provisions</i>								
(1)	2.54 (0.00)	−1.32 (0.03)	−0.44 (0.51)	−0.37 (0.49)	−0.47 (0.39)	−1.61 (0.01)	1.974 (0.03)	0.27 (0.00)
(2)	2.33 (0.03)	−0.96 (0.09)	−0.56 (0.38)	−0.37 (0.46)	−0.15 (0.75)	−1.17 (0.03)	1.86 (0.01)	0.17 (0.00)
(3)	2.20 (0.00)	−1.25 (0.04)	−0.35 (0.57)	−0.36 (0.48)	−0.25 (0.63)	−1.54 (0.01)	1.81 (0.01)	0.21 (0.00)
<i>Panel B: Dependent variable is a dummy for the existence of a specified share ratio for benefits</i>								
(4)	0.56 (0.19)	−1.49 (0.01)	0.39 (0.47)	0.50 (0.29)		0.16 (0.72)	0.14 (0.76)	−0.09 (0.88)
(5)	−0.76 (0.17)	−1.56 (0.00)	0.29 (0.58)	0.40 (0.40)	0.17 (0.71)		0.00 (0.99)	0.44 (0.44)
(6)	1.77 (0.00)	−1.53 (0.01)	0.32 (0.56)	0.56 (0.25)	0.17 (0.72)	−0.03 (0.95)	−0.19 (0.75)	0.18 (0.00)

The reputation dummy variable is the existence of an ongoing business relationship that takes value one if the government partner is the large defense contractor. If implicit enforcement mechanisms such as reputation are a substitute for explicit contractual restrictions, then CRDAs with these partners would be less complete after controlling for motive, for-profit status, and types of asset sharing. Therefore, this coefficient should be negative.

The results in Table 7 show a significant negative relationship between the reputation dummy and the dependent variables that proxy for the level of contractual enforcement.¹² In line with the expectations from Table 6, it seems likely that the results are driven by the existence (or absence) of a specified share ratio for benefits. To confirm this, we estimate similar regressions using the individual provisions (other than share ratio) as dependent variables. These regressions were insignificant.

While this reputation finding appears to be largely based on the existence or absence of a specified share ratio, it is still consistent with prior research on the relationship of implicit and explicit contracting. When the parties have had extensive prior dealings and anticipate future business outside of the CRDA, they are more willing to take the calculated risk that they can agree on an appropriate sharing of benefits in the future. Our data does not permit us to distinguish among the explanations for this “reputation effect.” The parties may believe that their other contract relationships would be harmed if they attempted to expropriate their advantage in the CRDA, in line with the existing mutual hostage explanation offered by Williamson (1983b). Our findings are also consistent with the empirical work of Gulati (1995), who finds that repeated alliances between two partners are less likely than other alliances to use joint-equity as an enforcement mechanism. Gulati (1995) argues that the result is due to increased levels of trust between the parties.

This finding linking explicit and implicit contracting is interesting in terms of its implications for long-term contractual relationships. Benefits from most joint product CRDAs would begin at a minimum of about 3 years from contract inception and potentially last for many years thereafter. Articulating defined share allocations up front is risky for both parties since current assessments of value and relative investment may change in the future. Crocker and Reynolds (1993) argue that contract incompleteness may be efficient under circumstances where there is a great deal of uncertainty. But Taylor (1993) observes that the risks of expropriation are high in R&D type contracts due to difficult value assessments and large monitoring costs. Telser (1980) discusses the notion of a self-enforcing agreement, which may have relevance in the context of a CRDA. Enforcement is possible

¹² As an additional check on the results, we removed all of the not-for-profit organizations from the sample. This obviates the need for the “for-profit” control variable. The reputation results are virtually identical to those shown in Table 7.

because it may be more costly for one party to expropriate advantage on the CRDA because of the retaliation by the other party in another contract. The implication is that incomplete contracting may be more beneficial for parties that have and expect to continue other business relationships.

4.3. Comparisons between CRDAs and franchise agreements

We observe that isolated CRDA partners enter more complete contracts to protect their future interests. They do not have the ongoing business relationship that supports incomplete CRDA contracting. These findings on joint R&D agreements have parallels to other contexts such as franchising, where franchisees may often be isolated partners. Hadfield (1990) argues that franchisees have been victims of incomplete contracts.

At the same time, government agencies may also want specific provisions in the contracts with isolated partners because isolated partners are less influenced by reputation considerations. An isolated partner could shirk on the agreement and have no concern for the impact of the expropriation on other business dealings.

This discussion suggests that either party could prefer a more complete contract. Since a contract exists, the parties have obviously reached “agreement.” But what if one party accepts the presence or lack of terms only at the insistence of the other? The typical instance may be where the government entity is dealing with a small private contractor. This point raises the issue of bargaining power.

The theorem of Coase (1960) is a useful place to begin a discussion of bargaining power in CRDAs. This theorem suggests that the parties have an incentive to negotiate an efficient agreement, even if they have unequal bargaining power. But transaction cost considerations, such as those associated with the actual negotiation and enforcement of the agreement, may undermine this equilibrium and permit inefficient contracting. To the extent that small contractors face higher transactions costs than their larger government counterparts, CRDAs could be “unfair” to these smaller parties.

CRDAs do resemble franchise agreements because of this potential one-sidedness. But even if CRDAs are a bad bargain for the smaller party, Rubin (1978) argues in the franchise context that no party is forced into becoming a franchisee. Consistent with this view, there is no evidence that smaller parties are forced to enter CRDAs. Klein (1980) suggests that reputation constrains the “stronger” party in franchising since future partners may be reluctant to enter in agreements if the prior contracts had been too one-sided. In the CRDA context, “abusive” agreements may well become very public information given the high-profile government agencies involved.

The issue of substitutes is also interesting in comparing franchise agreements and CRDAs. To the extent that there is a market for the franchiser’s product or service, the franchisee may choose to contract elsewhere. This reduces franchisers’ bargaining power. While some of the government resources in CRDAs are surely

unique, there may be potential for the small parties to find substitute contracting parties if the government entity drives too hard a bargain. In fact, many of the potential substitutes may be other government agencies, such as a competing laboratory. The reality of CRDAs is that smaller parties can bring resources with few low-cost substitutes to the agreement. One particular example is marketing or distribution expertise for technical products. If finding a substitute is costly to the government entity, the agreements may reflect the relatively even balance of inputs that the parties bring to the proposed joint effort.

5. Caveats

While the results presented in Sections 3 and 4 are consistent with contracting theory, they are also open to another more basic interpretation. The empirical regularities may simply reflect the nature of the joint investment that the parties are making. Our data and methods do not allow us to dismiss this possibility, and some discussion of this alternative view is appropriate.

Section 3 shows that CRDAs with joint product purposes tend to be longer and have more enforcement provisions. But an exchange of information should not take as long as joint product planning, in most cases. Moreover, since an exchange of information does not consider a specific product, provisions such as a specified share ratio are not needed. There is also less of a reason to share property. Under this reasoning, the empirical regularities in Section 3 are a mere reflection of the investment being made, and not necessarily a result of “hold up” considerations. This confounding is important to recognize as a limitation of our study.

Section 4 demonstrates that agreements between ongoing partners are less complete than agreements between isolated partners. This could simply reflect the administrative realities of contracting with a new partner. If the parties have had no prior contracts, then they are more likely to want detailed provisions to guide the new relationship. This could be thought of as “contracting start up costs.” Our results show that agreements between ongoing partners are less complete. This could be due to a reduction of “contracting start up costs,” or to reputation effects. We cannot distinguish between these two explanations.

The other major caveat involves the public-sector nature of the sample. Despite our assumptions and arguments about the changing incentives in the public sector, the government agencies in the sample may not negotiate with value maximization as a goal. As such, any attempts to extend these results to a corporate context should be done with caution.

6. Summary and conclusions

Empirical studies of the network organizations formed by joint R&D agreements are rare, largely because these contracts are often proprietary. We examine a

sample of 107 CRDAs between federal government and other for-profit and not-for-profit entities. We find that CRDAs support a range of purposes, from information sharing to committed attempts to produce a joint product. CRDAs also offer a means for organizations to share a variety of resources, including individual expertise, and access to facilities or intangibles such as data or software.

CRDAs with joint product purposes tend to be longer in duration, and have more enforcement mechanisms than information sharing CRDAs. One straightforward explanation is that these relationships simply reflect the nature of the joint investment. Sharing information should involve less time and interaction than planning for a joint product. But the empirical regularities in CRDAs also reflect a cost–benefit tradeoff, as greater contractual enforcement costs offset the potentially more rewarding outcomes. The results suggest that the “hold up” theories developed and tested in the context of tangible inputs such as raw materials also have application in the context of intangible inputs such as R&D.

We also find that when the parties have extensive business dealings outside of the CRDA, the CRDA contract itself is less complete. This could be due to the administrative contracting realities. Strangers in contracting should have a need for more complete agreements. But these empirical regularities are also consistent with an interaction between explicit and implicit contracting. In particular, we find that the CRDAs between ongoing partners tend to leave the sharing of future benefits unspecified, as opposed to specifying the division explicitly *ex ante*. One explanation is that reasonable behavior in *ex post* CRDA division of benefits is enforced by the threats to the mutual hostages in other agreements between the parties. An alternative interpretation is that prior dealings and trust allow the parties to take more calculated risks in the current agreement. Our data does not allow us to disentangle trust from threat explanations. We thus bundle them together as a reputation effect.

From the analysis of relationships among CRDAs’ purposes, the nature of shared assets, and enforcement mechanisms, we can directly assess the costs and benefits associated with contracting for intangible inputs. Since the government agencies in our sample cannot use equity participation as a means of control, they are “forced” into contracting. CRDAs offer the empirical advantage of high standardization that permits them to be consistently scored. From this empirical basis, this paper provides a foundation for contractual analyses of more stylized corporate R&D agreements. Generalizing our results to a corporate context, however, must be done with caution since the governmental entities may not be acting to maximize value in a corporate sense.

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