Fighting Fires Together: Essays on Alliances Among Fire Departments

by

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Abstract

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Organizations enter into strategic alliances for economic value that cannot be achieved by working alone. Despite the potential benefits many alliances fail to meet their goals, destroy value, and end in termination. Success within alliances is neither automatic nor assured. The ways that organizations arrange their alliances to contend with impediments to success is of great practical and theoretical importance. This thesis studies how formal and informal arrangements arise over time and influence the performance of U.S. fire departments.

The first study empirically describes how formal contracting influences performance of the alliance and its members. I analyze a sample of responses by US fire departments to fires over 11 years, and I describe how contracting affects four dimensions of performance: arrival minutes, resolution minutes, property damage, and casualties. I find (i) the effect of contracts varies across qualitatively different outcomes, (ii) that contracts deliver separate costs and benefits at the level of the alliance and the organization, and (iii) that estimates are sensitive to matching on pre-contracting covariates including social context.

The second study examines the role played by social context in contracting. Looking at the hazard of contracting between pairs of alliance partners I examine the effects of increased embeddedness in (i) focal relationships and in (ii) networks of outside relationships. I find that qualitative differences in prior interactions partly explain the decision

to formally contract. I find that differences in arrangements with other partners affect formal contracting both directly and indirectly through interpretations of dyadic history. These findings suggest that models of relational mechanisms that accumulate within a relationship work both in parallel and interactively with broader social networks.

The third study investigates how the design of alliances affects the performance of their members. I distinguish between (i) the extent to which departments rely on their own resources versus those of their alliance partners, (ii) the formality of arrangements, and (iii) performance in terms of property damage and casualties. I find that formal contracts are needed to improve some aspects of performance while informal arrangements are sufficient for others. This finding suggests a nuanced relationship among alliance structures and outcomes.

Dedication

For my grandmothers Selmy and Georgina, my sister Tina, my parents Robert and Yalta, and my wife Melissa.

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Chapter 1

Introduction

Although strategic management research has historically focused on competitive dynamics among firms, the last two decades has seen a shift towards greater emphasis on cooperative behaviors among organizations. Organizations engage in a wide variety of cooperative business dealings with other organizations. Some of these dealings occur within the context of more lasting and consequential relationships than others. For instance, important among these relationships are *strategic alliances* to exchange, share, or co-develop resources and capabilities with other organizations as a way to achieve common goals. Correspondingly, there is a growing body of research on strategic alliances among business and other organizations that evaluates entry into these partnerships, the differences among them, and their implications for performance. Examining these issues continues to challenge scholars of organizations, however.

Strategic alliances are diverse in structure and purpose so it is difficult to establish consistent performance criteria. Many alliances operate informally so it is difficult to observe their beginnings and often their existence. The activities that occur within the scope of an alliance are sometimes interdependent with activities of the member organizations so it is difficult to separate relevant routines, resources, and levels of effects. Furthermore, it is difficult to come by objective performance data. Notwithstanding these difficulties there is by now a large literature with a surprising variety of explanations about the causes and consequences of strategic alliances.

This dissertation examines the causes and consequences of an important consideration in strategic alliances: the use of formal versus informal arrangements. I pose three main questions which are addressed by each of the three studies that make up this dissertation. First, when are formal contracts good for performance? Second, what causes alliance partners to formalize relations given the availability of relational mechanisms? Third, how does formalizing alliances with written contracts affect the performance of their members under conditions of uncertain demand?

All three studies analyze U.S. fire departments in the period between 1999 and 2009. Together they progress through three levels of analysis: (i) the individual fire response (akin to a project or instance of production), (ii) the dyad consisting of alliance partners, and (iii) the organization. I focus on U.S. fire departments for the following reasons. First, it is an empirical setting where alliances are widespread and involve comparable goals and activities. Second, it is a setting with objective measures of performance that are consistent across both organizations and alliances—property damage, casualties, and response timing. Third, it is a setting in which it is possible to observe almost the entire diffusion of a new managerial practice for governing how organizations work together—formal written contracts. Fourth, it is a setting in which organizations have strong nominal interests in collaborating effectively yet struggle to do so because it is difficult to infer unobserved partner performance and to combine activities—a fertile setting to analyze the contracting behavior and outcomes of organizations in alliances.

My first study (Chapter 2), entitled *Alliance Contracts and Fire Response Performance*, describes stylized empirical regularities in the linkages between formal contracts among fire departments and performance at the level of the fire. Using a sample of 493,490 fires and measures of four aspects of performance I am able to distinguish effects that stem from coordination benefits and cooperation benefits of alliance contracts. Using data on cooperative versus in-house instances of production I am able to distinguish effects at the level of the alliance and the member organization. I find that alliance contracts tend to improve performance when measured by casualties, to worsen performance when measured by resolution minutes, and to have no significant effect on performance when measured by arrival minutes and property damage. The study offers two main contributions. First, it provides new empirical findings on when contracts improve the performance of the alliance and the organization adding to a growing literature on this topic. Insofar as formal alliances influence different aspects of performance in different ways researchers that unpack aspects of performance can form a more complete understanding of the individual pathways through which contracts add value. Second, it provides evidence that contracting effects may be loosely-coupled between the level of the alliance and the level of the member organizations. If formal alliances generate separate costs and benefits at the level alliance and the level of the participating organizations it is important for researchers to distinguish between these contributions at the same time.

My second study (Chapter 3), entitled *Formal Contracts: Partner History and Networks*, examines the effect on the hazard of formally contracting of qualitative differences in the (i) inside history of interactions, and (ii) outside network of arrangements for a pair of allied fire departments in a sample of 60,666 dyads in 256,296 dyad-years. I distinguish among the extent to which prior exchange between partners is lopsided and successful as well as the extent to which dyad partners have overlapping partnerships with and obligations to other partners. To address endogenous selection into formal alliances from unobserved heterogeneity in the propensity to formally ally I create two matched samples on which to perform the analysis: (i) dyads that interact at least once in the eleven year observation window, and (ii) dyads based on geographic proximity. I find that substantive differences in prior interactions partly explain the decision to formally contract. I also find that differences in arrangements with other partners affect formal contracting both directly and through interpretations of history. This suggests that models of relational mechanisms that accumulate within a relationship work both in parallel and interactively with broader network configurations. These findings imply that researchers must account for both the way in which alliances unfold over time and the broader social context in which an alliance is embedded to fully understand selection into formal contracts and their consequences.

My third study (Chapter 4), entitled *Coordination & Performance Trade-offs Under Uncertainty*, examines the impact of alliances on the performance of a sample of 29,714 U.S fire department-years. I distinguish among the arrangement of alliances in terms of (i) the source of resources, (ii) the formality of governance structures, and (iii) the realization of spiky demand. To overcome endogenous selection into cooperative exchange and formal contracts I use a combination of fixed effect and instrumental variables regression. I examine the change in fire department performance in a particular year from an increase in the frequency of resources received from partners and use of formal contracts that is caused by exogenous shifts in the cost and benefits of the alternatives. First, I find that the intensity of resource exchange with partners improves organization performance by loosening trade-offs associated with internal resource allocation problems but at the expense of reduced control. These results imply that the study of internal resource allocations is incomplete without also considering the resources available through partners. Second, I find that layering formal contracts onto existing alliances influences performance in a nuanced manner. Formal contracts ensure consummate performance when property damage (not casualties) is the salient outcome; however, conditional on high uncertainty formal arrangements improve coordination when the number of casualties is the salient outcome. Thus the study of formal alliances is incomplete unless the mechanisms linking contracts with different aspects of performance are considered together.

These three essays endeavor to extend our thinking about the contribution of alliances to differences in performance among organizations. Collectively these papers advance our understanding of how networks of alliances channel material resources to organizations, the ways in which formal arrangements shape the flow of these resources, and the role played by the social context in which alliance members operate.

Chapter 2

Alliance Contracts and Fire Response Performance

2.1 Introduction

Organizations enter into strategic alliances to pursue economic value that cannot be achieved by working alone (Gulati and Singh 1998, McEvily and Zaheer 1999, Gulati 1999, Agarwal, Croson, and Mahoney 2010).[1] Despite the potential benefits many strategic alliances fail to meet their goals, sometimes destroy shareholder value, and often end in termination (Kale and Singh 2009, for an overview). Success within alliances is neither automatic nor assured. Consequently, the governance of alliances is the subject of a large body of research from scholars studying organizations.

Strategic alliances involve mixed motivations and an inherent tension between cooperation and competition that can impede successful outcomes. Chief among these impediments are threats of exploitation by opportunistic partners (Khanna, Gulati, and Nohria 1998) and difficulties coordinating expectations and actions by well-meaning part-

[1] A strategic alliance is a relationship between separate organizations involving the "exchange, sharing, or codevelopment of resources or capabilities to achieve mutually relevant benefits" (Gulati 1995a) via asset pooling contracts or exchange agreements.

ners (Gulati, Lawrence, and Puranam 2005). Accordingly, a variety of factors that influence the extent to which these impediments arise and are resolved have been linked with the success of alliances (Kale and Singh 2009, for an overview). While some of these factors are emergent and difficult to influence others are subject to direct and deliberate managerial intervention. One such intervention—the use of complex contracts to govern alliances—has been a recurring focus in this setting (Argyres, Bercovitz, and Mayer 2007, Reuer and Ariño 2007). Insofar as contracts coordinate collaboration among alliance partners, reduce conflict, and limit opportunism they add value to the activities they govern.

Understanding the factors that affect the performance of alliances holds an important place in the research agenda for scholars interested in strategic management, but it remains a challenging and debated area of inquiry (Gulati 1998, Zollo, Reuer, and Singh 2002). From a theoretical standpoint, alliances are arranged in diverse ways for diverse purposes. From an empirical standpoint, it is difficult to come by consistent and objective performance data. There are a variety of findings linking both informal and formal governance with performance. On the one hand, researchers have found that informal mechanisms such as experience (Hoang and Rothaermel 2005) and trust (Gulati and Nickerson 2008) improve the performance of the alliance and their organizations. On the other hand, there is also evidence that more hierarchical controls (Sampson 2007) and formal contracts (Poppo and Zenger 2002) also positively influence performance. Since informal mechanisms can arise in the presence of formal governance these modes are not mutually exclusive; however, the interaction between these governance modes remains an open question (Puranam and Vanneste 2009). Theory and evidence suggests they may be substitutes (Corts and Singh 2004) and/or complements (Ryall and Sampson 2009, Argyres, Bercovitz, and Mayer 2007)—complicating our understanding of how alliance formality contributes to performance.

Mechanically, formal contracts improve the coordination of activities and reduce the threat of opportunistic behavior among alliance partners. Contracts are limited to the details they specify but are incomplete and so do not cover all relevant contingencies. In contrast, informal arrangements are not limited to explicit details and so effect coordination and reduce opportunism through more diffuse understandings. As substitutes, formal contracts may reduce performance by crowding out or reducing the effectiveness of relational mechanisms such as trust and understanding (Puranam and Vanneste 2009). Crowding out can occur when alliance partners rely more heavily on the details of the contract than on the mechanisms developed from working repeatedly together such as mutual knowledge and shared norms. It can also occur through the process of contracting which may be construed by alliance members to signal the absence of trust or even mistrust (Macauley 1963). Formal and informal organization modes benefit alliances by different means, and though these means may substitute (or even conflict) with each other when they are used together they can be mutually reinforcing (Gulati and Nickerson 2008). As complements, formal contracts enhance performance in the presence of relational governance mechanisms that have emerged over time: covering contracting shortfalls and clarifying unspoken expectations (Poppo and Zenger 2002, Bercovitz, Jap, and Nickerson 2006). So there remain open questions about when formal arrangements will improve performance and when informal arrangements alone will improve performance.

The purpose of this paper is to contribute new empirical findings on formal contracting when organizations repeatedly interact, exploring in greater depth the effects on performance of the organization mode of alliances. Specifically, I examine the response to 493,490 fires—instances of production which can be thought of as discrete projects—in the municipal fire service industry to determine how contracts affect casualties, property damage, and response times. Three major findings emerge from analysis linking contracts with performance: (i) evidence that the effect of contracts varies across qualitatively different outcomes, (ii) evidence that contracts deliver separate costs and benefits at the level of the alliance and the level of the organization, (iii) evidence that the estimates are sensitive to matching observations on pre-contracting covariates including alliance history and social context.

These results have three main implications for research on alliances. First, our understanding of formal alliances will be incomplete if researchers fail to consider the how the individual elements of performance are affected at the same time. Contracts enhance alliances along several dimensions. The distinction among outcomes made in this study—consistent with the literature—is between (i) coordinating activities and (ii) encouraging partners to cooperate. In this sense, the pursuit of different outcomes is associated with different challenges: some involving greater coordination problems, others involving greater threats of opportunism. Therefore, while it is useful to understand the combined effects of contracts on aggregate performance researchers cannot fully understand the distinct pathways by which contracts benefit alliances without unpacking performance. Furthermore, interactively these differences will contribute to the selection process by which organizations enter into formal alliances. That is because organizations contract by anticipating performance improvements along some dimensions but not others. For instance, fire departments that experience slow arrival times or property damage outcomes on alliance fires will perceive the benefits of subsequently entering into a formal contract in a different manner than departments with a history of rapid collaborative responses or positive firefighter safety outcomes. This suggests that research must consider how qualitative differences in the history of interactions and their outcomes affect contracting choices. Without a finer understanding of the ways in which contracts benefit alliances researchers run the risk of overemphasizing the importance of some mechanisms, underemphasizing others, and conflating the effects of multiple mechanisms.

Second, the effects of contracts on the performance of the alliance may be decoupled from (and possibly conflict with) the effects on the performance of the member organizations. For instance, contracts may provide safeguards against threats posed by alliance activities to participants that impede success within the alliance. Therefore, researchers focusing only on one level of analysis may not account for important costs and benefits that arise at the other level of analysis. Without understanding the ways in which performance arises at both levels of analysis researchers may form a partial picture of the ways in which formal alliances influence performance.

Third, researchers must examine how alliances unfold over time—cross-sectional analysis obscures important conditioning details. In particular, chapter 3 and a growing body of research on alliances dynamics, demonstrates that the pre-history of informal interactions that occur before formally allying will influence how contracts are employed and affect performance. Therefore, researchers that construe the alliance to have begun with the formal contract might observe alliances that arise from very different processes. For instance, formal contracting may arise as a means of addressing realized failures in the working relationship. It may arise as a result of effective information sharing, well-developed understandings, and the trust. Failure to account for these differences can result in misleading inferences.

Following Ryall and Sampson (2009), I take an inductive approach and provide descriptive results that are relevant to our existing understanding of strategic alliances and their governance modes. Consequently, this study begins with empirical analysis and is followed by a discussion that relates the findings to the major ideas on alliances in management research. In this discussion I review the relevant literature and contrast it with the most interesting results from this study. The approach taken in this study contributes to existing empirical literature on several dimensions. This study unpacks performance into four constituent parts using objective measures. Unpacking performance in this way permits more comprehensive comparisons than traditionally available in studies of this kind. In this sense, this research adds to the stream of research analyzing on the specific ways in which alliances benefit performance (Baum, Calabrese, and Silverman 2000). This study also distinguishes between performance that accrues directly from activities of the alliance and performance that accrues indirectly to the organization. Most research in this areas examines performance at either the level of the alliance or the level of the organization. This study does both and demonstrates empirical regularities that may be used to advance theory development in the area.

2.2 Description of setting and contracts

U.S. fire departments are organized at the local level of government with service areas, authority, and budgets circumscribed by political boundaries. Because these organizations face unpredictable demand for their services and are constrained by their available resources proximate fire departments regularly work together to respond to incidents across these boundaries. These arrangements are known in the industry as mutual aid. The joint production of fire services by separate fire departments is a fertile environment for studying problems coordinating work and ensuring that parties deliver consummate performance. Fire departments do not use uniform routines, expectations, language, and technologies for fighting fires. These differences can make it difficult to combine the resources of allied departments effectively. Furthermore, many of the actions taken by partnered fire departments are not readily observable, and the outcomes on fire responses are highly uncertain so it is difficult to infer unobserved partner performance. Alliance contracts among fire departments are intended to address these issues.

2.2.1 Alliance contracts among fire departments

Although U.S. fire departments have allied for most of their history the last 20 years has seen these relationships start to be governed by written alliance contracts known in the industry as automatic aid. Under automatic aid agreements allied departments provide a first response across jurisdictional boundaries according to pre-negotiated plans that are implemented at regional call centers with direct communications to the firehouses of the member departments. These contracts plan responses to incidents according pre-arranged timing, location as well as other characteristics of the incident, alliance members, and the environment. Contracts allocate decision-making authority between partners. They establish expectations for deployed personnel and apparatus, and they describe protocols for conducting cooperative activities. They also assign and describe what constitute legally enforceable responsibilities for each partner. While these agreements reduce free-riding behaviors they are primarily coordinating devices to ensure that actions are aligned across partners.

According to industry informants there are three main reasons why alliance contracts began diffusing through this population in the 1990s (Loboschefski 2006). First, consolidation of call-center facilities at the county level made it possible to dispatch fire resources across jurisdictional boundaries using written documentation with much greater ease. Second, the Insurance Service Office—a national organization that rates fire department capabilities and determines how insurance companies set rates—began to credit departments that had alliance contracts yielding lower insurance costs for the department and community. Third, the National Fire Protection Association (NFPA)—the organization that devises and publishes fire department standards of practice—doubled the recommended number of firefighters available for fighting structure fires.[2] This change placed immediate pressure on departments to deploy more firefighters to structure fires so that they could comply with the new standards of best practice. Working with alliance partners provided a ready source of additional personnel. While these institutional changes were made to improve department performance they were not intended to facilitate contracting. Although these exogenous factors shifted the costs and benefits of contracting among fire departments differences in the timing of adoption are driven by a variety of partner-specific factors.

[2]NFPA 1500 incorporate the "two-in/two-out" which suggests that for every pair of firefighters inside a structure there must be another pair on standby outside the structure.

For instance, the findings of chapter 3 suggest that proximate departments are more likely to enter into automatic aid agreements when the history of exchange is lopsided and when past performance on cooperative responses is poor. The results of this study also suggest that dense interconnections among outside partners increase the probability of establishing an automatic aid contract, and that these networks shape the way that dyadic history is interpreted—diminishing the effects of dyadic history. Automatic aid contracts are intended to smooth cooperation among departments and thereby facilitate interactions among alliance partners.[3]

2.2.2 Sample

The main source of information on U.S. fire departments comes from the National Fire Incident Reporting System (NFIRS). NFIRS is a set of forms, procedures, and infrastructure for gathering information about U.S. fire departments and their activities. The system is maintained by the US Fire Administration, a division of the US Department of Homeland Security, but it is administered at the level of the fire department with the support of state governments. A database containing NFIRS information for all participating departments is available to the public for the years 1999 to 2009—the period directly following the institutional changes described above.

The original sample includes 28,447 distinct fire departments (94 percent of the 30,165 total in 2009 estimated by the National Fire Protection Association) and a total of 9,926,268 runs from a specific department to a specific incident in the period between 1999 and 2009. I screened the sample a number of ways. First, I excluded observations with missing values for any of the control variables leaving 7,597,856 remaining observations. Among these 1,168,533 observations were mutual aid runs involving alliances among proximate departments. Next, I screened on observations with non-missing val-

[3] In table 2.8 there is evidence that alliance contracts are associated with a substantial increase in cooperation among fire departments.

ues for arrival minutes, casualties, and property damage leaving a remaining 4,156,223 observations.[4] Finally, in order to work with a more computationally tractable dataset I selected observations for a random sample of (i) 5 percent of the fire departments represented leaving 140,979 observations for an unmatched sample, and (ii) 20 percent of the fire departments represented leaving 493,490 observations from which to assemble a matched sample of 133,960 observations.

2.2.3 Measures

Measuring the performance of an alliance is varied and debated (Gulati 1999). Using the survival of an alliance to measure performance is problematic because it does not adequately distinguish between success and failure in many settings. Using firm-level accounting measures such as sales growth and financial measures such as abnormal stock returns is problematic because they do not adequately distinguish the extent to which an alliance accomplishes its goals. Using managerial assessments solve these problems by explicitly distinguishing between different aspects of alliance performance via direct elicitation and by providing consistent measures across large samples of alliances; however, they are problematic because they rely on the subjective evaluation of individual managers, because it is difficult to distinguish among levels of performance, and because it is difficult to measure performance over time.

This research overcomes each of these problems by examining performance in the following manners. First, measures are consistent across the alliances in this setting because the productive activities that occur within fire departments' alliances are highly comparable. Second, the activities that occur within the alliance are also consistent with the activities at that occur at the level of the organization. Third, the data is

[4] Because property damage estimates are sometimes difficult to reliably establish many departments do not include these in their NFIRS reports. Over 90 percent of both the casualties variable and the arrival minutes variable are non-missing valued. Since the resolution minutes variable has so many missing values models including this variable use a subsample of the main sample.

archival and as such less likely to be contaminated by retrospective biases and subjective managerial interpretation. Fourth, by distinguishing between instances of production that occur within the alliance and those that occur in-house it is possible to separate contributions to the organization and contributions to the alliance. Finally, this study considers four important outcomes for this industry and so unpacks multiple dimensions of performance each of which raise different problems that are addressed by contracts. Descriptive statistics are presented in table 2.1.

Fire departments exist to protect lives and property from fires and other hazards. Consequently, casualties and property damage are natural variables with which to assess performance on individual incidents. I measure casualties with the sum of firefighters and civilians harmed as a consequence of the fire.[5] On average there are 29 casualties per thousand fires. I measure property damage with the deflated dollar value estimate of the real property and contents destroyed by the fire.[6] On average there is $17,021 in property damage per fire with a highly skewed distribution.

Dependent variables. Effectively controlling a fire will protect both life and property; however, these goals often come into direct conflict creating conditions where department managers must trade-off success at one goal against the other. Because departments members have distinct responsibilities to their own jurisdictions, the preference to protect life over property is even more extreme under alliances. In this sense, departments providing aid are less willing to risk the lives of their members to protect an alliance partner's property than the department with primary responsibility. Furthermore, the professional ethics of firefighters place the protection of life above all else.[7] In this sense,

[5]A person injured or killed either as a result of the incident or during the mitigation of the incident. An injury is physical damage to a person that requires either (1) treatment by a practitioner of medicine within 1 year of the incident, or (2) at least 1 day of restricted activity immediately following the incident. Deaths also include people who die within 1 year because of injuries sustained from the incident.

[6]Rough estimation of the total loss to the structure and contents, in terms of the cost of replacement in like kind and quantity. This estimation of the fire loss includes contents damaged by fire, smoke, water, and overhaul. This does not include indirect loss, such as business interruption. I apply a logarithmic transformation to this variable.

[7]For instance, the firefighters oath establishes this priority in referring to the protection of life not

pursuing these goals under alliances raise different problems. Ensuring that partners discharge their duties in a manner than is consistent with the spirit of the arrangement (i.e. ensuring cooperation) is much less problematic for protecting lives than property.

Like any emergency response, timeliness is important to successful fire responses (Athey and Stern 2002). The longer a fire is left unchecked the more destruction it causes. As a result, fire service professionals closely monitor the time it takes to respond to a fire. I measure two aspects of timing: (i) the number of minutes between the first alarm and arrival at the incident (arrival minutes), and the (ii) number of minutes between the arrival at the incident and the time the incident is under control (resolution minutes). Arrival minutes are tracked and reported to the public as average response times by most departments. Response times are determined by jurisdictional coverage (i.e. the availability and location of personnel and apparatus) as well as well-coordinated mechanisms for allocating and dispatching these resources to fires. Similarly, resolution minutes are determined by the availability of resources at the scene—the quantity and kind of specialized skills and equipment— as well as well-coordinated mechanisms for organizing and deploying these resources to protect lives and suppress the fire.

Alliance partners provide material resources that increase the availability of personnel and apparatus that can be deployed in place of and jointly to individual fires for a focal department; however, they involve a larger coordination challenge than in-house resources. Owing to hierarchical control associated with internal production, it is easier to effect this kind of coordination in-house than in conjunction with alliance partners where control and authority are divided. On average it takes departments 7.49 minutes to arrive at a fire, and 31.62 minutes to suppress the fire and clear the incident.

Independent variable. Interested in exploring the effect of alliance contracts on

property: "I promise concern for others. A willingness to help all those in need. I promise courage - courage to face and conquer my fears. Courage to share and endure the ordeal of those who need me. I promise strength - strength of heart to bear whatever burdens might be placed upon me. Strength of body to deliver to safety all those placed within my care. I promise the wisdom to lead, the compassion to comfort, and the love to serve unselfishly whenever I am called."

these outcomes, I measure a contract with a dichotomous variable to distinguish between incidents that occur before or after a department has its first alliance contract in place. This variable was constructed using the date on which the first incident involving a formal alliance contract was identified in the dataset for entry into the contract regime. Although the date distinguishes between very fine temporal periods (i.e. from one day to the next) this date will be observed later than the actual date on which the contract came into effect. In the sample, 53% of fires occur in the presence of an alliance contract.

Controls. I include a set of controls that may be correlated with performance and contracting regime. These controls are based on characteristics of individual incidents. Fire types and property uses generate hazards with different risks and difficulties for fire departments. These characteristics can greatly influence the outcome of an incident.[8] Equally important to the response outcomes are the fire resources available on scene including firefighting personnel and special apparatus such as pumper trucks and ladders.[9] On average departments respond to fires with 8.2 firefighters and 3.7 apparatuses. Finally, there are strong temporal factors associated with the production of fires and fire services which may be correlated with both the structure of alliance contracts and the outcome to be explained. Consequently, I include controls for hour-of-day to account for differences in traffic that may affect the ability to arrive quickly. I include controls for the day-of-week to account for differences that might arise from weekends versus workdays, for instance. I also include controls for month-of-year to account for season effects such as

[8] Fire type codes the actual situation that emergency personnel found on the scene when they arrived. These codes include the entire spectrum of fires including: (1) structure fires, (2) Fire in mobile property used as a fixed structure, (3) Mobile property (vehicle) fire., (4) Natural vegetation fire., (5) Outside rubbish fire, (6) Special outside fire, (7) Cultivated vegetation, crop fire, and (8) all other types. Each individual property has a specific use, whether a structure or open land. This entry refers to the actual use of the property where the incident occurred. Property use specifies the how a property is used, not the configuration of the building or other details of the property. This variable describes uses for structure and outside fires: for example, (1) Church, place of worship, (2) Restaurant or cafeteria, (3) Dump or sanitary landfill, etc.

[9] These variables include total complement of fire department personnel and apparatus (suppression, EMS, other) that responded to the incident. This includes all fire and EMS personnel assigned to the incident whether they arrived at the scene or were canceled before arrival.

weather. Finally, I control for the US state in which the department is located to account for different institutional regimes in which alliance contracts may operate.

2.2.4 Methods

I test the effect of alliance contracts on four meaningful outcomes: arrival minutes, resolution minutes, property damage, and casualties. The unit of analysis is the fire department run. A fire department run observation is generated when fire department j responds to incident i on day t in ZIP code z. The basic specification involving pooled cross-sectional analysis of these observations is

$$Y_{ijtz} = \theta^1(contract_{jt}) + (controls)'_{ijtz}B^1 + \varepsilon^1_{ijtz} \tag{2.1}$$

In equation 2.1 Y_{ijtz} is the performance outcome to be explained, $(contract_{jt})$ is an indicator for whether department j has an alliance contract in place on day t. $(controls)_{ijtz}$ is a vector of control variables including: personnel, apparatus, property use, incident type, hour-of-day, day-of-week, month-of-year, and U.S. state. ε^1_{ijt} is the residual performance. θ^1 and B^1 are the coefficients to be estimated.

In order to interpret θ^1 as the causal effect of contracting on performance the strong assumption of strict exogeneity of residuals over time is required. Two main violations of this assumption are likely to arise in this setting: (i) fixed differences in departments may be correlated with alliance contracts and performance over time, (ii) fixed differences in where fires occur may be correlated with the design of alliance contracts and realized performance. I address these problems using a difference-in-difference research design.

First, I include department fixed effects to control for correlations across observations derived from unchanging differences in departments such as managerial skill. Second, I supplement this model with fixed effects specific to a department and ZIP code to control for correlations across observations derived from fixed differences in where incidents occur and realized performance. For instance, some areas under a department's jurisdiction might be harder to access, be closer to alliance partners, have lower income residents, and so receive both different treatment under alliance contracts and realize different performance outcomes. Furthermore, contracts often specify details in terms of response areas.

$$Y_{ijtz} = \theta^2(contract_{jt}) + (controls)'_{ijtz}B^2 + (department)_d + (Zip)_z + \varepsilon^2_{ijtz} \tag{2.2}$$

In effect model 2.2 delivers an estimate of θ^2 that compares the change in performance for departments that contract with the change in performance for departments that do not contract over the same time period.[10] I estimate equation 2.2 using ordinary least squares (OLS) clustering the standard errors on the focal fire department.

In order to have a causal interpretation two remaining problems must be addressed. First, the difference-in-differences estimator requires an exogenous treatment. Although the spread of alliance contracts was initiated by institutional changes that are plausibly exogenous of contracting the actual timing of adoption was not random. Second, in order to separately compare the effects of alliance contracts on performance for in-house runs versus alliance runs I need to further address selection concerns. Specifically, signing contracts is likely to alter the frequency with which departments cooperate with their alliance partners and possibly the distribution of run characteristics for in-house versus alliance runs before and after contracting. I deal with both problems sequentially with matching procedures.

Empirically, I start with all fires for a random sample of departments. Then I take all fires for "treated" producers (those with contracts) and then search for nearly exactly matching fires responded to by control group producers (those without contracts). The

[10]Figure 2.1 in the appendix to this chapter includes plots for the pre- and post- treatment trends for each of the dependent variables. The dummy variable estimates are relatively noisy and unstable; however, there are no discernible trends that would drive a spurious relationship between contracting and performance such as a pre-treatment performance dip.

purpose of the matching procedure is to select a set of fires that establish the performance path associated with contracting departments had they not contracted with their alliance partners. I use a nonparametric matching method to control for the confounding influence of pre-treatment control variables called coarsened exact matching (CEM) (Iacus, King, and Porro 2011).[11]

The choice of control group observations occurs in the following manner. First, I chose a relatively small set of covariates on which I want balance between the treatment and control groups. Next, I create a large number of strata that covers the entire support of the joint distribution of these covariates. Each observation is then placed in a unique stratum. Any stratum that has either no fires that occur under contract or no fires that occur in the absence of a contract are pruned from the sample. Finally, within each stratum I select a unique control and treatment fire.

The procedure matches on a coarsened support of the joint distribution of covariates rather than precisely the same values for every covariate. Control fires are chosen if they roughly share the following characteristics: (1) distance to incident, (2) the number of existing contracts in calendar year, (3) the lopsidedness of the department's exchanges with its alliance partners in prior two years, (4) interactions with all alliance partners in calendar year, (5) interactions with overlapping alliance partners, (6) personnel, (7) apparatus, and (8) timing.[12]

I start with a universe of 489,342 fires produced by a 20% random sample of departments. Out of these fires 286,718 (59%) are produced in the presence of an alliance contract. This group of treated fires are then matched from the set of fires from the control group of fires that occur outside a contract. I successfully matched 73,436 out of these 286,718 fires (26%) each with a single control observation.

To address the problem of selection on alliance versus in-house fire runs I perform

[11] The procedure has been implemented in Stata 10.1 (Blackwell, Iacus, King, and Porro 2009)

[12] These covariates are selected to capture the social context of alliances consistent with the findings of Chapter 3.

further matching on the matched sample on the basis of contracting. I control for pre-treatment differences in fires that are allocated to cooperative rather than in-house production before and after contracting by matching on the following characteristics: (i) time of day, (ii) number of alliance contracts, (iii) property use, (iv) distance to incident, (v) personnel, and (vi) apparatus. This group of treated fires are then matched from the set of fires from the control group of fires that occur outside a contract. I successfully matched 16,436 alliance fires out the 146,872 fires (11%) that were already matched with multiple control observations for a final matched sample of 137,428 observations.

2.3 Discussion of results and implications

This study asks: When do formal contracts improve performance? I begin by examining broad patterns in the data. I present estimates of the association between contracting and performance on four qualitatively different outcomes using pooled OLS regression (Pooled-OLS) (see table 2.2). Then I examine more closely how cooperative runs differ from in-house runs with unconditional summary statistics (see table 2.3). Next I present difference-in-differences estimates (DD-OLS) controlling for fixed differences in departments and the Zip codes in which fires arrive (see table 2.4). Finally, I estimate the effect of alliance contracts on performance distinguishing between effects at the level of the alliance and the level of the department. sI present the difference-in-differences estimates for the unmatched sample (see table 2.5) and for the coarsened exact matched sample (see table 2.7)—the results for the latter taking a stronger causal interpretation. For each dependent variable I display a pair of estimates one for in-house runs (the odd numbered models) and the other for alliance runs (the even numbered models).

In the pooled regression of performance on contracting in table 2.2 the estimates suggest that contracts increase arrival minutes (model 1), decrease resolution minutes (model 2), decrease property damage (model 3), and have no effect on casualties (model

4) on the unmatched sample. However, on the matched sample contracts have no impact on response timing but decrease property damage and casualties (models 3 and 4). The differences between the results on the unmatched and matched samples suggest that pre-contracting heterogeneity in fires may be responsible for the link between contracting and performance.

In-house runs differ from runs involving the help of alliance partners. For a comparison consider the unmatched sample averages in table 2.3. First, in-house runs involve substantially less property damage and fewer casualties than alliance runs: $10,332 compared to $74,098 and 23 compared to 79 per thousand fires, respectively. Next, alliance runs take more than three times as long to resolve than in-house runs: 74 minutes compared to 24 minutes. Next, alliance runs involve more costly coordination of work that (i) may influence the amount of time it takes to complete an incident response, and (ii) takes more time to dispatch resources. In fact, the average arrival minutes for in-house runs are 38 percent faster than for alliance runs. Alliance runs also involve a larger number of personnel and apparatus than alliance runs: 8 personnel compared to 10 and 3.6 apparatus compared to 4.7, respectively. Finally, the composition of alliance fires is also qualitatively different. They are more likely to be structure fires (+20.1%) that occur in residences (+13.4%) and heavy industry structures (+2.5%) than in-house fires which in turn are more likely to be rubbish fires (+10.1%), to occur in manufacturing/processing structures (+7.3%) and outdoor structures (+19.4%).

These differences suggest that departments are more likely to call for help from alliance partners when fires are more severe—resulting in large losses, more deployed resources, longer responses—and when they are occur in residential structures. These incidents are more likely to benefit from cooperation with alliance partners because the need for help is greater. In this setting it is clear that alliances supplement fire departments' constrained material resources available for attacking individual fires. These differences may also account for contracting—a device for allocating cooperation to these incidents—and its resulting outcomes. In fact, alliance contracts may be used to alter how departments work together by coordinating partner resources according to a single geographic plan that jointly considers the resources of multiple departments irrespective of political boundaries. Therefore, the effect of alliance contracts may work in part through the selection of fires for cooperative versus in-house production in ways that produce better total outcomes.

After controlling for fixed differences in departments and the Zip code in which fires occur the estimates for arrival minutes and property damage are statistically and materially unchanged while the estimates for resolution minutes is no longer significant and the estimate for casualties is now negative and significant in models 1 to 4 of table 2.4. This suggests that fixed differences in departments (e.g. managerial skill, endowments, etc) and the locations of the fires (e.g. state of housing stock, roadway access, etc) may drive the empirical link between contracting and performance. After balancing the fires on pre-contracting covariates, the estimated effect of contracting on resolution minutes is positive and statistically significant—suggesting worsening performance—and the estimate for casualties remains negative and statistically significant—suggesting a robust positive performance effect along this dimension.

At the level of the department, the estimates suggest that alliance contracts improve performance when measured by arrival minutes (model 1), property damage (model 5), and casualties (model 7) but worsen performance when measured by resolution minutes (model 3) in the unmatched sample (table 2.5). At the level of the alliance, the estimates suggest that contracts have no effect on either arrival minutes (model 2) or resolution minutes (model 4), have a negative performance effect on property damage (model 6), and a positive significant effect on casualties (model 8) in the unmatched sample (table 2.5). After controlling for pre-contracting covariates estimates suggest that contracts still decrease casualties (see table 2.7) at both levels of analysis and that the increase in resolution minutes remain economically and statistically meaningful; however, the effects on arrival minutes and property damage are not statistically different than zero.

2.3.1 Distinguishing coordination from motivation benefits

These results are broadly consistent with prior findings suggesting that formal governance enhances the performance of alliances (Poppo and Zenger 2002) and organizations involved in alliances (Sampson 2007). Theory suggests that governance mechanisms influence both the coordination of activities and the incentives for members to cooperate (Williamson 1985, Gulati and Singh 1998). Distinguishing among these sets of mechanisms is difficult, however. For instance, Sampson (2007) argues that the choice of organization form increases performance through incentives to share information.[13] It is not clear from this analysis whether the benefits of organization form follow from incentive alignment alone, however. By analyzing the effect of contracting on qualitatively different outcomes in the fire department setting it is possible to distinguish among coordination and incentive effects. That is because the challenges to reducing casualties are different than the challenges to reducing property damage in alliance activities.

Specifically, alliance partners are intrinsically motivated to provide consummate performance when life is at risk while they have incentives to shade on performance when only property is at risk. In short, casualties take priority over property damage for fire department members and their constituents. As a result, alliance contracts are not needed to align interests and ensure cooperation when casualties are the salient dimension of performance. Despite informality being sufficient to deliver consummate partner performance alliance contracts have a robust negative effect on casualties. The estimates are materially and statistically significant for both alliance and in-house fires (models 7 and 8 respectively) and for both the unmatched and matched samples (tables 2.5 and 2.7 respectively). They suggest that the use of formal contracts decreases casualties from an

[13] Under high technological diversity Sampson (2007) finds that joint ventures performance much better than contracts, and she argues that alliance members benefit more from information sharing under these circumstances.

average of 72 per thousand fires to 6 per thousand fires for cooperative incidents, and from 35 per thousand fires to 17 per thousand fires for in-house incidents.[14] This provides strong evidence that contracts add value by coordinating the activities of alliance partners separate of resolving incentive conflicts (Gulati, Lawrence, and Puranam 2005).

In contrast, the time it takes to resolve a fire incident increases after contracting—suggest a negative performance consequence. By shifting more severe incidents from in-house production to cooperative production contracts may introduce sharper incentives to protect lives over property. Alliance partners make sharper trade-offs between life and property than focal departments who have a larger stake in preserving both. As a result, we observe a trade-off between resolution times and casualties. It takes longer for alliance partners to bring a fire under control because they may be demonstrating a preference for saving lives over property. Specifically, firefighters have to make choices about whether to risk their lives to save a building. If alliance partners are more likely to "let a building go" and to focus on saving lives it will take longer for an incident to be resolved.

Furthermore, the effect of alliance contracts on property damage is unstable and inconsistent across levels of organization and estimation samples. The difference in results may suggest how selection is occurring. First, the effect of contracts on property damage from table 2.5 indicates the existence of a trade-off between alliance and in-house performance. The estimates imply that contracts reduce property damage on in-house fires but increase property damage on alliance fires. This evidence suggests that fires may not be assigned between alliance and in-house production in the same way before and after contracting. Second, the estimates on the matched sample differ from the unmatched sample in ways that suggest selection on property damage performance. When estimated on the matched sample, the sign of estimates agree for alliance and in-house runs, but they are not statistically distinguishable from zero. These results suggest selection effects

[14]These baselines are from the unmatched sample summary statistics in table 2.3.

in the unmatched sample worth exploring.

There are at least three ways in which these selection effects may occur in this setting. First, contracts may influence the choice of occasions in which departments cooperate to include fires with more severe risks of property damage. Second, partners have incentives to shade on property damage performance on fire responses for partners. So, contracting may also influence the choice of occasions in which departments cooperate to include fires for which informal alliances are insufficient to ensure consummate performance by partners. Third, alliance contracts may directly substitute in-house responses for alliance partner responses.[15] Contracts then are used to organize outsourcing. In this sense, contracts are associated with more property damage on alliance responses because of the motivation and coordination costs associated with outsourcing. In general, this suggests that organizations are not just contracting for direct mechanisms that improve coordination of activities and alignment of interest but indirectly through the choice of occasions when alliance partners will collaborate to best achieve mutual benefits.

These results imply that research on formal alliances will be incomplete if researchers do not unpack the elements of performance. Contracts enhance alliances along several dimensions. This study considers how contracts benefit alliance activities separately by coordinating activities and by encouraging partners to cooperate. I find strong empirical evidence that contracts benefit alliance activities through gains in coordination, and that contracts involve selection processes on outcomes involving incentive conflict. Examining the combined effects of contracts on performance by looking at aggregate measures of performance obscures and conflates the distinct pathways by which contracts benefit alliances. Unpacking salient aspects of performance may allow researchers to examine how contracts exert multiple effects on performance at the same time.

[15] This is to be distinguished from joint responses in which partners supplement a department's material resources.

2.3.2 Distinguishing organization and alliance performance

Contracts reduce casualties for in-house fires and for alliance fires. The magnitude of the effect on alliance fires is nearly twice as large on an absolute basis, however. Insofar as alliance contracts improve coordination among partnered departments the estimated effect on alliance runs is as expected; however, evidence of performance improvements among in-house fires requires greater explanation of the institutional details. There are at least two ways in which contracts can reduce casualties at the level of the department separate of the the effect on alliances.

First, contracting may shift fires that would have been served in-house to alliances in way that alters the composition of fires in each category. For instance, the descriptive statistics in table 2.6 demonstrate that the composition of alliance runs differ after contracting. Specifically, in the unmatched sample average property damage on alliance runs more than doubles, casualties decrease by a third, arrivals decrease by 1.7 minutes, and resolutions decrease by 44 minutes from contracting.

Alliance runs also involve fewer resources after contracting: an average of four fewer personnel and 3 fewer apparatus per fire. A larger proportion of alliance runs involve residential (+5%) and business (+1%) properties, and a smaller proportion involve heavy industry (−4%) and manufacturing (−2%) properties. Additionally, contracting is associated with changes in the distribution of fires by type. After contracting, there is an increase in structure fires (+4%), vehicle fires (+2%) , and rubbish fires (+1%) as well as a decrease in vegetation fires (−6%) and mobile property fires (−1%).[16] These differences suggest that contracts influence the selection of instances of collaboration—on the basis of severity, run type, and resource intensity—for which the division of in-house and allied production may produce better overall results. Viewed this way, a reduction in casualties

[16]After constructing the matched (CEM) sample the differences diminish substantially. Similarly, the differences in covariate between alliance and in-house runs decrease after matching, as shown in table 2.3.

for in-house fires is thus generated by taking these more severe fires out of the risk set. At the same time, these incidents are better dealt with via cooperation among partners under contracts that manage the ways in which partners interact when working together.

Second, contracts provide an effective device for allocating resources to deal with concurrent fires. Alliance contracts ensure that partner resources are used to ensure better backing coverage when fire resources are deployed to incidents. This would have two effects. With greater assurance of backing coverage provided by alliance contracts departments (i) are better prepared to deal with incidents that overlap in time, and/or (ii) can hold fewer resources in reserve when responding to fires.

One of the ways that alliance contracts are intended to enhance alliance activities of fire departments is through timely responses. Because there is no advantage to be gained by responding to alliance fires with less urgency than in-house fires improvements along this dimension of performance stem from coordination improvements.[17] However, the estimates suggest that alliance contracts reduce the average time it takes to get to in-house fires but not alliance fires. There could be several explanations for this result that raise theoretically interesting questions.

Insofar as alliance contracts smooth the process by which resources are deployed between partners they should benefit alliance activities through improved coordination. Insofar as alliance contracts permit partners to allocate material resources to enhance general response times—i.e. by providing better overall or backing coverage—they should benefit in-house activities by jointly planning and combining resources more effectively. Observing positive effects at the level of the organization but not at the level of the alliance suggest that alliance contracts may not benefit the organization indirectly through successful outcomes at the level of the alliance but directly by permitting managers better configure resources at the level of the organization.

[17] Industry informants explained that the benefits of arriving both quickly and ahead of alliance partners are overwhelming and widely understood.

Consider these findings in light of existing research in which performance is examined at either the level of the alliance or the organization. At the level of the alliance, for instance, Hoang and Rothaermel (2005) examine how alliance experience affects a specific goal of particular R&D joint ventures—innovative output as measured by the successful discovery of a new drug. Looking at success more generally, Poppo and Zenger (2002) examine how alliance governance affects managerial satisfaction with production and governance efficiency. Studies in this line focus on the various ways in which different alliance characteristics influence performance within alliance exchanges; however, these studies ignore whether the effects (i) are consistent across outcomes or (ii) flow through to member-level performance. At the level of the organization, Sampson (2007) analyzes the impact of alliance organizational form on one aspect of performance: firms' innovative product (i.e. patenting). Looking at performance more broadly, Baum, Calabrese, and Silverman (2000) evaluate the role of alliance networks on start-up performance with multiple growth and innovation outcomes noting and discussing but not analyzing variation in the effects according to the aspect of performance considered. Furthermore a set of studies in this line focuses on how alliance activities collectively affect overall organization performance (Lavie 2007, Goerzen 2007, Kale and Singh 2007, Koka and Prescott 2008).

The results of these studies and the findings of this study suggest that analyzing the effects of alliances and contracts on separate levels of analysis at the same time may provide fruitful avenues for understanding the precise ways in which contracts benefit organizations. This study provides evidence of coordination benefits from contracts that arise at the level of the department and the level of the alliance separately. Future research should consider how contracting affects performance through these distinct pathways to create joint surplus-value for alliance members. By decomposing benefits across levels of analysis researchers can gain a fuller understanding of how costs and benefits of contracts arise and contribute to the success or failure of the alliance.[18]

Organizations also enter into alliances to access resources that improve the position of the organization even though success within the alliance may not be achieved. For instance, Sorenson and Waguespack (2006) find that producing films with the same partners reduces the box office performance of individual projects. Although this interpretation goes beyond the scope of the paper, producers might rationalize the reduction to alliance-level performance (i.e. the film) because of the benefits to the overall portfolio of producers' films from such relations. This interpretation is consistent with the effects of portfolio or networks of alliances which may individually perform poorly but collectively contribute to the success of the organization. Without considering how alliances affect performance at the level of both the alliance and the organization we may misconstrue the benefits of alliances. Without understanding the ways in which performance arises at both levels of analysis it is difficult for researchers to form a complete picture of how formal alliance influence performance.

2.3.3 Identifying alliances based on formality

Finally, in this setting organizations have a history of interactions with alliance partners that precede formal alliances. It is in this sense that these alliances proceed from relying on informal controls to the use of more formal modes in the use of written contracts. While this is certainly true in the fire department setting it is often true among other organizations. Alliance contracts represent a formal tie between organizations; however, relations between organizations may exist prior to contracting. For instance, these relations often occur at the individual level through friendships or other connections among members of each organization. They may occur through meetings in which organizations

[18] Consider the cost of to alliance members that place valuable resources at risk through their alliance activities. For instance, in technology alliances partners often share valuable information but create appropriability hazards (Oxley 1997). Exchanging knowledge in this way may strengthen the ability to achieve the goals of the alliance while weakening the broader position of partners in activities outside the alliance.

share information or discuss the possibility of allying. They may also occur through pilot projects and even as fully functioning alliances that operate covertly in the absence of formal governance. In such cases, the history of interactions prior to formally allying may be consequential. In particular, the history of interactions may influence the design of contracts, the purpose for adopting them, and the implications for subsequent performance.

There is substantial evidence that informal mechanisms—such as trust, learning, and the creation of norms—can enhance the performance of alliance activities (McEvily, Perrone, and Zaheer 2003, Gulati and Nickerson 2008, Vanneste and Puranam 2010). This research implies that contracting effects are sensitive to the history of interactions among an organization and its alliance partners. If researchers fail to account for differences in the history of interactions preceding the formalization of relations they will have fail to understand the ways in which contracts benefit an alliance and its member organizations. In light of the evidence of selection effects associated with property damage outcomes the history of performance may have a substantial affect on the design and use of formal contracts.

For instance, in cases where informal arrangements were sufficient to effect successful outcomes with respect to property damage the use of formal contracts may simply reinforce the relationship and thereby complement informality; however in cases where informal arrangements were not sufficient to effect successful outcomes the use of contracts may act as a substitute for informality. This implies that researchers must consider alliances as a dynamic process that unfolds over time. Therefore, analysis of alliances and their governance modes performed in cross-section may be misleading.

2.4 Conclusion

In this paper, I examine the relationship between contracts for organizing alliances between fire departments and the performance on fire responses. I find that these alliance contracts tend to improve performance when measured by casualties, to worsen performance when measured by resolution minutes, and to have no significant effect on performance when measured by arrival minutes and property damage.

I see several contributions from this work. First, I provide new empirical findings on how contracts influence the performance of the alliance and the organization adding to a growing literature on this topic (Baum, Calabrese, and Silverman 2000, Poppo and Zenger 2002, Bercovitz, Jap, and Nickerson 2006, Sampson 2007, Gulati and Puranam 2009). Insofar as formal alliances influence different aspects of performance in different ways—coordinating activities and motivating members to deliver on their promises—researchers that unpack aspects of performance can form a more complete understanding of the individual pathways through which contracts add value.

Second, I provide evidence that contracting effects may be only loosely-coupled between the level of the alliance and the level of the member organizations. Insofar as formal alliances generate separate costs and benefits at the level alliance and the level of the participating organizations it will be useful for researchers to distinguish between these contributions at the same time.

Third, I analyze a setting where alliances progress from informal to formal governance and find evidence from matching on the social context and history of interactions between a department and its allies that the trajectory of relationships is likely to influence the reasons for formalizing a relationship and later the consequences of doing so. Therefore, researchers must examine how these relationships unfold over time to develop a more complete understanding of the ways in which formal alliances add value to exchange between alliance partners.

The fact that the composition of alliance fires changes after contracting suggests reasons for selecting into formal contracts: (i) to gain access to supplemental material resources with which to better respond to more severe fires, (ii) to enact priorities between saving lives and saving property, and (iii) to free-up in-house resources with which to garner better outcomes on concurrent production of fires cooperatively and in-house.

There are important limitations with this research. First, although matching reduces heterogeneity in the composition of fires that occur under contracts and within alliances the procedure used for matching only balances on chosen covariates and only does so in a coarse manner. Second, to get around computational limitations I was forced to use a relatively small sample of departments than are available. Concerns about the efficiency of the estimates and sampling errors would be addressed by making use of all the available data. Third, the empirical setting is such that concerns for opportunism (free-riding here) are much smaller than concerns for effectively coordinating alliance activities. To be sure, the effect of contracts on how alliance members capture the value created from exchange would be more fully explored in settings in which opportunism concerns are more prominent.

Despite these limitations, the the results provide potentially provocative evidence on the link between formal alliances and performance. The measurement of performance along multiple dimensions using archival data for a large sample of comparable set of alliances and governance mechanisms facilitates a fuller understanding of the organization of alliances. As a descriptive analysis with coarse summaries, stylized associations, and estimates that take on relatively strong causal interpretations this study complements existing theory and suggests directions for future research on this topic.

Table 2.1: Summary statistics: overall

Sample	**Unmatched**			**Matched (CEM)**		
Variable	**Mean**	**Std. Dev.**	**N**	**Mean**	**Std. Dev.**	**N**
Property damage	17,021	791,076	140,979	10,635	133,528	133,960
Casualties	0.029	0.248	140,979	0.031	0.295	133,960
Response minutes	7.494	21.476	140,979	8.298	24.754	133,960
Resolution minutes	31.62	77.962	33, 225	38.099	89.364	41,281
Contract	0.53	0.499	140,979	0.5	0.5	133,960
Personnel	8.214	9.922	140,979	8.083	10.722	133,960
Apparatus	3.748	25.625	140,979	4.142	36.7	133,960
Matching controls						
Distance	4.382	20.174	140,979	2.579	13.44	133,960
Total contracts	2.605	3.431	140,979	0.945	1.618	133,960
Lopsided exchange	20.343	45.084	140,979	6.544	26.442	133,960
Mutual partner experience	30.486	46.653	140,979	11.059	19.455	133,960
Total interactions	1198.41	4412.481	140,979	306.156	734.37	133,960
Property type						
Assembly	0.023	0.149	140,979	0.023	0.149	133,960
Educational	0.01	0.099	140,979	0.01	0.099	133,960
Health Care/Detention/Correction	0.007	0.082	140,979	0.007	0.082	133,960
Residential	0.408	0.491	140,979	0.408	0.491	133,960
Mercantile/Business	0.037	0.19	140,979	0.037	0.19	133,960
Heavy industry	0.023	0.151	140,979	0.023	0.151	133,960
Manufacturing/Processing	0.01	0.098	140,979	0.01	0.098	133,960
Storage	0.027	0.163	140,979	0.027	0.163	133,960
Outside/Special Property	0.447	0.497	140,979	0.447	0.497	133,960
Fire type						
Structure fire	0.379	0.485	140,979	0.379	0.485	133,960
Mobile property fire	0.011	0.106	140,979	0.011	0.106	133,960
Vehicle fire	0.207	0.405	140,979	0.207	0.405	133,960
Vegetation fire	0.207	0.405	140,979	0.207	0.405	133,960
Rubbish fire	0.127	0.333	140,979	0.127	0.333	133,960
Outside fire	0.021	0.142	140,979	0.021	0.142	133,960
Cultivated fire	0.014	0.117	140,979	0.014	0.117	133,960

Table 2.2: Pooled-OLS regression results: average effects

Dep Var	(1) Arrival minutes	(2) Resolution minutes	(3) Property damage	(4) Casualties	(5) Arrival minutes	(6) Resolution minutes	(7) Property damage	(8) Casualties
Matching	None	None	None	None	CEM	CEM	CEM	CEM
After contract	1.238***	-4.421***	-0.378***	-0.000	-0.308	0.142	-0.190***	-0.014***
	(0.178)	(1.142)	(0.022)	(0.002)	0.235	1.175	0.033	0.002
Personnel	-0.007	1.022***	0.088***	0.004***	-0.047***	1.088***	0.060***	0.004***
	(0.005)	(0.127)	(0.003)	(0.000)	(0.012)	(0.112)	(0.013)	(0.001)
Apparatus	-0.001***	0.006	0.002***	0.000	0.000	0.009	0.001	0.000
	(0.000)	(0.005)	(0.000)	(0.000)	(0.001)	(0.007)	(0.001)	(0.000)
Fire type	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Property use	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hour-of-day	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day-of-week	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-of-year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Department FE	No	No	No	No	No	No	No	No
ZIP code FE	No	No	No	No	No	No	No	No
# Obs	140,979	33,225	140,979	140,979	133,960	41,281	133,960	133,960
Adjusted R^2	0.108	0.141	0.438	0.066	0.129	0.183	0.412	0.064

Note: All models are estimated with OLS. The unit of analysis is an incident (i) responded to by a particular department (j) on a particular day (t) in a particular ZIP code (z). Robust standard errors in parentheses clustered on departments. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.3: Summary statistics: alliance and in-house fires

Sample	**Unmatched**				**Matched (CEM)**			
Run type	**Alliance (n=14,789)**		**In-house (n=126,190)**		**Alliance (n=18,484)**		**In-house (n=115,476)**	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Property damage	74,096	1,526,077	10,332	652,528	42,166	325,725	5,588	59,306
Casualties	0.079	0.476	0.023	0.204	0.085	0.626	0.022	0.195
Response minutes	11.32	28.557	7.045	20.439	11.544	23.274	7.78	24.944
Resolution minutes	73.925	128.862	24.226	62.22	80.779	129.749	28.709	74.503
Contracts	0.767	0.423	0.502	0.5	0.524	0.499	0.496	0.5
Personnel	10.011	12.964	8.003	9.48	10.279	20.714	7.731	7.987
Apparatus	4.738	26.917	3.632	25.467	5.858	49.987	3.867	34.089
Matching controls								
Distance	4.48	20.884	3.439	11.144	3.185	13.275	2.483	13.463
Total contracts	4.223	4.916	2.414	3.157	1.342	2.156	0.882	1.504
Lopsided exchange	34.374	104.268	18.692	31.095	12.149	41.427	5.647	23.035
Mutual partner experience	32.328	46.943	30.27	46.615	15.377	26.693	10.368	17.933
Total interactions	1,934	9,038	1,111	3,475	509.456	1,106	273.621	649.601
Property type								
Assembly	0.021	0.142	0.023	0.15	0.016	0.127	0.028	0.165
Educational	0.008	0.09	0.01	0.1	0.005	0.072	0.011	0.103
Health Care/Detention/Correction	0.005	0.072	0.007	0.083	0.004	0.063	0.011	0.105
Residential	0.528	0.499	0.394	0.489	0.505	0.5	0.505	0.5
Mercantile/Business	0.035	0.183	0.038	0.191	0.033	0.18	0.045	0.208
Heavy industry	0.045	0.208	0.021	0.143	0.057	0.233	0.032	0.175
Manufacturing/Processing	0.019	0.009	0.092	0.138	0.017	0.129	0.013	0.114
Storage	0.056	0.231	0.056	0.024	0.153	0.223	0.043	0.203
Outside/Special Property	0.273	0.446	0.467	0.499	0.293	0.455	0.293	0.455
Fire type								
Structure fire	0.559	0.497	0.358	0.479	0.532	0.499	0.532	0.499
Mobile property fire	0.032	0.175	0.009	0.094	0.036	0.185	0.013	0.113
Vehicle fire	0.079	0.27	0.223	0.416	0.071	0.257	0.128	0.334
Vegetation fire	0.225	0.418	0.205	0.403	0.263	0.44	0.206	0.404
Rubbish fire	0.037	0.188	0.138	0.345	0.035	0.183	0.063	0.244
Outside fire	0.015	0.122	0.021	0.144	0.015	0.123	0.015	0.122
Cultivated fire	0.008	0.091	0.015	0.12	0.014	0.119	0.006	0.08

Table 2.4: DD-OLS regression results: average effects

Dep Var	(1) Arrival minutes	(2) Resolution minutes	(3) Property damage	(4) Casualties	(5) Arrival minutes	(6) Resolution minutes	(7) Property damage	(8) Casualties
Matching	None	None	None	None	CEM	CEM	CEM	CEM
After contract	1.231***	1.025	-0.676***	-0.005***	0.012	4.836***	-0.033	-0.025***
	(0.185)	(1.429)	(0.026)	(0.002)	(0.243)	(1.340)	(0.030)	(0.004)
Personnel	-0.003	1.131***	0.100***	0.004***	-0.027***	1.502***	0.054***	0.003***
	(0.005)	(0.146)	(0.004)	(0.000)	(0.009)	(0.1550	(0.016)	(0.001)
Apparatus	-0.002**	0.005	0.001	0.000	-0.003***	0.013	0.003***	0.000
	(0.001)	(0.007)	(0.001)	(0.000)	(0.001)	(0.010)	(0.001)	(0.000)
Fire type	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Property use	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hour-of-day	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day-of-week	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-of-year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Department FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZIP code FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# Obs	140,979	33,225	140,979	140,979	133,960	41,281	133,960	133,960
Adjusted R^2	0.108	0.141	0.438	0.066	0.129	0.183	0.412	0.064

Note: All models are estimated with OLS. The unit of analysis is an incident (i) responded to by a particular department (j) on a particular day (t) in a particular ZIP code (z). Robust standard errors in parentheses clustered on departments. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.5: DD-OLS regression results: unmatched

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep Var	Arrival minutes		Resolution minutes		Property damage		Casualties	
Sample runs	In-house	Alliance	In-house	Alliance	In-house	Alliance	In-house	Alliance
Matching	None	None	None	None	None	None	None	None
After contract	-0.806**	0.150	3.383***	7.731	-0.158***	0.207*	-0.035***	-0.076***
	(0.360)	(0.604)	(1.752)	(6.582)	(0.033)	(0.110)	(0.004)	(0.017)
Personnel	-0.005	-0.051*	1.980***	4.011***	0.056***	0.055***	0.003***	0.004***
	(0.013)	(0.030)	(0.582)	(0.977)	(0.008)	(0.010)	(0.000)	(0.001)
Apparatus	-0.003	-0.025	-0.002	0.047	0.003***	0.048**	0.000	0.003
	(0.002)	(0.029)	(0.013)	(0.302)	(0.001)	(0.024)	(0.000)	(0.002)
Fire type	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Property use	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hour-of-day	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day-of-week	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-of-year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Department FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZIP code FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# Obs	126,190	14,789	28,282	4,943	126,190	14,789	126,190	14,789
Adjusted R^2	0.054	0.340	0.101	0.232	0.443	0.497	0.067	0.171

Note: Full sample includes all runs for a random 5% sample of departments. All models are estimated with OLS. The unit of analysis is an incident (i) responded to by a particular department (j) on a particular day (t) in a particular ZIP code (z). Robust standard errors in parentheses clustered on departments. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.6: Summary statistics: contract regime (alliance fires)

Sample	Unmatched				Matched (CEM)			
Contract regime	**After (n=11,345)**		**Before (n=3,444)**		**After (n=9,683)**		**Before (n=8,801)**	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Property damage	83,852	1,739,428	41,956	180,987	40,620	299,991	43,866	351,880
Casualties	0.073	0.481	0.101	0.459	0.076	0.575	0.095	0.676
Response minutes	10.917	20.145	12.65	46.51	11.183	18.022	11.941	27.93
Resolution minutes	63.16	106.263	107.464	178.036	77.116	123.376	85.479	137.368
Personnel	9.036	10.259	13.221	19.018	10.293	26.062	10.264	12.406
Apparatus	4.054	11.321	6.992	51.797	5.622	40.934	6.118	58.348
Matching controls								
Distance	3.423	11.407	3.491	10.26	3.455	16.299	2.88	8.651
Total contracts	5.272	5.09	0.607	1.124	1.635	2.511	1.019	1.621
Lopsided exchange	42.631	116.981	5.903	11.401	13.388	50.702	10.786	27.795
Mutual partner experience	36.985	50.312	16.271	27.235	14.408	27.343	16.444	25.918
Total interactions	2,391	10,195	358.173	1,328	559.119	1338.36	454.802	771.519
Property type								
Assembly	0.02	0.142	0.021	0.144	0.017	0.128	0.016	0.125
Educational	0.009	0.096	0.004	0.066	0.006	0.076	0.004	0.066
Health Care/Detention/Correction	0.003	0.051	0.01	0.097	0.004	0.063	0.004	0.063
Residential	0.541	0.498	0.485	0.5	0.501	0.5	0.509	0.5
Mercantile/Business	0.037	0.189	0.027	0.161	0.034	0.18	0.033	0.179
Heavy industry	0.036	0.186	0.076	0.266	0.048	0.214	0.067	0.25
Manufacturing/Processing	0.015	0.122	0.033	0.18	0.017	0.129	0.017	0.129
Storage	0.056	0.229	0.059	0.236	0.051	0.22	0.054	0.225
Outside/Special Property	0.271	0.445	0.278	0.448	0.305	0.46	0.281	0.45
Fire type								
Structure fire	0.569	0.495	0.528	0.499	0.535	0.499	0.527	0.499
Mobile property fire	0.029	0.169	0.039	0.193	0.032	0.176	0.04	0.195
Vehicle fire	0.082	0.275	0.068	0.251	0.069	0.253	0.073	0.26
Vegetation fire	0.211	0.408	0.273	0.446	0.265	0.441	0.261	0.439
Rubbish fire	0.039	0.194	0.029	0.168	0.035	0.184	0.035	0.183
Outside fire	0.014	0.116	0.02	0.139	0.016	0.125	0.015	0.122
Cultivated fire	0.006	0.078	0.016	0.125	0.011	0.105	0.018	0.133

Table 2.7: DD-OLS regression results: matched on contracts and aid runs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep Var	Arrival minutes		Resolution minutes		Property damage		Casualties	
Sample runs	In-house	Alliance	In-house	Alliance	In-house	Alliance	In-house	Alliance
Matching	CEM	CEM	CEM	CEM	CEM	CEM	CEM	CEM
After contract	-0.027	0.338	2.833***	8.238	-0.038	-0.056	-0.018***	-0.066**
	(0.274)	(0.318)	(1.275)	(6.163)	(0.030)	(0.105)	(0.002)	(0.032)
Personnel	-0.058***	-0.008**	0.932***	1.494***	0.082***	0.025***	0.003***	0.003***
	(0.010)	(0.004)	(0.087)	(0.386)	(0.006)	(0.011)	(0.002)	(0.002)
Apparatus	-0.002	-0.006***	0.007	0.022	0.003***	0.002**	0.000	0.000
	(0.002)	(0.002)	(0.007)	(0.043)	(0.001)	(0.001)	(0.000)	(0.000)
Fire type	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Property use	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Hour-of-day	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day-of-week	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month-of-year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Department FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ZIP code FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# Obs	115,476	18,484	33,837	7,444	115,476	18,484	115,476	18,484
Adjusted R^2	0.134	0.426	0.146	0.221	0.406	0.541	0.053	0.216

Note: CEM sample is matched on all runs for a random 20% sample of all departments. The coarsening variables include: distance to incident, number of existing contracts, the lopsidedness of the department's exchanges in alliances, interactions with partners, and interactions with overlapping partners, model controls variables. Balancing on contracts prunes observations to a k-to-k solution, while balancing on cooperation relaxes this restriction. All models are estimated with OLS with weights for matched sample. The unit of analysis is an incident (i) responded to by a particular department (j) on a particular day (t) in a particular ZIP code (z). Robust standard errors in parentheses clustered on departments. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

2.5 Appendix

Table 2.8: Cooperation regression results

	(1)	(2)	(3)	(4)
Dep Var	Cooperate	Cooperate	Cooperate	Cooperate
Estimator	OLS	Logit	OLS	Logit
After contract	0.063***	0.865***	0.023***	0.234***
	(0.002)	(0.026)	(0.002)	(0.018)
Personnel	0.001***	0.015***	0.001***	0.016***
	(0.000)	(0.001)	(0.000)	(0.001)
Apparatus	0.000	0.000	-0.000**	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
Property use	Yes	Yes	Yes	Yes
Incident type	Yes	Yes	Yes	Yes
Hour-of-day	Yes	Yes	Yes	Yes
Day-of-week	Yes	Yes	Yes	Yes
Month-of-year	Yes	Yes	Yes	Yes
State	Yes	Yes	Yes	Yes
Observations	140,979	140,979	133,960	133,960
Adjusted R^2	0.146		0.073	
Pseudo R^2		0.174		0.093

Note: Robust standard errors in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

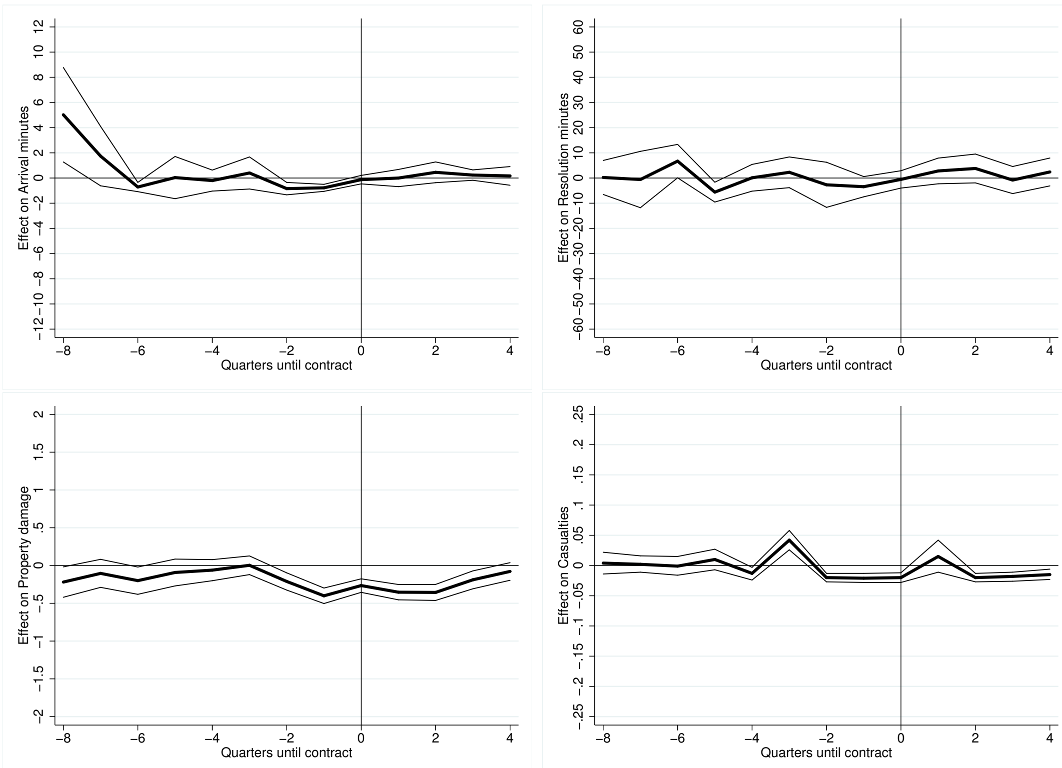


Figure 2.1: Pre and post treatment trends

This figure contains graphs plotting the dummy variable estimates for the quarterly effects of contracting in the periods before and after contracting for matched fire departments that eventually enter into an alliance contract. Estimates are generated by replacing the contracting variable with dummy variables for the quarters before and after contracting in the model specified in equation (2.2).

Chapter 3

Formal Contracts: Partner History and Networks

3.1 Introduction

How collaborating organizations structure the way they work together can impact both the success of an alliance and the success of the participating organizations. This paper focuses on antecedents to the decision to formalize previously informal arrangements by establishing a written contract between partnered organizations. In situations of repeated exchange between the same organizations relational mechanisms that affect how they behave come into play. Partners that repeatedly interact can establish trust and reputations which can improve cooperation. These organizations are also able to directly acquire information about each other and learn how to work together to improve coordination. Given the availability of relational mechanisms how do partnered organizations govern their relations?

I address this central question with two specific questions. First, given that formal governance alternatives are influenced by relational mechanisms (Ryall and Sampson 2009), and that not all interactions between allied organizations equally contribute to the formation of relational mechanisms (Gulati 1995a, Vanneste and Puranam 2010) what role do substantive differences in the history of exchange play in the decision to use a formal contract? Second, given that alliances between two organizations are embedded in a larger network of outside relations (Gulati 2007), and that these relations exert an influence on behavior within the alliance (Greif 1993, Robinson and Stuart 2007), how does social context of an alliance affect how substantive differences in the history of exchange are linked with formal contracting?

Questions about the link between relational and formal governance are of continued interest among organizational scholars. Management research that largely draws on agency, transaction cost, and social exchange theory examines variation in contract choices. These studies are divided between those that analyze static mechanisms linking relational and formal governance (Poppo and Zenger 2002, Vanneste and Puranam 2010) and those that analyze how relationships and governance unfold over time (Corts and Singh 2004, Reuer and Ariño 2007, Ryall and Sampson 2009). Because is it difficult to measure relational mechanisms reliably researchers have largely chosen to focus on identifying either specific mechanisms in cross-section or rough relational dynamics over time.[1] This has limited researchers' ability to theorize about and test how relational mechanisms arise over time and interact with governance decisions.

This study address this shortcoming by examining how the antecedents to relational mechanisms between alliance partners arise over time and influence decisions to enter into formal contracts. Specifically, I analyze two sources of feedback from past experience with the same partner: (i) the extent to which partners observe norms of reciprocity,

[1]Although survey-based approaches permit more rigorous measurement of complex and subtle constructs such as trust and reputation, they have limitations when trying to observe the dynamic process of how relationships unfold over time. Repeated sampling over time requires substantial effort, and it is difficult to exploit institutional changes identified retrospectively. Although aggregate measures of interaction history constructed from archival data are more widely available they obscure and conflate the effects of multiple mechanisms for governing collaborations. Aggregate measures of history allow us to examine the combined effects of different relational mechanisms as they unfold over time but not the individual mechanisms believed to be in operation nor in what manner. Therefore it is difficult to make precise statements about the relationship between relational and formal governance mechanisms.

and (ii) the extent to which prior interactions with the same partner yield positive outcomes. Alliance partners that observe reciprocal exchange over time are more likely to develop trust and reduce fears that partners will behave opportunistically in the future (Gouldner 1960, Blau 1964). So I argue that these organizations have diminished incentives to employ the costly and constraining controls of formal contracts. Similarly, alliance partners that observe better outcomes from their prior interactions will have greater confidence (i) in achieving consummate performance and effective coordination in subsequent collaborations, and (ii) in accepting risk within the relationship (Baum, Rowley, Shipilov, and Chuang 2005). As a result, these organizations will also have diminished incentives to employ formal contracts to ensure that each party discharges their responsibilities appropriately and to ensure that each party takes actions that are predictable to the other. This approach permits closer analysis of the constituent mechanisms that emerge via prior interactions in a dynamic context of relations unfolding over time.

In addition to the relational mechanisms that emerge between pairs of alliance partners there are influences from outside the relationship that affect how these partners behave within the relationship. The larger social networks in which an alliance is embedded represent one such influence. Questions about the link between social networks and governance choices are of continued interest among organizational scholars. An important insight of this literature is that networks of interactions help to make information about actors and their conduct more observable. Accordingly, this research has shown that current partner networks influence subsequent partner selection (Granovetter 1985, Gulati 1995b), enforce certain behaviors (Greif 1993), and provide pathways for information (Baum, Rowley, Shipilov, and Chuang 2005, Robinson and Stuart 2007). Although partner networks can exert a direct influence on how organizations behave in their dyadic interactions (Raub and Weesie 1990, Robinson and Stuart 2007) these networks may also exert an indirect influence on how partners interpret feedback from prior exchange within a particular alliance. Therefore, analysis that fails to consider differences in a partnership's network characteristics may confound effects derived from within the relationship with those derived from without.

This study address this shortcoming in the literature by incorporating the social influence of outside parties into a theory linking relational mechanisms and formal contracts. I distinguish between differences in the extent to which a firm and its partners (i) are embedded in the same network of mutual third parties (i.e. network closure) and (ii) have pre-existing formal contracts with outsiders. On the first point, I begin with the well-established idea that network closure increases the flow of information between partners. Network closure directly diminishes the value of formal contracting by reducing the likelihood of partners behaving opportunistically and experiencing coordination failures, and it indirectly diminishes the effect of reciprocal norms on contracting by raising each partner's tolerance for deviations. On the second point, I argue that outside contracts are both ongoing obligations and occasions for learning-to-contract. Outside contracts directly increase the value of formal contracting by decreasing outside obligations and inside contracting costs, and it indirectly enhances the effect of reciprocal norms on contracting by reducing each partner's tolerance for deviations from reciprocal norms.

The empirical setting for this study is the US fire services industry. Alliances among US fire departments are very common. In these relationships proximate departments work across the jurisdictional boundaries to respond to emergencies. These alliances have existed as long as the member fire departments, and for almost their entire history have been governed by"handshake" agreements. In the last two decades departments began to add formal written contracts to these relationships. With publicly available information covering a large sample of fire departments from 1999 to 2009 it is possible to construct networks of proximate, partnered, and contracted fire department pairs. It is also possible to objectively measure details of individual interactions such as the exchange of resources and meaningful performance outcomes. These features make this a useful setting in which to address this study's questions.

3.2 Theory

3.2.1 Formal contracts versus informal agreements

Longterm agreements between organizations represent an important governance alternative to market exchange and vertical integration. Agreements are maintained by mechanisms that safeguard the assets at risk in the exchange and devices to facilitate coordination of member contributions (Ring and Van de Ven 1992, Gulati 1995a). These agreements may include formal contracts which employ governance structures that differ in important ways from those that emerge in agreements that rely only on informal arrangements.

Formal contracts provide signatories with written descriptions of the actions to be take under different circumstances: rights and obligations, coordination programs, and frameworks for resolving disputes. These documents are negotiated ahead of time and are stated in terms that can be verified by outside parties (Baker, Gibbons, and Murphy 2002). The ability to verify whether the behavior of contract parties comply with the terms of the agreement permits parties to invoke legal means to enforce compliance and resolve disputes. Although legal mechanisms provide some assurances to collaborating organizations the threat of invoking their authority is often sufficient to ensure cooperation.

Formal contracts are costly and incomplete, however. Specifying more contract detail *ex ante* can involve a good deal of analytical effort and imagination. Furthermore settling on the final terms can involve difficult negotiations. These efforts can take up considerable managerial attention, involve lengthy data collection efforts, and result in costly legal fees. Contracts also often involve *ex post* controls such as bonding, monitoring, and verification which are costly. Because it is costly to contract on all possible risks contracting parties will intentionally omit some foreseen risks from contracts—particularly, those for which the perceived benefits do not outweighs the expected costs. Some risks are unforeseen, however. Owing to limits on human imagination and the ability to process information contract parties will unintentionally exclude important provisions. So, organizations often economize on and overlook provisions that prove to be useful had they been anticipated and detailed. As a result, contracts are incomplete and the possibility for disputes and opportunistic behaviors is not fully addressed.

Many dealings between organizations occur without the planning and sanctions of formal contracts (Macauley 1963). In contrast with formal contracts, informal arrangements rely on unwritten codes about how each party should behave to ensure cooperation (Baker, Gibbons, and Murphy 2002).[2] These expectations come from norms that each party brings to the relationship and those that are formed by repeatedly interacting over time. Additionally, they may occur at the individual level when members of organizations develop personal relationships across organization boundaries that involve trust and affection—both of which can smooth coordination and can hasten accommodations to unforeseen change (Granovetter 1985, Powell 1990). Compliance with codes of conduct are sustained not by the threat of court intervention but by the threat of damaging the relationship and foregoing future benefits. The relational mechanisms that emerge in long-term collaborations thus permit partners to reach accommodations when unforeseen events occur. These arrangements are not constrained by the need for provisions to be detailed in terms that can be verified *ex post*. As a result, they can cope with a wider range of outcomes and scope of information than formal contracts.

Contracts with a larger number of provisions offer more safeguards to protect the relationship from a larger number of risks (Puranam and Vanneste 2009, Ring and Van de Ven 1992). Under efficient contracting partners will specify the amount of detail they

[2] I use informal and relational interchangeably throughout the paper. Consistent with the literature, the most important difference between relational or informal arrangements and formal contracts is the the agreements are written and enforceable by legal means.

expect to provide the greatest net benefits to the exchange. One can think of an informal arrangement as equivalent to a relationship which is governed by a formal contract that contains no written detail whatsoever. I assume that organizations make contracting decisions they perceive to be efficient—that is, they contract when the perceived benefits justify the expected costs. In ongoing relationships informal mechanisms are available to partners for safeguarding and coordinating exchange. Since the addition of formal contracts to such relationships involves additional costs observing a contract implies that the perceived benefits of the contract must outweigh these costs.

3.2.2 Observed reciprocity and prior alliance performance

The social context that develops from the inside history of exchange over the course of a partnership undoubtedly plays an important role in how relations are governed (Granovetter 1985, Williamson 1991, Ring and Van de Ven 1992). A particularly important prosocial mechanism that often emerges is trust.[3] Trust facilitates the operation of many social systems. It is particularly important when simultaneous exchange is not possible, and when it is difficult to precisely specify obligations (Arrow 1974). It provides exchange partners with confidence that each party will live up to the expectations of their arrangement, and that each party will take actions to accommodate the relationship should conflicts arise. Trust is an organizing principle for subdividing work among interdependent parties that may not have perfectly aligned goals and that face uncertainty (McEvily, Perrone, and Zaheer 2003)—a powerful governance mechanism that diminishes the risks of working across organization borders.

Viewing exchange as a social phenomenon rather than a purely economic one has its foundations in sociology theory. Blau (1964) describes social exchange as occurring

[3] I defined trust as the willingness to be vulnerable to the decisions and actions of another party based on confident positive expectations about the motives and intentions of that party. In less precise terms, the expectation that partners will not behave opportunistically (Gulati 1995a, McEvily, Perrone, and Zaheer 2003, for review).

when favors are granted that create obligations to be repaid in the future. Because these obligations are not precisely specified in advance there is no way to ensure that the favor returned is appropriate. As a result social exchange tends to involve feelings of personal indebtedness, gratitude, and trust. Reciprocity plays an important part in these transactions. The norm states that people should help those that have helped them with a return of proportional value (Gouldner 1960). There is a related logic from economics for rationalizing cooperative behavior in games of repeated cooperation where reciprocal exchange is employed as a signal of trustworthiness (MacLeod 2007, for review).

Trust emerges to the extent that exchange parties observe the norms of equity and reciprocity over the course of the relationship. When someone provides a favor this act demonstrates trust. When recipients return the favor this response assures the sender that the original extension of trust was justified. On the other hand, failure to reciprocate generates a loss of trust. As organizations repeatedly interact they learn about each others' intentions by observing actual behavior which provides a basis for trust formation or loss. Trust emerges when exchange parties believe that their partners have fulfilled the obligations of the relationship and these mutual obligations encompass an equitable exchange.

Trust affects a variety of organizational phenomena that are important to collaboration (Dirks and Ferrin 2001, for review). It can improve communications, reduce conflicts, and positively influence how partner behaviors are interpreted, for instance. The existence of trust between partnered organizations can make contracting more effective and less costly. Partners that incorporate more provisions into their contracts may enjoy protection against foreseen risks. However, partners that incorporate fewer details but rely more on trust may enjoy more robust protection against risks that arise under greater uncertainty (McEvily, Perrone, and Zaheer 2003, Williamson 1985) and complexity (Tadelis 2002) or among outcomes that are difficult to verify (Bernheim and Whinston 1998).

Scholars have argued that trust is generated through repeated interactions and so repeated interactions provide a reasonable proxy for trust (Gulati 1995b); however, the logic described suggests that not all interactions contribute to trust formation. These interactions may equally provide occasion for the development of trust or mistrust. From an empirical standpoint there is doubt regarding the link between repeated interactions among organizations and the emergence of trust (Gulati and Sytch 2008). Furthermore, repeated interactions conflate learning how to work together with learning about partner intentions and the state of cooperation (Zollo, Reuer, and Singh 2002). This suggests that history between partners may be necessary but not sufficient for the formation of trust, and that links between the amount of history between partners and governance choices may arise for reasons distinct from trust. Therefore, it is necessary to examine the substance of interaction history to assess how trust is related with governance choices.

Following Gouldner's (1960) and Blau's (1964) logic of social exchange, when exchange is not immediately reciprocal there will necessarily be periods of inequity between exchange partners. Larger and longer periods of inequity are associated with greater risks that repayment will be perceived as unequal (i.e. lopsided) and that trust will erode. In such circumstances indebted partners are more likely to seek out contracts as a means of ensuring equitable exchange in the future and a remedy for an absence of trust. Therefore,

> **Hypothesis 1:** the more lopsided the history of exchange between partnered organizations the more likely they are to enter into a formal contract (H1).

The success of past collaborations provides useful feedback for interpreting the effectiveness of existing governance structures. The more frequently partners have successfully interacted in the past the more likely they are to develop confidence that subsequent exchanges will be mutually beneficial. This confidence leads partners to share information more freely with each other than partners that have a history of unsuccessful interactions. Greater sharing reduces information asymmetries and the risks of opportunistic behavior (Ring and Van de Ven 1992). As a result, a history of successful interactions permits alliance partners to rely less on contractual provisions designed to mechanically align incentives and reduce information asymmetries.

Performance feedback from the past also influences the likelihood of organizational change in the future. Behavioral theories of the firm argue and show that failure to achieve aspirations induces search processes to remedy performance shortfalls (Cyert and March 1963, Greve 2003). Partners with a history of achieving worse outcomes within the alliance are more likely to fall short of aspirations and subsequently pursue managerial interventions. Because problems that stem from how partners work together are common sources of failure in alliances governance mechanisms are a major focus of managerial attention (Kale and Singh 2009). Informal mechanisms—such as trust, learning, and reputations—tend to emerge slowly over time and so are less susceptible to direct managerial intervention. In contrast, formal contracts with their concrete plans and responsibilities are more susceptible to direct managerial intervention. So, for organizations experiencing poor outcomes, formal contracts present a tool for effecting immediate and direct change in how partners work together. Therefore,

> **Hypothesis 2:** the worse the history of performance among partnered organizations the more likely they are to enter into a formal contract (H2).

3.2.3 Mutual partners and outside contracts

Trust is an important influence on cooperative behavior within a relationship, and it emerges from a variety of sources. It can come from expectations of continuity that may arise from the prospect of valuable future interactions (Levin 2003) and a high degree of interdependence (Pfeffer and Salancik 1978). As described above, it can emerge from a history of direct exchange between two organizations. It can also come from outside information accumulated through networks of related parties (Beckman, Haunschild, and

Phillips 2004). In particular, social networks play an important role in transmitting useful information such as endorsements and trustworthiness (Granovetter 1985, Gulati and Gargiulo 1999, Robinson and Stuart 2007).

Reputations emerge if an organization's future partners are informed about its current behavior. The extent to which future partners are informed in turn depends on the embeddedness of the organizations at risk of partnering (Raub and Weesie 1990). Organizations are more likely to extend trust to partners that have a reputation among related organizations for being trustworthy (MacLeod 2007): for instance, by following the norms of equity with prior partners. Since information regarding a partner's trustworthiness is not easily observable network structures play an important role in collecting, transmitting, and evaluating this information.

Outside partners can provide a trusted source of information regarding what to expect of a focal partner when interactions are infrequent. As a result, second-order ties can serve several important functions. Greater interconnectedness (or network closure) increases information flow and the visibility of actions taken by network members (Reagans and McEvily 2003, Baum, Rowley, Shipilov, and Chuang 2005). As a result, reputation mechanisms become more powerful and thereby deter actions that would signal untrustworthiness (Gulati 1995b, Robinson and Stuart 2007).

Network closure can also provide a social enforcement mechanism in which network members collectively punish observed deviations from cooperative norms (Greif 1993). More recent economic theory, supported by experimental evidence, suggests that exchange partners are more willing to extend trust when there is a greater number of common parties (Karlan, Rosenblat, Möbius, and Szeidl 2009). Having more common partners increases network flow for enforcing reciprocity independent of the embeddedness of members within a focal partnership.

When organizations are embedded in networks of densely interconnected partners their behavior is more observable and so the costs (benefits) of behaving badly (well) influence their actions. Mutual third parties close these networks and give rise to network forms of governance that operate in conjunction with relational and contractual governance. In the presence of network governance the value of contracting as a means of inducing better behavior within an alliance diminish. Therefore,

> **Hypothesis 3A:** the more outside partners shared between members of a partnership (i.e. common partners) the less likely they are to enter into a formal contract (H3A).

Differences in shared third party ties across partner pairs may exert not just a direct effect on individual behavior within the focal partnership but may also affect how feedback from prior experience working together influences governance choices. Because exchange partners must endure periods of inequity between the completion of reciprocal exchanges they require trust. The longer the periods of inequity the greater the requirement of trust. Organizations are more likely to extend trust to organizations that have a good reputation among related organizations. As a result, focal partnerships that operate in the presence of a strong outside reputation system can endure longer periods of inequity and still establish trust. That is, partnerships are more likely to withstand longer delays in reciprocity and unbalanced exchanges in the presence of more common partners because of the trust that these interconnections provide to partners. Partnerships in which members share a larger number of outside partners can better trust their partners to behave according to expectations because information about transgressions are much more likely to reach other partners—negatively affecting their reputations.

In addition to transmitting reputation information, common partners provide a mechanism for transmitting information about dyadic entitlements and obligations among interconnected parties. This is important because the norm of reciprocity which sustains trust is not strictly a directed principal preoccupied "paying it back." Rather, the norm also applies to indirect social exchange in which actors "pay it forward" to a party other than the one from which a favor was originally received (Ekeh 1974, Bearman 1997).[4] I assume that organizations do not behave in a completely altruistic manner, and that they are more likely to extend favors to partnered than non-partnered organizations. This assumption is supported by recent theory and evidence on individuals which suggests that grants increase as visibility between partners improves (Baker and Levine 2009, Leider, Möbius, Rosenblat, and Do 2009). When a pair of partners is more embedded in a network of common partners there is more information available to each party regarding the obligations and entitlements of the parties engaged in generalized exchange. That is, partners can better assess the extent to which obligations are paid forward and generalized exchange is indeed reciprocal. Members of a partnership will place less emphasis on the extent to which direct exchange between them is reciprocal when generalized exchange norms are at work.

Additionally, greater interconnection among members of partnerships through shared third-party ties increases the likelihood that these members will be exposed to and adopt similar ways of doing things, that they will use the similar terminology, and that they will abide the same norms. That is, that they will converge on similar production technologies and interpretive frameworks. Organizations that converge on similar operating procedures, vocabularies, and technologies are more likely to have compatible processes and better communications with which to rapidly sense and signal the actions to be taken. Therefore, partnerships embedded in more densely interconnected networks are more likely to enjoy smooth coordination and better performance. As a result, the expected gains to coordination of establishing formal contracts will be relatively smaller. Furthermore, the increased network flow generated by common partners will reduce information asymmetries between partners. Consequently, prior performance will have a smaller impact on the likelihood that partnered organizations will share information.

To summarize, shared third-parties increase the flow of information between part-

[4]This is also known as transitivity in the network literature (Gulati and Gargiulo 1999).

nered organizations. Increased network flow enhances external reputation effects; facilitates indirect reciprocity; increases the likelihood of partners having common operating standards and communications patterns; and, reduces information asymmetries between partners. Stronger external reputation mechanisms faced by partners and the operation of indirect reciprocity increase a partnership's tolerance for deviations from perfectly reciprocal exchanges. The enhanced coordination partners experience from having more compatible operating procedures and the lower information asymmetries reduce the relative value of using formal contracts as a remedy for poor performing collaborations. Taken together, the arguments suggest that

> **Hypothesis 3B:** more common partners will diminish the effect of lopsidedness on the likelihood that partners will formally contract (H3B).

> **Hypothesis 3C:** more common partners will diminish the effect prior performance on the likelihood that partners will formally contract (H3C) .

Formal contracts between organizations are negotiated, mutually agreed upon, and explicit. Formal contracts also carry the threat of court intervention for failures to cooperate with the terms of the agreement. As a result, exchange parties focus attention on the written document as a reference point to assess whether each party has fulfilled their part of the arrangement (Hart and Moore 2008). In contrast, exchanges that occur under informal arrangements involve more diffuse obligations. As a result, partners are more likely to hold asymmetric evaluations of what constitutes giving and receiving like for like and thereby experience greater perceived imbalances (Flynn 2006). For these reasons, dyadic relations governed by formal contracts are expected to carry stronger mutual obligations than those governed solely with informal understandings.

Members of a focal partnership are often engaged in relationships with multiple partners. Focal partnerships with more outside partners are subject to more competing demands than those with fewer outside partnerships. Because organizations are capacity constrained they must ration the favors they provide. Competing demands therefore must be prioritized. Like the focal partnership, outside partnerships may be governed with formal contracts or informal agreements. Priority may be determined by a variety of factors—including prior obligations accumulated through a history of repeated exchange, for instance. However, partners that use contracts as reference points of assessing cooperation will be less forgiving of deviations than the more diffuse obligations associated with informal arrangements alone. As a result, the demands on an organization from partners with formal contracts are more likely to take priority over demands from partners with informal arrangements.

Organizations often repeat actions and decisions they have made before. Such repetition can form the basis for learning. Indeed a large body of research suggests that organizations learn from experience (Argote 1999, for review). Contracting is a complex process involving substantial effort and skill. Knowing what provisions to include, how to specify them, and how to come to an agreements can affect the success of the collaboration. Contracting know-how can be developed through experience contracting in the past. Recent research suggests that organizations learn to contract by repeatedly doing so. In their case study on contracts in the computer industry, Mayer and Argyres (2004) find evidence of changes in contractual provisions over time that suggest firms learn to contract with each other. Argyres and Mayer (2007) argue that contract design capabilities rest on learning about the details to include in a contract while Argyres, Bercovitz, and Mayer (2007) find evidence of learning to contract in the complementarity between contingency planning and task description.

Alliances with members that have contracting experience are more likely to have developed know-how with which to contract more effectively than alliances with members that lack this experience. Therefore, alliance partners with a larger number of contracts with other organizations (i) face stronger external demands on their resources and (ii) are more likely to possess the contracting know-how. Setting up a formal contract between a pair of partnered organizations increases the priority of this focal relationship relative to the other relationships in which the member organizations are embedded. In this way contracts reduce the competition for access to alliance partner resources by outsiders—thereby raising the value and consequent probability of contracting. Partnerships where the members possess more contracting know-how can setup more effective contracts in a more efficient manner—consequently raising the probability of contracting. Taken together, these arguments imply as a baseline that the more outside contracts possessed by partnered organizations the more likely they will be to enter into a formal contract.

The presence of outside contracts may also affect how members of a focal partnership interpret the feedback from prior dyadic interactions. Specifically, because outside contracts increase competition for the resources and attention of the organizations in a focal partnership the relationship will only tolerate smaller deviations from (i) reciprocal norms and (ii) good outcomes before taking steps to improve how the relationship operations. Partners will be less tolerant of longer or larger departures from equitable exchange because the risk that equity will not be satisfactorily restored is higher when there are demands of greater priority outside the focal relationship. That is because outside obligations will reduce the ability and willingness of partners to fulfill the diffuse obligations associated with indebtedness accrued under informal arrangements.

Similarly, poor performance on prior collaborations is more likely to be viewed as a more serious problem in the presence of a larger number of outside contracts. That is because outside contracts generate interdependencies that make coordinating within a focal partnership more difficult. Formal contracts provide explicit plans with provisions that can account for obligations generated by outside contract partners. In particular, they can provide ways to deal with conflicts that arise with outside partners. Because outside contracts also provide concrete evidence of outside demand on alliance members—a potential source of poor performance—a worse history of performance will increase the probability of seeking out formal contracts as a remedy in the presence of a larger number of outside contracts. In summary, outside contracts diminish the tolerance that alliance partners have for imbalance and poor performance in the relationship and intensify the value of seeking contractual remedies. Therefore,

> **Hypothesis 4A:** more outside contracts will enhance the effect of lopsidedness on the likelihood that partners will formally contract (H4A).

> **Hypothesis 4B:** more outside contracts will enhance the effect of performance on the likelihood that partners will formally contract (H4B).

3.3 Model, data and empirics

3.3.1 Fire departments

Fire departments constitute distinct organizations with their own funding, assets, and authority. Nonetheless, it is imperative to collaborate across these organizational lines. The resources and services of proximate departments make up an important part of a department's production technology. Fire departments are budget constrained while fires require urgent attention and arrive unpredictably in location and timing. Of course fire services cannot be stored. As a result, government officials have the difficult task of providing sufficient resources to address the most serious demands without overburdening the community's resource base. Furthermore, service areas are often defined by political boundaries not by geographic impediments to collaborations among adjacent departments. It is not surprising then that 23 percent of fire department runs involve assistance from another department.

In the past mutual aid occurred solely under handshake agreements between fire chiefs of neighboring departments. More recently, departments began entering into formal contractual relations. These contracts specify the services to be provided, the circumstances under which requests for help can be refused, the allocation of liability, workers' compensation responsibility, and how to integrate command functions. The most recent edition of the *Fire Chief's Handbook* discusses formal contracting for mutual aid:

> "The practice of fire departments helping one another is nothing new. However, often such arrangements are informal in nature, and not infrequently are even unwritten contracts...A written contract forces the parties to consider what their expectations are of the other party, and memorializes those expectations for the benefit of those who may not have been around when the original agreement was made. A mutual aid contract is a contract like any other. It sets out certain rights and obligations of the parties and liability can flow from failure to abide its terms." (Barr and Eversole 2006, Ch.4; p.175)

US fire departments began entering into formal contracts known as automatic aid agreements in the last two decades. These arrangements involve pre-arranged plans as well as reciprocal rights and obligations enshrined in written documents and operating technologies. These agreements have legal force and are recognized by the Insurance Service Office which rates fire department capabilities nationally for insurers. Mutual aid arrangements in the absence of an automatic aid agreement only sometimes involve written contracts. In contrast mutual aid arrangements in the presence of automatic aid agreements almost always involve written contracts that have both legal and operational force. Therefore the adoption of automatic aid has been associated with an increase in formal contracting among US fire departments.

Mutual aid among fire departments provide opportunities to create value by raising service levels without increasing resource allocations. Because these organizations are not setup to accumulate wealth, because the stakes are mortal, and because professional ethics encourage helping behavior incentive problems are muted. Nonetheless, departments are able to appropriate value from a mutual aid relationship by free-riding and/or delivering only perfunctory performance *ex post*. Coordination problems are more widely acknowledged in the industry, however. Because departments employ different production technologies—different equipment, different response standards, different terminology, different operating procedures, etc.—it can be difficult to work together.

3.3.2 Identification strategy and estimation

This study addresses the determinants of contractual relations between separate US fire departments. I model the probability that a particular fire department j contracts with another given fire department k for the ongoing exchange of resources and services in a given period t. In principle the analysis might consider contracting among every possible dyad and estimate the effects of covariates on the likelihood of realizing a contract. As Sorenson and Stuart (2001) point out the use of so many repeated observations is problematic because: (i) repeated observations of the same organizations create non-independence among cases, (ii) standard errors will be under-estimated for organizational covariates that do not varying across observations, and (iii) estimation is computationally burdensome.

While sampling reduces these problems it fails to account for the fact the estimates are driven by contract realizations. Consequently, following Sorenson and Stuart (2001) I include all contract realizations that appear in the data. I then construct two set separate samples for the analysis. Whereas Sorenson and Stuart (2001) generate a matched sample of potential ties the existing relationships among fire departments provide a reasonable basis for comparison. Therefore, attention is restricted to the subsample of dyads formed by departments that interact at least once in the eleven year observation window.[5] Since contracting is a new governance technology which diffused through a population of relatively stable alliance relationships this sample best reflects the dyads at risk of contracting. The average fire department enters the sample 17 times rather than the 20,224 times in the matrix of all possible contractual relations each for an average of 5 years. To address the dependence among errors over time robust standard errors are estimated clustering on the the department pair (j, k).

[5] I refer to this sample in the tables as "partners."

To further address selection concerns an additional sample was created by matching in the following manner.[6] First, I screened the sample to include only dyads that eventually contract. Next, I screened and matched these dyads with two additional dyads: a dyad including one of the contracting members and another department for which there is evidence of partnership in the sample, and another dyad for which there is no evidence of partnership but that is geographically proximate to the original contracting department.[7] I present analysis on this sample as a robustness check.

The empirical goal is to estimate the relationship between formal contracting choices, two inside history variables (lopsidedness of prior exchange and past performance), and two outside network variables (mutual third-party ties and pre-existing contracts with outside partners). Each observation is for a partnership between department j and department k in year t: therefore the unit of analysis is the dyad-year. I model the probability that a particular fire department j enters into a contract for organizing how it works with a given partner k in period t in the following manner:

$$Pr(Contract_{jkt} = 1|X_{jkt}) = \Phi(X'_{jkt}\Theta) \tag{3.1}$$

In equation (3.1), the probability of a contract for dyad jk in t is a function $\Phi(.)$ of X_{jkt} vector of variables and Θ vector of parameters to be estimated. X_{jkt} includes the following variables: the lopsidedness (H1) and performance (H2) of prior exchanges, mutual partners (H3A), outside contracts, and interaction terms for lopsidedness with both mutual partners and outside contracts (H3B, H3C) as well as performance with both mutual partners and outside contracts (H4A, H4B).

I model and estimate equation (3.1) in three ways: first, as a probit model where $\Phi(.)$ follows a standard normal cumulative distribution function estimated by a maximum-likelihood (ML) procedure; second, a linear probability model (LPM) where $\Phi(.)$ forms

[6] I refer to this sample in the tables as "matched."

[7] A threshold of 15 miles was selected to form networks of proximate departments.

a linear combination of variables and coefficients estimated with ordinary least squares (OLS); third, a logit model where $\Phi(.)$ follows a logistic function estimated by ML. I focus on the probit estimates because this model is robust to intertemporal correlation among errors that will naturally arise with repeated observations over time (Train 2003). I present estimates for the LPM and logit models as robustness checks. The results are presented both numerically and graphically following the approach outlined by Zelner (2009) for nonlinear models.

3.3.3 Data and sample

The dataset from which I draw a sample is an unbalanced panel including roughly 24,000 US fire departments.[8] The dataset covers about 85 percent of the total population, and includes observations in the period between 1999 and 2006. The sample was collected by the USFA through individual fire department efforts to record information using the National Fire Incident Reporting System (NFIRS)—a standardized reporting format.[9] After matching department run data and accounting for non-reports, other missing data, and excluding observations after the first year in which formal contracts are identified the regression sample includes 256,296 dyad-years: 60,666 unique dyads of partnered departments each with an average of 4.2 years in the sample.[10] by removing observa-

[8]Because the panel is unbalanced the networks of some partnerships will be incomplete for departments that are not reporting in the same year. To address selection concerns the analyses were conducted on three samples restricted by the proportion of each partnership's networks that are reporting in every sample year from the least restrictive sample which ignores this issue (presented below, n=163,960), partnerships with at least 50% of partners reporting in every year (n=135,246), and 100% reporting (n=18,982). The estimates are consistent across each sample. In all cases the coefficients increase in magnitude as the sample becomes more restrictive, but the estimates become less precise with wider confidence intervals around the predicted probabilities. Overall, the results are robust to missing information on networks that result from the unbalanced panel.

[9]NFIRS was first established in 1974 to gather and analyze information on the magnitude of the nation's fire problem, but only gained broad adoption in the last decade. The USFA provides a public-release format of data available since the the most current NFIRS version was introduced in January 1999. This version represents the most comprehensive reporting format since the system began.

[10]In their raw form the data contain detailed information about each department-run: that is, each time a reporting department is called to respond to an incident. About 23 percent of fire runs involve assistance from at least one other department—totaling roughly 1.5 million department runs. Using a matching file provided by the USFA and validation with an algorithm that matches runs based on

tions for dyads once they have contracted this research design can be interpreted as a hazard model in which the estimated coefficients represent the effect on the probability of entering into a contract conditional on not having done so already.

3.3.4 Measures

Dependent variable. I measure formal contracts between two partners as an indicator variable for the first year in which collaboration occurs with the use of an automatic aid agreement. Although some departments use written documents without automatic aid agreements almost all automatic aid agreements are enacted with contracts that include written documentation and binding legal authority.

Independent variables. The inside history variables use two-years of prior data to develop measures of prior experience of exchange between partners. Note that because my sample is left censored I cannot observe partnerships from the time they are first formed. In fact, these partnerships are likely to date back over a century. The moving-window approach makes sense for two reasons.[11] First, the most recent years of experience are the most salient to decision-makers—there is likely a substantial discount on distant history. Second, the data set covers a period following an important institutional shift that made collaborating more important and consequently generated new dynamics in collaborating experience.[12] I measure the extent to which norms of reciprocity between partnered departments have been observed in the past with lopsidedness: the absolute difference between the sum of aid given by one partner and aid returned by the other in the prior two years. I measure prior performance with the logarithm of the total

location, timing, and assistance the data were converted from department-runs to partner-runs yielding a total of roughly 660,000 partner-runs. These data were then converted to partner-years and after accounting for years where one partner did not report or there were other missing data a regression sample of 163,960 observations remained among 49,016 partnerships.

[11] I estimated the models using every possible history window permitted by the 8 year sample available to me, and the results were robust to these different operationalizations.

[12] This shift is the 1998 statement of the "two-in/two-out" rule—a national fire protection operating guideline. This rule raised the importance of cooperating across organizational lines because the guideline calls for twice the redundancy of firefighters when attacking structure fires than in the past.

value in 1999 US dollars of contents and real property lost on aid runs per dyad per year. Both lopsidedness and prior performance are highly skewed across partnership-years: the means are very small relative to the the 99th percentile values even for the logarithm of prior performance. This is not surprising given the wide variation in the size of political jurisdictions which determine department sizes: according to the USFA 14 percent of all departments are career or mostly career and protect 61 percent of the U.S. population.

Controls. I include several control variables. To account for the baseline opportunity for partners to implement formal contracts that involve automatic dispatching I include a control for whether departments are located across a state border (different states) and the distance between jurisdictions. These controls address concerns that variation in the presence of state borders and greater distance separating partners might affect the nature of the collaboration experienced, the network characteristics of the dyad, and the likelihood of establishing a formal contract that might spuriously drive the hypothesized effects. Different states is measured with a dummy variable indicating that partnered departments are located in two different states. Because of differences in state authority over how departments are funded and constrained by state laws, partners that are located across state lines are likely to face greater difficulties specifying adequate formal contracts and implementing the necessary supporting devices than those located in the same state.

I measure distance with the geodesic distance in miles between the center of the Zip code in which each department headquarters is located. Partners located farther apart may develop different interaction histories (e.g. drawing incidents from a different part of the severity distribution), face a different risk set for outside partner networks (e.g. less likely to have common partners), and confront different contracting challenges (e.g. more detailed rules for automatic dispatching) than those that are closer together. So, without controls for distance the relationship between interaction histories, networks, and contracting may be biased.

I also control for a more traditional transaction cost shifter of optimal governance choice: uncertainty (Richman and Macher 2006, for review). Transactions involving greater uncertainty lead to more hierarchical governance choices in the presence of specific assets; however, unpredictability (a particular form of uncertainty) tends to be associated with governance structures on the market end of the spectrum.[13] More unpredictable transactions place greater demands on partners to jointly adapt. Because formal contracts entail stronger bureaucratic controls than informal arrangements, and because an integrated organization can be construed as a nexus of complex contracts, I consider formal contracts to be closer to the hierarchy end of the market-hierarchy continuum than informal arrangements. I measure unpredictability with the partnership average of the ratio of the 95^{th} percentile daily personnel load for each department over the mean daily personnel load per dyad per year. The logic of this measure is that partner years with large differences between days with average demands and days with high demands will have a harder time predicting demands within these years.

Additionally, I control for the baseline demands on each partnered department with the total number of fires responded to per dyad per year. I control for the frequency with which each dyad interacts with a count of current interactions, and the demands for assistance from other aid partners with outside aid runs. Finally, I control for the aggregate number of prior interactions per dyad per year with the cumulative sum of current interactions in the prior two years. This measure is commonly used to proxy for the extent to which partners are embedded in their dyadic relations.

[13]The empirical evidence relating uncertainty and governance choice is inconsistent. This may be due to the different types of uncertainty that have been analyzed (Richman and Macher 2006)

3.4 Results

3.4.1 Inside history

The first question this paper asks is: "How do substantive differences in prior interactions among repeated exchange partners affect formal contracting?" To answer this question I focus on two features of prior interactions: the lopsidedness of exchange and the quality of realized performance among partnered organizations. These variables have more clear theoretical links with formal contracting decisions than aggregate prior interactions alone. First, the lopsidedness of relations measures of the extent to which members of a focal partnership observe the principal of reciprocity thereby enhancing the formation of trust and reducing the need for formal contracts to ensure equitable exchange. Second, the quality of realized performance measures the extent to which members should trust that the relationship contributes to organizational goals thereby reducing the marginal benefits of formal contracts as a means of better coordinating activities across partners.

Table 3.2 presents estimates of the main effects of lopsidedness and prior performance on the decision for a focal partnership to formally contract (i.e. contract). The estimate of the coefficient on lopsidedness in model (6)—which includes a full set of control variables and year fixed effects—is positive and statistically different than zero. This suggests that partnerships in years where the recent history of exchange is more lopsided, and therefore the norms of reciprocity are less closely observed, are more likely to establish formal contracts. Graph (a) in figure 3.1 depicts the predicted probability of entering into a formal contract for different values of lopsidedness. These values are point estimates but are subject to uncertainty from sampling error and un-modeled random factors. This uncertainty is estimated and presented in figures 3.1 through 3.4 as 95% confidence intervals according to the simulation-based approach developed by King, Tomz, and Wittenberg (2000). A two standard deviation increase in lopsidedness is associated with an increase in the predicted probability of formal contracting equal to roughly 8 percentage points.[14] Over the range of observed values of lopsidedness from the mean to the 99th percentile the predicted probability increases by 32 percentage points. These results provide support for H1.

The estimate of the coefficient on prior performance in model (6) of table 3.2—measured as the logarithm of prior material losses on aid runs—is also positive and statistically significant. This suggests that partnerships in years where the recent performance of collaborations is worse are more likely to formally contract. Graph (b) in figure 3.1 depicts the predicted probability of entering into a formal contract for different values of prior performance. A two-standard deviation increase in prior performance is associated with an increase in the predicted probability of formally contracting equal to roughly 6 percentage points.[15] Over the range of observed values of prior performance from the mean to the 99th percentile the predicted probability increases 14 percentage points. These results provide support for H2.

3.4.2 Partner networks

The second question this paper asks is: "How do differences in the outside network of partners for members of a repeated exchange relation affect the decision to establish a formal contract?" To answer this question I focus on two features of outside networks: the number of common partners and the number of outside contracts among members of a focal partnership. This paper argues that it is important to consider the impact of differences in key network characteristics when evaluating the link between the relational mechanisms that emerge in repeated exchange and formal contracting. First,

[14] When considering the difference between the upper boundary of the 95% confidence interval around the predicted probability at the mean value of lopsidedness and the lower boundary on the interval around the predicted probability at two standard deviations above the mean the increase diminishes to 4 percentage points.

[15] When considering the difference between the upper boundary of the 95% confidence interval around the predicted probability at the mean value of prior performance and the lower boundary on the interval around the predicted probability at two standard deviations above the mean the increase also diminishes to 4 percentage points.

organizations embedded in networks are influenced by their social context in ways that directly affect how they behave within their dyadic relationships. Second, differences in these networks influence how members translate experience within dyadic relationships into mechanisms for governing a partnership over time. This paper argues that common partners increase network flow which enhances a partnership's tolerance for wider deviations from reciprocal exchange and good prior performance. It also argues that formal contracts with outside partners (outside contracts) alter focal partner priorities and obligations creating increased competition for focal partner attention and resources. Because this competition may be reduced by establishing a formal contract with explicit negotiated obligations the marginal effect of more lopsided prior interactions and worse performance is expected to be greater for partnerships with more outside contracts.

The estimate of the main effect of common partners on formal contracting in model (6) of table 3.2 is negative and statistically significant. This suggests that partners with more shared outside partners are less likely to establish formal contracts—providing support for H3A. Table 3.3 presents the point estimates of the coefficients on the interactions between common partners and the inside history variables: lopsidedness and prior performance. The estimated coefficients on these interactions presented in model (5) of table 3.3 are negative and statistically significant. This suggests that more common partners decrease the effect of lopsidedness and prior performance on formal contracting—providing support for H3B and H3C, respectively.

Putting these results into more concrete terms, partnerships with four additional common partners (equal to less than two standard deviations) have a predicted probability of formal contracting that is 8 percentage points lower than the predicted value at the mean.[16] Over the broader range of observed common partners values, the predicted prob-

[16]When considering the difference between the lower boundary of the 95% confidence interval around the predicted probability at the mean common partners and the lower boundary on the interval around the predicted probability at two standard deviations above the mean the decrease is reduced to 6 percentage points.

ability for the 99th percentile is 16 percentage points lower than the predicted probability at the mean value. Figure 3.3 presents the predicted probabilities for different values of common partners, lopsidedness, and prior performance. In graph (a), the difference between the upper and lower 95th percentile number of common partners is statistically significant at between -10% and -26% for different levels of lopsidedness. In graph (b) the difference in predicted probabilities between the upper and lower 95th percentile number of common partners is statistically significant at between -9% and -28% for different levels of prior performance. These results provide further support for H3B and H3C.

The estimate of the main effect of outside contracts on formal contracting in model (6) of table 3.2 is positive and statistically significant. This suggests that focal partners with more outside contracts are more likely to establish formal contracts—providing support for the baseline prediction. The estimated coefficients on the interaction between outside contracts and lopsidedness presented in model (5) of table 3.3 is small but positive and statistically significant. This suggests that more outside contracts increase the effect of lopsidedness on formal contracting. The estimated coefficients on the interaction between outside contracts and prior performance is positive and statistically significant. This suggests that more outside contracts increase the effect of prior performance on formal contracting. These results provide support for H4A and H4B, respectively.

Analysis of predicted probabilities is also instructive. Figure 3.4 depicts these results using differences in predicted probabilities between the upper and lower 95th percentile values of outside contracts for different values of the inside history variables. In graph (a) of this figure, the difference between the upper and lower 95th percentile number of outside contracts is statistically significant at between 4% and 34% for different levels of lopsidedness. In graph (b), the difference in predicted probabilities between the upper and lower 95th percentile number of outside contracts is statistically significant at between 36 and 38 percent for different levels of prior performance. These results are unambiguous: an increase in outside contracts increases the effect of lopsidedness and prior performance on formal contracts. These results provide strong support for H4A and H4B. However, its worth noting that the size of the increase decreases substantially for larger values of lopsidedness suggesting that the moderating effect only holds for small departures from reciprocal norms.

3.4.3 Robustness

The results are robust to three modifications to the primary research design: use of a linear probability model, a logistic link function, and a matched sample of departments. The results of these modifications are presented in tables 3.4 for the primary sample and table 3.5 for the matched sample. In the linear probability model the coefficients can be interpreted directly as as changes in the probability of contracting—that is, the slope of the conditional expectation function. The logit assumes a different link function than the probit and offers a point of comparison. Both the LPM and logit estimates broadly conform to the probit estimates. The LPM estimates are smaller in magnitude than both the probit and logit estimates, but they are qualitatively similar in all cases but the interaction between lopsidedness and common partners where the coefficient is not statistically different than zero.[17] The estimates in the matched sample are also broadly consistent across models. While the magnitude of the effects of the inside history variables is larger for the matched sample then the partner sample the magnitude of the effects of the partner network variables is smaller. The interactions effects are less stable for the LPM estimates on the matched sample then the partners sample. They are however broadly consistent with the main findings with the exception of the estimate of the coefficient on the interaction between prior performance and common partners which is not statistically different from zero.

[17] Among the sample which includes dyads for which there is evidence of interaction all three models yield consistent estimates of the main effects of lopsidedness, prior performance, mutual partners, and outside contracts on the probability of contracting (see table 3.4 for details). All coefficients are statistically significant and carry the same sign.

3.5 Discussion and conclusion

Mechanisms that arise from a history of prior interactions and the prospect of future interactions are available for governing the way partners behave in repeated collaborations. This paper argues that variation in the amount of history between partners tells us relatively little about what governance structure organizations are likely to choose. Rather, it is the substantive differences in this history that determine how relational mechanisms arise in repeated exchange relations and how these mechanisms influence governance choices.

This paper focuses on two important aspects of history: the extent to which partnered organizations have observed (i) the norm of reciprocity (antecedent to the emergence of trust) and (ii) poor performance on collaborations (antecedent to organizational change and the loss of trust) over the course of their relationship. The results suggest that partners with a recent history of lopsided exchange and poor alliance performance are more likely to enter formal contracts than those that have observed the norm of reciprocity and good performance—at least for the US fire departments in this time period.

This paper also considers how behavior within a partnership and feedback from prior interactions may be subject to differences in the outside arrangements of other partners. In so doing this analysis explores the possibility that two partnerships with similar interaction histories may make different governance choices because of differences that arise from the network of partners outside the relationship. I distinguish between the direct effects of network governance and the moderating effect of outside networks on the insider history of interactions between partner pairs.

I focus on two aspects of outside networks: first, whether partnered organizations with more mutually-shared partners (a source of increased network of information) are less likely to form formal contracts; second, whether partnered organizations with more formal contracts with outside partners (a source of contracting experience and competing priorities) are more likely to formally contract. The results suggest that these aspects of outside networks have strong direct explanatory power—offering an alternative source of relational mechanisms that can apply to partnered organizations but that originate outside the relationship.

In considering the indirect effects of outside networks, paper analyzes whether the presence of a larger number of shared third-parties and formal contracts shape the way that partners interpret feedback from prior interactions within the dyadic relationship. In particular, I argue that partnerships with more common partners can withstand larger deviations from reciprocal norms and good alliance performance while partnerships with more outside contracts will tolerate smaller deviations from reciprocal norms and good alliance performance. Although the effects are relatively small, the evidence is broadly supportive of these arguments. This suggests that socialized views of governance choice in repeated exchange relations should consider not just the dyadic context of exchange or the broader network of partnerships in which the organization is embedded but also the interactions between the two.

This research provides relatively strong empirical evidence of associations between the inside history, outside networks, and contracting choices of partnered organizations. Although the foregoing analysis includes a rich control structure the non-random assignment of both interaction histories and network structures it is difficult to make strong causal claims. Nonetheless, this research provides a starting point for investigating how network structures interact with dyadic histories to influence the way that partners structure their relationships. Although this paper makes more clear predictions about how partner histories influence governance choice as they unfold over time, subsequent work should focus on cleanly identifying the independent effects of relational mechanisms that are retrospective (i.e. trust) from those that are prospective (i.e. reputation) in the context of rich dynamics between partners and their outside network of partners.

This research finds that the link between the history of interactions among allied organizations and choices about how to govern these relationships is shaped by the social context in which the alliance is embedded. This has at least one important implication for future research. The history of interactions between alliance partners is fixed whereas the social context in which the alliance operates is not. For instance, managers can add a shared alliance partners and thereby access their history of interactions. Similarly, they can prune a contractual obligation to outside partners relieving outside pressure on the material resources of the alliance. Given that the network of outside arrangements moderates the link between inside history and governance choice organizations can deliberately shape their networks to favorably alter the way that sunk histories link with governance choices. The past does not then exert a fixed and unchanging influence on present decisions but is in fact subject to backward manipulation by managers who can alter the current configuration of outside networks. This implies the presence of a dynamic process by which prior interactions generate feedback that shapes the egocentric networks of alliance partners. This speculation supplements the view that networks shape the tie formation process by suggesting a feedback process from the partner-pair to the network. Therefore, future research should consider how dyadic histories influence not just governance choices but the subsequent configuration of an organizations wider network of partnerships.

Table 3.1: Summary statistics

		Partner sample		Matched sample	
Variable	**Description**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Contract	Indicates partners first use formal contract	0.22	0.41	0.07	0.26
Different States	Indicates members are in different states	0.03	0.17	0.44	0.5
Unpredictability	p95(daily person-runs)/mean(daily person-runs)	3	1.6	2.81	1.37
Distance	Geodesic miles between headquarters Zip codes	15.4	31.27	14.11	32.58
Outside aid runs	# aid runs between dyad members and other members	52.87	72.7	48.53	66.47
Fires	Total fire load of partners	131.03	283.84	128.95	532.93
Current interactions	# aid runs	1.94	5.82	0.72	2.17
Prior interactions	# aid runs in the prior two years	3.09	9.77	0.77	2.5
Lopsidedness	absolute exchange difference in the prior two years	1.63	6.21	0.37	1.41
Prior performance	$ loss on aid runs in the prior two years	95,712	2,937,786	25,920	385,030
Common partners	# outside partners have in common	2.27	2.58	3.05	7.88
Outside contracts	# of formal contracts with other partners	3.71	3.85	2.82	2.84

Table 3.2: Probit regression results: main effects

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	Contract	Contract	Contract	Contract	Contract	Contract
Estimator	Probit	Probit	Probit	Probit	Probit	Probit
Unit of analysis	j, k, t	j, k, t	j, k, t	j, k, t	j, k, t	j, k, t
Model	Control	Lopsid-edness	Prior perf-ormance	Common partners	Outside contracts	Full main
Sample	Partners	Partners	Partners	Partners	Partners	Partners
Prior interactions	0.072***	0.020***	0.054***	0.068***	0.063***	-0.005^{+}
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)
Lopsidedness		0.130***				0.125***
		(0.005)				(0.004)
Prior performance			0.040***			0.046***
			(0.001)			(0.001)
Common partners				0.053***		-0.047***
				(0.003)		(0.003)
Outside contracts					0.186***	0.201***
					(0.003)	(0.003)
Different states	-0.423***	-0.391***	-0.420***	-0.374***	-0.506***	-0.526***
	(0.041)	(0.041)	(0.041)	(0.041)	(0.047)	(0.048)
Distance	-0.002***	-0.002***	-0.002***	-0.001***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Unpredictability	0.001	0.004	0.002	-0.002	-0.020***	-0.014***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Fires	-0.000	-0.000**	-0.000	-0.000	0.000**	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Outside aid runs	0.001***	0.001***	0.001***	-0.000	-0.005***	-0.005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Aid interactions	0.131***	0.129***	0.128***	0.124***	0.144***	0.148***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Log-likelihood	-93563	-90345	-92375	-92929	-79627	-75121
Pseudo R^2	0.307	0.331	0.315	0.311	0.410	0.443

All specifications are with the unit of analysis at the partner-pair-year (j,k,t) level (n=256,296). Robust standard errors in parentheses clustered on 60,666 department pair dyads. $^{+}$ $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.3: Probit regression results: interaction effects

	(1)	(2)	(3)	(4)	(5)
Dep. Var.	Contract	Contract	Contract	Contract	Contract
Estimator	Probit	Probit	Probit	Probit	Probit
Unit of analysis	j,k,t	j,k,t	j,k,t	j,k,t	j,k,t
Model	Common partner interactions		Outside contract interactions		Full
Sample	Partners	Partners	Partners	Partners	Partners
Lopsidedness	0.139***	0.125***	0.069***	0.126***	0.098***
	(0.006)	(0.004)	(0.005)	(0.004)	(0.005)
Prior performance	0.046***	0.050***	0.046***	0.018***	0.030***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)
Common partners	-0.036***	-0.041***	-0.051***	-0.053***	-0.019***
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Outside contracts	0.200***	0.201***	0.188***	0.187***	0.172***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Lopsidedness × Common partners	-0.005***				-0.010***
	(0.002)				(0.001)
Prior performance × Common partners		-0.001***			-0.005***
		(0.000)			(0.001)
Lopsidedness × Outside contracts			0.015***		0.015***
			(0.000)		(0.000)
Prior performance × Outside contracts				0.006***	0.007***
				(0.000)	(0.001)
Year FE	Yes	Yes	Yes	Yes	Yes
Log-likelihood	-74983	-75102	-73716	-74619	-72905
Pseudo R^2	0.444	0.443	0.454	0.447	0.460

All specifications include the following controls which are not shown but are available upon request: different states indicator, distance between partners, unpredictability of fire arrivals, total fire load, aid runs to outside partners, current interactions, cumulative prior interactions. All specifications are with the unit of analysis at the partner-pair-year (j,k,t) level (n=256,296). Robust standard errors in parentheses clustered on 60,666 department pair dyads. $^{+}$ $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.4: Comparison of results for alternate models: partnered sample

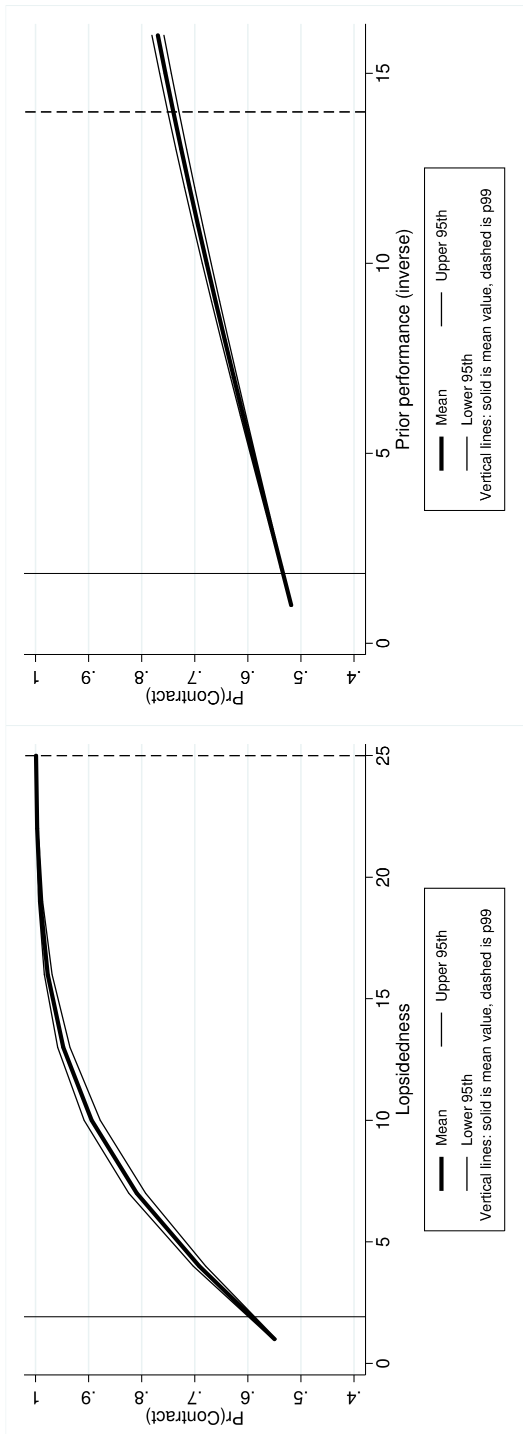
	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	Contract	Contract	Contract	Contract	Contract	Contract
Model	Probit	LPM	Logit	Probit	LPM	Logit
Estimator	MLE	OLS	MLE	MLE	OLS	MLE
Unit of analysis	j, k, t	j, k, t	j, k, t	j, k, t	j, k, t	j, k, t
Sample	Partners	Partners	Partners	Partners	Partners	Partners
Prior interactions	-0.005^{+}	0.001^{+}	-0.005	-0.006**	0.001**	-0.012**
	(0.003)	(0.000)	(0.005)	(0.003)	(0.000)	(0.005)
Lopsidedness	0.125***	0.007***	0.293***	0.098***	0.019***	0.096^{+}
	(0.004)	(0.001)	(0.014)	(0.005)	(0.002)	(0.052)
Prior performance	0.046***	0.014***	0.072***	0.030***	0.006***	0.056***
	(0.001)	(0.000)	(0.002)	(0.002)	(0.000)	(0.009)
Common partners	-0.047***	-0.008***	-0.091***	-0.019***	-0.006***	-0.028***
	(0.003)	(0.001)	(0.006)	(0.003)	(0.001)	(0.007)
Outside contracts	0.201***	0.042***	0.364***	0.172***	0.039***	0.278***
	(0.003)	(0.001)	(0.005)	(0.003)	(0.001)	(0.009)
Lopsidedness × Common part.				-0.010***	0.000	-0.046***
				(0.001)	(0.000)	(0.010)
Prior performance × Common part.				-0.005***	-0.001***	-0.007***
				(0.001)	(0.000)	(0.002)
Lopsidedness × Outside cont.				0.015***	-0.001***	0.094***
				(0.000)	(0.000)	(0.025)
Prior performance × Outside cont.				0.007***	0.002***	0.008***
				(0.001)	(0.000)	(0.003)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Unpredictability	No	Yes	No	No	Yes	No
Distance	No	Yes	No	No	Yes	No
Interactions	No	Yes	No	No	Yes	No
Outside runs	No	Yes	No	No	Yes	No
Fires	No	Yes	No	No	Yes	No
Log-likelihood	-75121		-74613	-72905		-70397
R^2	0.443	0.427	0.447	0.460	0.443	0.478

All specifications are with the unit of analysis at the partner-pair-year (j,k,t) level with additional controls not shown for unpredictability, distance, across border, interactions, outside aid runs, and fire load. For models 2 and 5 these controls enter in as fully saturated quintile dummy variables. For models 2 and 5 I report adjusted R^2 estimates and for all other models the pseudo R^2 estimates. All specifications are with the unit of analysis at the partner-pair-year (j,k,t) level (n=256,296). Robust standard errors in parentheses clustered on 60,666 department pair dyads. $^{+}$ $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.5: Comparison of results for alternate models: matched sample

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.	Contract	Contract	Contract	Contract	Contract	Contract
Model	Probit	LPM	Logit	Probit	LPM	Logit
Estimator	MLE	OLS	MLE	MLE	OLS	MLE
Unit of analysis	j, k, t	j, k, t	j, k, t	j, k, t	j, k, t	j, k, t
Sample	Matched	Matched	Matched	Matched	Matched	Matched
Prior interactions	-0.129***	-0.008***	-0.265***	-0.116***	-0.009***	-0.250***
	(0.016)	(0.001)	(0.037)	(0.013)	(0.001)	(0.025)
Lopsidedness	0.101***	0.016***	0.221***	0.125***	0.009**	0.249***
	(0.013)	(0.002)	(0.029)	(0.016)	(0.004)	(0.040)
Prior performance	0.027***	-0.000	0.067***	0.005	-0.006***	0.024+
	(0.005)	(0.001)	(0.013)	(0.006)	(0.001)	(0.013)
Common partners	-0.035***	0.000	-0.103***	-0.021***	0.000	-0.079***
	(0.006)	(0.000)	(0.010)	(0.006)	(0.000)	(0.010)
Outside contracts	0.172***	0.018***	0.340***	0.163***	0.016***	0.321***
	(0.007)	(0.001)	(0.011)	(0.007)	(0.001)	(0.011)
Lopsidedness × Common part.				-0.021***	-0.002**	-0.057***
				(0.006)	(0.001)	(0.012)
Prior performance × Common part.				0.002	0.000	0.006
				(0.002)	(0.000)	(0.004)
Lopsidedness × Outside cont.				0.010+	0.004***	0.038**
				(0.005)	(0.002)	(0.016)
Prior performance × Outside cont.				0.003**	0.002***	0.006+
				(0.002)	(0.000)	(0.003)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Unpredictability	No	Yes	No	No	Yes	No
Distance	No	Yes	No	No	Yes	No
Interactions	No	Yes	No	No	Yes	No
Outside runs	No	Yes	No	No	Yes	No
Fires	No	Yes	No	No	Yes	No
Log-likelihood	-7103		-7599	-7050		-7518
R^2	0.415	0.275	0.379	0.420	0.283	0.386

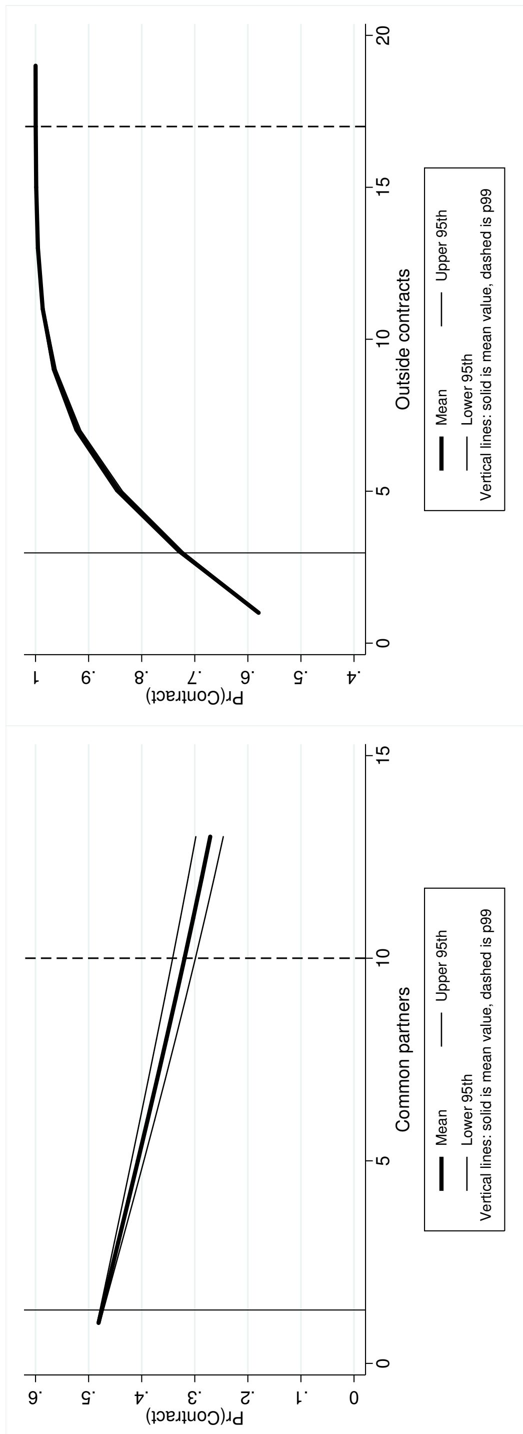
All specifications are with the unit of analysis at the partner-pair-year (j,k,t) level with additional controls not shown for unpredictability, distance, across border, interactions, outside aid runs, and fire load. For models 2 and 5 these controls enter in as fully saturated quintile dummy variables. For models 2 and 5 I report adjusted R^2 estimates and for all other models the pseudo R^2 estimates. All specifications are with the unit of analysis at the partner-pair-year (j,k,t) level (n=45,943). Robust standard errors in parentheses clustered on 10,245 department pair dyads. $^+$ $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.



(a) Lopsidedness

(b) Prior performance

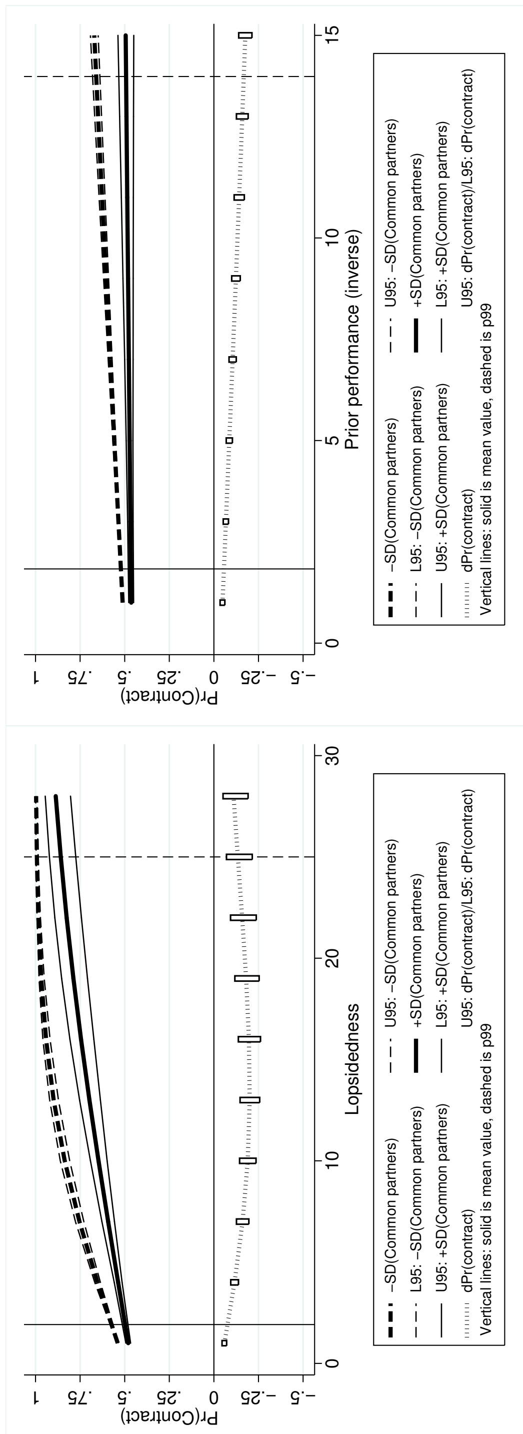
Figure 3.1: Effect of partner-specific history on formal contracting



(a) Common partners

(b) Outside contracts

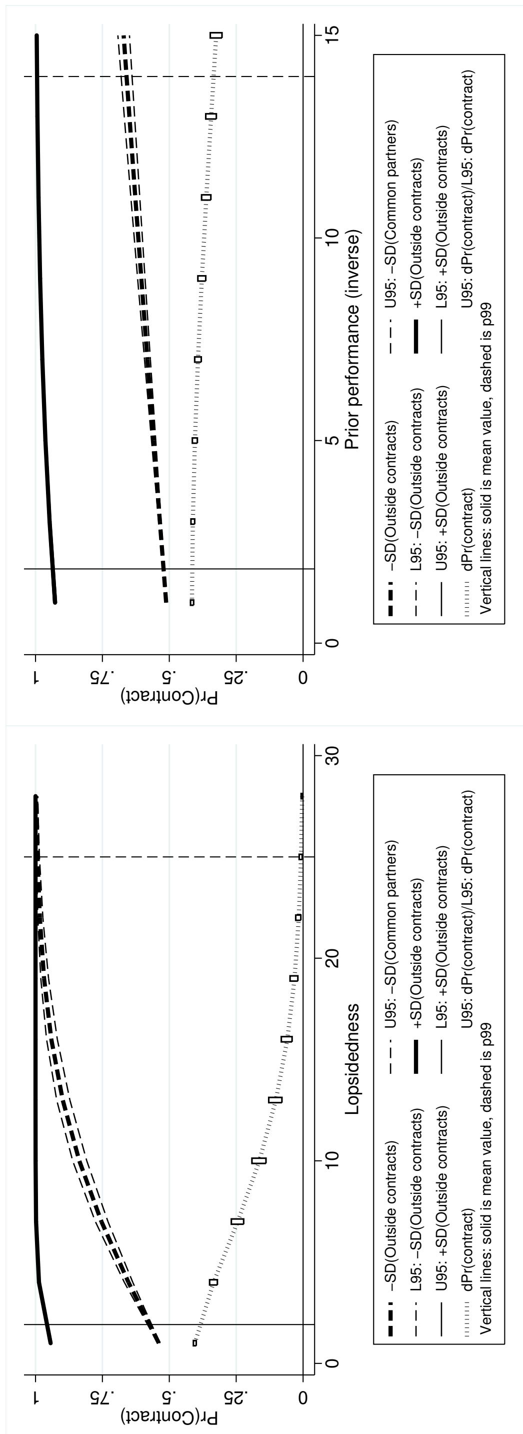
Figure 3.2: Effect of outside networks on formal contracting



(a) Lopsidedness by common partners

(b) Prior performance by common partners

Figure 3.3: Moderating effect of common partners on partner-specific history effects



(a) Lopsidedness by outside contracts

(b) Prior performance by outside contracts

Figure 3.4: Moderating effect of outside contracts on partner-specific history effects

Chapter 4

Coordination & Performance Trade-offs Under Uncertainty

4.1 Introduction

Managers often face emergencies. These are strategic threats and opportunities that have a small probability of occurring, but when they do occur require urgent attention. Because it is costly, difficult, or impossible for managers to prepare for all emergencies in advance (or to adjust after the fact) organizations may lack the resources needed to respond effectively.[1]

One way that this problem arises is when managers commit to resources before realizing uncertain demand. In such situations managers are faced with a dilemma as resource commitments involve trade-offs between the cost of hitting resource constraints when demand is high and the cost of idling resources when demand is low. Consider the challenges to passenger airlines, hotels, energy suppliers, shippers, and hospitals where capacity decisions are made prior to the revelation of demand. Airlines, for instance, commit to service levels through substantial investments in aircrafts, flight crews, and

[1] Resources are broadly defined as anything an organization can use to accomplish its aims.

terminal services in the face of highly variable demand. Firms in this industry make these commitments based on expectations about probable demand; however, it is not uncommon for weather problems to create abnormally large deviations from these expectations. In particular, serious storms create serious capacity problems that are costly and difficult to address. One way airlines can prepare for these emergencies is to carry idle capacity for when emergencies strike; however, the cost of doing so is enormous. Similar problems exist for energy suppliers that experience shocks from unusually hot or cold weather; for hotels that experience shocks from the coincidence of major tourist attractions and business events; for container shippers that experience shocks from rapid changes in trade flows; and for hospital emergency rooms that experience shocks from disasters like earthquakes and terrorism.

Organizations can however turn to alliance partners to deal with uncertainty (Beckman, Haunschild, and Phillips 2004) and to access urgently needed resources in the absence of spot markets (Stuart and Sorenson 2007, Forbes and Lederman 2009).[2] Accordingly organizations in the industries described above are heavily involved in alliances for sharing complementary assets, pooling capacity, and exchanging resources. Even though alliances may be helpful in this way the resources borrowed from partners are less easily controlled than resources owned by the organization. As a result the exchange of resources with alliance partners can introduce cooperation and coordination problems that must be resolved through the design of effective governance structures (Gulati and Singh 1998, Elfenbein and Lerner 2003). Herein lies the paradox of alliances. Although they provide organizations with an important strategic alternative they are risky and often fail (Kale and Singh 2009). These issues raise unanswered questions about the linkages between the design of the organization in the context of alliances and the performance of the organizations that enter into them. So this paper asks: How do alliances affect the performance of their members?

[2]Subject to the condition that demand for help among partners is not positively correlated over time.

This central question is explored with two specific questions about how organizations allocate and structure the exchange of resources with alliances partners: that is, how they design the architecture of their alliances. First, this study distinguishes between resources that are (i) internally-owned and (ii) the services of resources that are owned by alliance partners. Given that internally-owned resources are more controllable than resources owned by partners, and that partner resources provide comparatively greater flexibility to adjust to realized uncertainty, what role do differences in the origin of resources play in determining organization performance? Second, this study distinguishes between (i) alliance agreements that are primarily informal and psychological and (ii) agreements that are also formal and written. Given that formal contracts strengthen control over partner behavior, and that informal arrangements permit comparatively greater partner discretion, what role does the addition of formal alliance contracts to existing relationships play in determining organization performance?

The research setting is the U.S. municipal fire services industry. Managers often use the metaphor of 'putting out fires' to describe situations in which they deal with emergencies. This study takes inspiration from this metaphor for its empirical context, and it focuses on how patterns of interactions between separate US fire departments are related to department effectiveness. Fire chiefs make difficult capacity decisions with the primary objective of protecting the lives of community members from fire. These decisions occur against a backdrop of tight budgets and pressure to save personal property. To loosen the trade-off between hitting capacity constraints in times of emergency and idling costly resources during slow periods, most departments exchange fire services with neighboring departments. While some departments manage these exchanges informally with 'handshake agreements' others manage them with formal written contracts.

This setting has several advantages for exploring the research questions posed above. First, organizational boundaries correspond to political jurisdictions and ties between departments are based on proximity. As a result, decisions to ally are exogenous to organizational boundary choices. Second, the sample covers a period in which formal written contracts for organizing alliances diffused through a large fraction of the population. As a result, I observe changes in the structure of exchange at the organizational level. Third, archival data is available on fire departments with detailed information about demand and performance. As a result, it is possible to construct credible measures of demand uncertainty and objective measures of performance.

This paper contributes to our understanding of how the allocation and structure of resource exchanges within alliances contribute to differences in performance among the member organizations. In so doing it builds on the resource-based, alliance, and organization design literatures. First, resource-based theory stresses characteristics that give rise to special resource positions (Hoopes, Madsen, and Walker 2003, for a review), but this research does not consider how differences in where resources originate constrain or enhance the way these resources are applied. This study begins to fill this gap by assessing the performance effects of resources that are owned by the organization and the effects of qualitatively similar resources owned by alliance partners.

Second, the alliances literature stresses the tension between value created by combining complementary resources and the frictions that arise at the interface between partners (Kale and Singh 2009, for a review), but this research offers conflicting theories and evidence about what constitutes optimal alliance architecture choices (Gulati and Nickerson 2008, Puranam and Vanneste 2009, Ryall and Sampson 2009). This study furthers our understanding of alliances by directly analyzing the incremental contribution to performance of increased resource-exchanges with partners and the addition of formal written contracts for governing these exchanges by using measures of constructs that are normally difficult to obtain.

Finally, the literature on organization design stresses the influence of structures within individual corporations that are used to contain and combine strategic resources (Harris and Raviv 2002, Karim 2006), and it has long established the importance of structural fit with the environment (Lawrence and Lorsch 1967, Nadler and Tushman 1997, Davis, Eisenhardt, and Bingham 2009). However, this research does not distinguish between interdependent design decisions that occur within and between organizations at the same time. Additionally, this research has not fully explained the mechanisms by which architecture influences organization performance. This study fills these gaps in two ways. It shows that the intensity of resource exchange with partners improves organization performance by loosening the trade-offs associated with internal resource allocation problems but at the expense of reduced control. Thus the study of internal resource allocations is woefully incomplete unless the resources available through partners are also considered.

It also shows that laying formal contracts onto existing alliances influences performance in a nuanced manner. Specifically, in distinguishing between the performance of alliances when they are informally governed and when they switch to being formally governed it finds that formal contracts are not needed for collaboration on critical aspects of performance: in this setting, the reduction of casualties. They are needed for improving performance on property damage. This suggests that alliance contracts influence different organizational outcomes differently. Thus the study of formal alliance contracts is woefully incomplete unless the mechanisms linking these contracts with different aspects of performance are also considered.

4.2 Theory

4.2.1 Organizational slack: internal and partner resources

From a practical standpoint when managers invest in resources they must decide whether to design a lean or slack organization.[3] This and other design decisions are made before realizing uncertain future demand, and they usually involve commitments that are costly

[3]Following Nohria and Gulati (1996) I define organizational slack as the difference between current resources and the expected resource demands of current business.

or impossible to adjust *ex post*. As a result, under uncertain demand organizational slack involves a trade-off between (i) the cost of hitting capacity constraints when demand is high and (ii) the cost of idling resources when demand is low. On the one hand, this is problematic because hitting capacity constraints creates opportunity and adjustment costs.[4] On the other hand, this is problematic because idling resources creates inefficiency and waste.

From a theoretical standpoint our understanding of the link between organizational slack and performance is divided among longstanding views that (i) it enhances performance as an input for growth and change (Penrose 1959, Cheng and Kesner 1997) and a buffer against unexpected adversity (Thompson 1967, Cyert and March 1963, Miller and Leiblein 1996, Tan and Peng 2003), and views that (ii) it diminishes performance as a source of waste (Leibenstein 1966, Ghemawat 1991, Borenstein and Farrell 2007). Internal slack—defined as slack resources that are owned by the organization—can arise from good fortune, prudence, or simple misjudgments; however, it can also arise from discretionary investments. For instance, internal slack can come from investments in routines and resources that can by easily re-configured (Baldwin and Clark 2000, Karim 2006). It can come from relaxing control processes for making decisions (Miller and Leiblein 1996, Gavetti, Levinthal, and Ocasio 2007). It can also come from production and other organizational buffers (Thompson 1967, Levinthal and March 1993).

These various sources of internal slack enhance the ability of the organization to respond to uncertain demand: that is, variations in quantity and kind that generate capacity emergencies. Internal slack is costly, however. For instance, internal slack is associated with higher carrying-costs, increased managerial effort, and agency problems (Leibenstein 1966, Borenstein and Farrell 2007). Slack resources have been shown to encourage undisciplined problem-solving (Nohria and Gulati 1996). They are also asso-

[4] Opportunity costs arise when organizations are unable to satisfy demand and it evaporates. Adjustment costs arise when organizations are able to satisfy demand using costly resources acquired in spot markets or when organizations partially satisfy demand using available resources.

ciated with opportunistic rent-grabbing by managers (Jensen 1986) and the dissipation of created value by non-owners (Ghemawat 1991, Ch.5).

What does this trade-off imply for organization performance? High internal slack enhances the adaptability of the organization to uncertain demand by providing facilities to avoid hitting capacity constraints, but it does so at the expense of efficiency. Because demand that arrives in a volatile and erratic manner has a higher probability of hitting capacity constraints and/or idling resources I expect an increase in demand uncertainty to reduce organization performance as a baseline. The costs of hitting capacity constraints when demand is high compared with the costs of idling resources when demand is low vary by industrial activity.

Consider again the example of passenger airlines where managers face difficulties choosing the capacity needed to service routes with variable demand. Capacity commitments in this industry involve substantial commitments to resources (i.e. aircrafts, gate space, crews) for which the cost of idling in preparation for demand shocks such as bad weather are likely to swamp the cost of mollifying underserved customers by other means (e.g. free flights). Therefore the risk to the organization of idling resources is much greater than the risk of hitting capacity constraints for airlines. In contrast, the cost of high internal slack in the form of more emergency room physicians than are needed to satisfy expected current demand is much smaller than the cost of hitting constraints (e.g. patient morbidity and mortality) when major disasters create demand shocks. Consequently, the risk to the organization of idle doctor capacity for hospitals is much greater than the risk of hitting capacity constraints and failing to fulfill demand. Similarly, consider the difficulties that municipal fire departments face when confronted with a disaster given available equipment and personnel. In this industry, the cost to a community of a department with insufficient firefighters, expertise, and apparatus in casualties and property damage from major emergencies can quickly swamp the burden of idling these resources during periods of quiet.

In short, the effect of internal slack on organization performance will depend on the responsiveness of the costs of hitting capacity constraints relative to the responsiveness of the costs of idling resources. When the greater organizational risk is of hitting capacity constraints higher slack will improve performance. When the greater organizational risk is of idling resources lower slack will improve performance. This logic is consistent with and explains why Reuer and Leiblein (2000) find that organization slack is negatively related to financial risk in the control structure of their empirical model. Therefore, I propose that

> **Hypothesis 1:** An increase in internal slack will decrease (increase) the negative effect of uncertainty on organization performance for industries where the costs of hitting capacity constraints are more (less) severe than the cost of idling resources (H1).

Managers can make partial commitments in the form of investments in strategic options to secure access to resources in the future that are not currently owned by the organization (Foote and Folta 2002). Resources available in this way are also known as potential slack (Cheng and Kesner 1997). The advantage of these options is the flexibility they provide under conditions of uncertainty. Furthermore, these resources need not ever be owned by the organization. Alliances for instance provide organizations with the option of accessing partner resources in the future (Folta 1998).

Partner resources are owned or controlled by other organizations but can make up important elements of an organization's productive technology. In fact, early applications of network theory to organizations rationalized lasting relations as a way to procure resources under conditions of uncertain demand (Galaskiewicz 1985, for an early review). More recent research suggests that links between organizations can overcome a variety of internal resource problems. For instance, friendships can yield preferential resource allocations among production partners (Sorenson and Waguespack 2006) and the exchange of support among potential rivals (Ingram and Roberts 2000). New ventures can profit from ties to prominent investors (Stuart, Hoang, and Hybels 1999) and from better positions in organizational networks (Baum, Calabrese, and Silverman 2000).

Partner resources can substitute for internal resources. In this way, organizations can enjoy less binding capacity constraints and/or reduce their resource commitments (Reuer and Leiblein 2000). Partner resources can also complement internal slack. For example, alliance partners that collectively organize their resources can realize functional consolidation in situations where it is not feasible to alter the boundaries of the organization. Partners can co-specialize and share scarce resources, realize economies of scale in purchasing inputs, and smooth variable demand (Lynk 1995, Ingram and Roberts 2000). In these ways, partner resources loosen the trade-offs between the costs of hitting capacity constraints when demand is high and the costs of idling resources when demand is low that are associated with internal slack. However, because partner resources are not owned by a focal organization they are less controllable than resources over which a focal organization has full ownership.

It is not surprising then that despite the potential benefits alliances often fail (Kale and Singh 2009). Dividing activities between production partners introduces separate interests and decision rights that can create incentive and coordination problems. Although incentive problems are important considerations when designing alliances coordination problems can remain even after incentives problems have been resolved (Gulati, Lawrence, and Puranam 2005). The separation of production technologies across organization borders can create coordination problems that make it difficult for partners to know what actions to take as they subdivide complex and interdependent activities (Gulati and Singh 1998). For instance, incompatibilities can arise when partners attempt to combine resources with different technical interfaces or when partners with different operating procedures, terminology, norms, and expectations attempt to work together. Differences in technology and the separation of control can result in both incompatibilities and signaling frictions that reduce the effectiveness with which interdependent elements of collaborative work are performed (Williamson 1991, Gulati, Lawrence, and Puranam 2005).

As a result, partner resources encompass a trade-off between (i) improving performance by loosening the internal slack trade-off between efficiency and flexibility and (ii) worsening performance by loosening controls with which coordination of activities are achieved. Therefore an increase in the services of resources received from partners will improve organization performance when the benefits of loosening the trade-offs associated with internal slack exceed the costs associated with reduced control over these resources. Then as a baseline I expect partner resources to reduce performance when demand arrives in a stable and regular manner, and I propose that

> **Hypothesis 2:** An increase in partner resources received will diminish the negative effect of demand uncertainty on organization performance (H2)

4.2.2 Organizational structure: alliance formality

Most alliances lack a central authority to enforce how each partner behaves and so involve the incentive and coordination problems discussed above. Although they are often empirically intertwined incentive and coordination problems can pose distinct challenges (Williamson 1991). This paper emphasizes coordination problems which can arise even when both parties intend to cooperate (Gulati, Lawrence, and Puranam 2005).

Even though alliances lack a central authority that is not to say that these relations operate in the absence of any authority. On the contrary, they proceed in an architecture of controls (Gulati and Singh 1998). This architecture includes explicit formal structures such as joint ownership, information technology, and written contracts (Oxley 1997, Argyres 1999, Argyres, Bercovitz, and Mayer 2007). It also includes implicit informal controls such as reputation, trust, and general behavioral norms (McEvily, Perrone, and Zaheer 2003, Bercovitz, Jap, and Nickerson 2006). In order to effectively govern and structure the exchange of resources between alliance partners managers consider whether to use formal structures, which are susceptible to deliberate design, or to rely on informal mechanisms that may be available or emergent. This choice determines how alliance partners combine people and resources across organization borders to perform the tasks necessary to achieve their joint and individual objectives. These combinations form stable patterns of activity that affect how alliance partners deploy their resources. In this way, the design of inter-organizational exchange provides a occasion for managers to influence performance.

Alliance contracts are written codes of conduct for organizing how partners work together. They place explicit formal structure on collaborations by articulating expectations of the actions to be taken by each party ahead of time and which can be checked by outsiders afterwards. As a result, these agreements are limited to terms that can be easily specified *ex ante* and verified *ex post*. Informal mechanisms are available when organizations expect partnership to continue in the future. They involve unwritten codes of conduct that shape how organizations behave in their dealings with other organizations. In contrast with alliance contracts, informal arrangements are capable of incorporating details that would be prohibitively costly to specify and that are observed by only the contracting parties. Informal arrangements consequently allow partners to apply individual discretion using 'detailed knowledge of their specific situation and to adapt to new information as it becomes available' (Baker, Gibbons, and Murphy 2002). For the same reason these arrangements must be self-enforcing.

Coordination among alliance partners can be enhanced by alliance contracts which define standards, rules, and programs of action. Alliance contracts clarify—and in some cases eliminate the need for—signals about the actions partners will take during episodes of collaboration. These mechanisms improve coordination by making the actions of each partner more predictable to the other during episodes of collaboration.

Alliance contracts have important limitations, however. Because alliance contracts articulate explicit details partners must collect information, negotiate and specify terms, and implement plans. These all require effort not needed for informal arrangements. Because it is costly to specify details alliance contracts are incomplete: partners will stop adding detail when there is no additional value from doing so. Alliance contracts are also incomplete because the individuals writing them are boundedly rational and have cognitive limitations. It is simply not possible to imagine all contingencies. As a result, alliance contracts are incomplete and so are unable to provide direction to partners in all possible circumstances. However, the presence of informal mechanisms such as trust, reputation, personal affection that form through repeated interactions can compensate for the limitations of alliance contracts (Ryall and Sampson 2009, Argyres, Bercovitz, and Mayer 2007). Formal and informal controls align partner actions and interests by different means; however, when used together are shown to provide complementary controls (Poppo and Zenger 2002, Gulati and Nickerson 2008). Therefore, as a baseline I propose that

> **Hypothesis 3:** Adding formal contracts to previously informal arrangements among alliance partners will improve organization performance (H3).

Alliance contracts make use of more hierarchical controls to coordinate work than informal understandings through obligations based on anticipated contingencies. However, uncertainty 'evokes the unforeseen, indescribable contingencies' that generate realizations of contractual incompleteness (Elfenbein and Lerner 2003) and the need for partners to adapt their decision-making as uncertainty is resolved over time (Williamson 1991). Incomplete contracts can create friction from *ex post* adaptation (Tadelis 2002, Forbes and Lederman 2009). These frictions can arise from the need for additional communications and from haggling over what actions each party will take. Similarly, alliance contracts may require partners to take actions to satisfy the obligations of the contract which they would not take given their detailed knowledge of the situation. As a result, under higher than anticipated demand uncertainty alliance contracts will reduce the flexibility of partners to adapt and coordinate their activities (Davis, Eisenhardt, and Bingham 2009).

Informal arrangements are superior to alliance contracts in this regard. They permit each partner to incorporate new information into their decisions. Consequently, informal arrangements permit greater flexibility by providing partners with greater discretion to act as new information arrives. This is particularly helpful under increased demand uncertainty which generates more widely variant circumstances than are likely to have been anticipated when contracts were originally drafted. Accordingly I propose that

> **Hypothesis 4:** The positive effect on organization performance of adding alliance contracts to previously informal arrangements will be diminished by an increase in demand uncertainty (H4).

4.3 Model, data and empirics

4.3.1 Fire departments

In 2008 there were $15.5 billion in direct property damage, 16,705 people were injured, and another 3,320 people died as a result of fires in the US. In that year there were an estimated 30,170 fire departments employing 1,148,850 firefighters (Karter and Stein 2009). Fire services are relatively complex and require active management and planning. Trained professionals and volunteers are the most important input. They use protective equipment, command and control and communications systems, and specialty apparatus for rescues and fire suppression.

Fire departments are locally-funded, budget-constrained organizations. Because the *'stakes are high...[and] serious foul-ups can have serious consequences'* (Weick 1993) department members have incentives to work effectively and to continually improve performance. Fire departments provide services within geographic areas defined by political boundaries. These boundaries are not laid out to accommodate the operational concerns of firefighting, however. For this reason it is not surprising that proximate fire departments regularly collaborate by providing resources and services across political boundaries in a practice known as mutual aid.

Although this has not always been the case, today firefighting is provided with territorial exclusivity under local government authority. US fire departments are not profit-making organizations, and there are few opportunities for members to accumulate wealth. As a result competitive forces at play between proximate fire departments are limited and indirect; however, that is not to say that they are absent. Nonetheless, compared to other horizontally-related organizations fire departments have strong positive incentives to cooperate such as norms of equity, professional oaths of conduct, and opportunities to learn, share best practices, and consolidate support functions and training. They have few incentives to behave opportunistically because of a lack of product market competition, blunted labor market competition, and a lack of capital market competition. Furthermore, they have strong interdependencies across geographies, particularly among social and economic factors, that create strong mission alignment. As a result, fire departments are intrinsically motivated to cooperate. Nonetheless, fire departments provided relatively little assistance across organization boundaries until recently. Failures to collaborate across political jurisdictions suggest that working together is not a straightforward problem even when cooperation problems are less severe.

Mutual aid involves the exchange of non-money resources across organization boundaries. Although an age-old practice, this form of collaboration gained prominence following a change in national response guidelines in 1997. At this time, the National Fire Protection Association (NFPA) revised *NFPA 1500: Standard on Fire Department Occupational Safety and Health Program.* This standard sets out the minimum safety guidelines for emergency response personnel, and importantly incorporated the 'two-in/two-out' rule, which stipulates that for every pair of firefighters that are inside the structure there should be another pair outside the structure on stand-by. This rule doubled the recommended number of firefighters available on scene when entering a burning structure. One way to conform to the 1997 guideline for any given department was to call on neighboring departments to provide extra manpower. Thus in 1999, before fully conforming with the recommendation, fire departments engaged in an average of roughly 5 runs per year. By 2006, this figure rose to an average of 22 aid runs (see figure 4.1).[5] The change in NFPA 1500 increased demand for collaboration among neighboring departments; however, these interactions raise a variety of coordination problems.

First, historically training and equipment purchasing were performed independently at the department level. As a result, different departments developed different routines for fighting fires, different language for communicating commands and information about incident-specific details, and different technical systems for radio communication and water supply. Furthermore the choices made at the department level about these production technologies exhibit strong path dependence. Consequently, when departments work with their neighbors problems coordinating activities can arise at several places in the production of fire services. These problems range from technical incompatibilities between apparatus for supplying firefighters with water at fires and between mobile radio systems that operate on different frequencies to divergence in expectations about what constitutes appropriate equipment and procedures for handling particular incidents.

At the same time that changes in the NFPA 1500 occurred, a new practice for organizing collaborations among fire departments spread through the population—an arrangement known as automatic aid. Under automatic aid arrangements partners are obligated to respond to partner fires according to the terms laid out in formal written agreements. Automatic aid arrangements are pre-negotiated with contracts that specify the actions partnered departments will take under circumstances that call for collaboration. The contracts ascribe legal liability for the actions taken including, for instance, when it is

[5] Compliance with the rule is voluntary unless it is written into state law. Different states enacted this into law at different times or not at all.

permissible to deny requests for help. Automatic aid contracts also typically include terms that commit partners to joint training exercises, the allocation of authority rights for chiefs, terms for purchasing compatible equipment, and terms defining of standard terminology to be used. Additionally, these agreements are enacted in dispatching functions and response routines that establish the terms of the contract as default actions. In 1999 fewer than 3 percent of departments had adopted automatic aid agreements. By 2006, this fraction rose to two-thirds of departments (see figure 4.2). According to industry informants, in addition to the greater imperative to collaborate the increase in automatic aid may be attributable to (i) recognition on fire ratings by Insurance Service Office (ISO), and (ii) consolidation of emergency call centers at the county level with alarm dispatch circuits to the fire stations of proximate departments.[6]

4.3.2 Identification strategy and estimation

The empirical goal of this study is explain the performance of department d in year t as a function of (i) internal slack, (ii) partner resources, (iii) alliance contracts, (iv) demand uncertainty, and (v) a set of controls.

Fixed effects and lagged dependent variable models

The simplest approach is to run pooled ordinary least squares (OLS) regression of performance on the treatment variables; however, this requires strong assumptions to deliver consistent estimates.[7] I employ a research design based on two main empirical models: (i) an individual department fixed effects (FE) model, and (ii) a distributed lagged dependent variables (LD) model. Each model has different identifying assumptions and consequently different limitations, but taken together they offer a useful approach for

[6]ISO ratings affect the cost of fire insurance for the municipal government and property owners
[7]Importantly, that treatment variables are uncorrelated with the error in each period.

bounding the effects of interest (Angrist and Pischke 2009).[8]

The FE model addresses one form of omitted variables bias—fixed unobservable differences in departments that may affect the relationships under inspection. For instance, departments endowed with special culture, equipment, leadership, or skills may drive a spurious relationship between performance and the treatment variables. Similarly, departments in areas with structural characteristics such as lower population or building density, fire-prone construction materials, or poor roadways may also spuriously drive this link. Additionally, there may also be factors that are correlated with performance and the treatment variables that are invariant across departments in each year.[9] The main empirical model to be estimated is

$$Y_{dt} = X_{dt}\Theta_1 + U_{dt}\Theta_2 + (X_{dt}U_{dt})\Theta_3 + (control)_{dt}B + \eta_d + \varepsilon_{dt} \tag{4.1}$$

In equation (4.1), Y_{dt} is the outcome to be explained: loss from fires. X_{dt} is a vector of variables including internal slack (H1), partner resources (H2), and alliance contracts (H3). U_{dt} is department-specific uncertainty. The hypotheses are tested on the interaction between the elements of X_{dt} and U_{dt}. $(control)_{dt}$ is a vector of control variables including: year fixed effects, state-year trends, characteristics of demand, and inputs costs.[10] η_d is a department fixed effect. And, ε_{dt} is the residual. Θ_1, Θ_2, Θ_3, and B are the parameter vectors to be estimated.[11]

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[8] In principle, it is possible to relax the assumption of strictly exogenous regressors and estimate dynamic panel data models with individual effects via GMM in first differences (Arellano and Bond 1991); however, this requires the assumption that longer lags are uncorrelated with the differenced residuals. Since the residuals are the portion of output not accounted for by the covariates, and because production is likely to be correlated from one year to the next prior outcomes are likely to be correlated with the differenced residual.

[9] For instance, events with national impact such as the September 11^{th} attacks and the creation of the Department of Homeland Security might systematically affect both department performance and the treatment variables.

[10] Year fixed effects address period specific national shocks that affect all department equally–for example consolidation of U.S. Fire Administration into the DHS. And state-time trends account for state-wide changes over time such as the differential adoption of the 'two-in/two-out' rule.

[11] This specification is based on the identifying assumptions that the causal effects of the treatment variables are constant and additive, that all omitted variables are time-invariant, and that the treat-

This strict exogeneity assumption required by this model is strong. It is possible that there are omitted variables that vary over time. Of particular concern, there may be feedback from past performance on the treatment variables. For instance, internal slack or alliance contracts may arise in response to unusually severe incidents in the past: that is, transitory shocks yielding phenomena similar to 'Ashenfelter's dip.' Similarly, departments may seek out more aid in response to budgetary hardship or poor performance. Consequently, past performance may be a confounding variable not accounted for by η_d. The unique performance histories of each department can then be used to identify the causal parameters by estimating the following model:

$$Y_{dt} = X_{dt}\Lambda_1 + U_{dt}\Lambda_2 + (X_{dt}U_{dt})\Lambda_3 + (control)_{dt}\Gamma + \alpha Y_{dt-h} + \xi_{dt} \qquad (4.2)$$

where Y_{dt}, X_{dt}, U_{dt} and $(control)_{dt}$ are defined as before. ξ_{dt} is the residual. And, α, Λ_1, Λ_2, Λ_3, and Γ are the parameters to be estimated. In this model the strict exogeneity assumption is false by construction.[12]

I assume that the residuals (ε_{dt} and ξ_{dt}) are identically distributed but not independent. Because residual performance may be serially correlated within departments over time in the FE models—and by construction are correlated in the LD models—estimates of standard errors may be grossly under-stated (Bertrand, Duflo, and Mullainathan 2004). To address this dependence, robust standard errors are estimated clustering on the individual department.

ment variables are strictly exogenous conditional on the fixed unobserved effects. That is, when the observed Y_{dt} is either Y_{0dt} or Y_{Tdt} depending on treatment status $E[Y_{0dt}|\eta_d, (control)_{dt}, X_{dt}, U_{dt}] = E[Y_{0dt}|\eta_d, (control)_{dt}]$ where η_d captures all unobserved organizational characteristics that determine performance, Internal slack, partner resources, and alliance contracts for department d.

[12]The identifying assumption in this model is $E[Y_{0dt}|Y_{dt-h}, (control)_{dt}, X_{dt}, U_{dt}] = E[Y_{0dt}|Y_{dt-h}, (control)_{dt}]$ where Y_{dt-h} is a h-period lagged dependent variable. These models were estimate with $h = 1, 2$, but because the inclusion of longer lags reduces the regression sample and does not statistically or materially alter the results only estimates with $h = 1$ are presented below.

Instrumental variables approach

Fire departments are more likely to collaborate when there are serious fires that are likely to cause major damage. Similarly, fire departments are more likely to enter alliance contracts when the gains to doing so are expected to be greatest. As a result, the estimates of the coefficients on department adoption of formal contracts may be biased even after controlling for fixed unobservable differences between departments and their unique performance histories. To address these selection problems I use an instrumental variables (IV) approach estimated with a two-stage least squares (2SLS) procedure.[13] The choice of instruments exploits the fact that the costs and benefits of formal contracts and partner resources depend on the characteristics of organizations on both sides of the exchange. The choice of instruments also relies on the reasonable assumption that many partner characteristics are unrelated to the performance of the other party. As a result, partner characteristics offer instruments that have strong face validity.[14]

4.3.3 Measures

Dependent variables. Fire departments have two main objectives: (i) to protect life and (ii) to protect property from fires and fire hazards. Therefore property damage and casualties from fires provide natural measures of fire department performance. Property damage is calculated for each department from incident-level archival data as the annual sum of the replacement value of the structure and contents damaged by fire, smoke, water, and overhaul deflated to 1999 dollars.[15] Casualties are also calculated for each department

[13]For the IV approach to yield consistent estimates, the instruments must satisfy two conditions: (a) they must influence partner resources and the use of formal contracts (i.e. $E(W'_{d,t}Z_{d,t}) \neq 0$, where $Z_{d,t}$ is the vector of instrumental variables, and $W_{d,t}$ is the vector of potentially endogenous treatment variables including partner resources and formal contracts), but (b) not affect performance directly (i.e. $E(Z_{d,t}\varepsilon_{dt}) = 0$). Although these estimates are not readily generalized to the population they nonetheless deliver an estimate using plausibly exogenous variation in the treatment effects.

[14]This approach is similar to the approach proposed by Berry, Levinsohn, and Pakes (1995) that exploits the characteristics of other products in a market as instruments for cost and demand characteristics of a focal product.

[15]'This does not include indirect loss, such as business interruption' (USFA 2006, section 3-40)

from incident-level archival data as the annual count of civilians and firefighters injured or killed either as a result of the incident or during its mitigation.[16] There are $353,249 in property damage and 1.4 casualties per department per year.

Independent variables. This article examines the effect of internal slack and partner resources (i.e. external slack) on performance. Internal slack is measured with two components: a) current resources, and b) the expected resource demands of current business. Current resources are measured with archival data on the number of firefighters in a department in a given year. The choice of measure for the expected resource demands of current business is less obvious. This paper suggests that use of department-specific distributions of daily fire demands to understand how expectations correspond with allocations. In particular, fire departments, hospitals, and other organizations that face volatile demands and capacity constraints will aim for some level of reliability by overstaffing relative to the average demand (Lynk 1995).

This paper imagines that department managers who want to staff their organizations to adequately cover X percent of fire demands will analyze the empirical distribution of daily firefighter runs and select the number of firefighters that can cover demand on days at the X^{th} percentile. Consequently, this paper measures the expected resource demands of current business using the department-specific empirical distribution of daily firefighter runs in the prior year.

This paper uses the 95^{th} percentile of daily demands as a proxy for expectations for two reasons. First, it is less sensitive to outliers than the daily maximum or measures based on the standard deviation. Second, it is close to the prescribed method for department

[16]'An injury is physical damage to a person that requires either (1) treatment by a practitioner of medicine within 1 year of the incident, or (2) at least 1 day of restricted activity immediately following the incident. Deaths also include people who die within 1 year because of injuries sustained from the incident' (USFA 2006, section 3-42). In models with casualties as the dependent variable (i.e. Y_{dt}), rather than modelling the errors distributed as a Poisson random variable or a negative binomial random variable I transform casualties as follows: $\tilde{Y}_{dt} = log(Y_{dt})$ when $Y_{dt} > 0$, and $\tilde{Y}_{dt} = 0$ when $Y_{dt} = 0$. A control for this transformation is included for null values, $1(Y_{dt} = 0)$. This linearization permits use of the three approaches described above.

managers (Cote 2003, Chapter 6).[17] Slack resources are then calculated as the ratio of current resources (# firefighters$_{d,t}$) and the expected resource demands of current business (p95 daily firefighter runs$_{d,t-1}$). This measure captures the extent to which a department is prepared to address fires on the most difficult days. On average, the sampled departments maintain 2.3 times more firefighters than are needed to cover fires in the 95th percentile of daily demands in the prior year.

Partner resources—the quantity of additional resources received from partners—is measured with a count of firefighter runs received by the focal organization from mutual aid partners in year t. On average, the sampled departments received 76 firefighter runs per year. Once departments have decided to engage in collaborations they have alternatives for arranging these relations. This article advances a set of arguments about when more structure in the form of alliance contracts will have different performance consequences. Mutual aid between proximate departments may or may not be organized with an automatic aid arrangement. Automatic aid represents an unambiguous shift towards more formal and more highly structured arrangements. Mutual aid relations without an automatic aid agreement only sometimes involve written contracts.

In contrast, mutual aid relations with automatic aid agreements always involve written contracts. That is because automatic aid arrangements require investments in written legal contracts, joint training exercises, communications systems, and response protocols. Formality is measured as a regime change with an indicator variable that switches on in the first year that the department has at least one exchange under a alliance contract with any of its partners. In the sample, partnerships are governed by alliance contracts in 57% of department-years. Finally, this article examines how these variables are linked with performance by considering the role of deman uncertainty. Consistent with the strategic management literature, department-specific demand uncertainty is measured with daily

[17]The results are robust to variety of alternate measures including: the ratio of personnel to the maximum daily personnel runs, the inverse annual utilization of personnel (in terms of runs, total person-response minutes, and person-runs), and the inverse utilization demeaned by industry averages.

fire variability calculated as the cross-sectional standard deviation of daily department per department per year.[18]

Controls. Fire department performance depends heavily on the underlying demand for services in that year. Since a department's overall fire load is likely to be correlated with personnel decisions and performance it is included as a control; however, not all fire runs place the same demands on the organization. To control for compositional differences in overall demand that may be correlated with internal slack, partner resources, and alliance contract choices three measures of demand per department per year are included: a count of residential structure fires; a count of non-residential structure fires such as those that occur in offices, hospitals, and commercial buildings; and a count of outside fires such as those that occur in natural vegetation, garbages, vehicles, or mobile homes.

Measures of input costs are also included as controls to facilitate interpretation of performance as net productivity. One for labor and one for capital. Firefighter man hours are calculated for each department from incident-level archival data as the annual sum of firefighter hours spent responding to incidents.[19] This measure of labor-usage intensity is selected as a proxy for variable costs for three reasons: first, volunteers are paid on an hourly basis (which captures one aspect of economizing behavior); second, more time spent fighting fires places greater wear on equipment and apparatus; third, whether or not this effort is recognized in budgets it represents a real cost to stakeholders (another aspect of economizing behavior).

A similar measure was constructed for the time fire apparatus (e.g. engines, ladders, pumpers) were deployed to incidents to control for differential use of capital inputs: apparatus hours.[20] Mutual aid operates on the basis of reciprocity. As a result, the cost

[18]The estimates are robust when using alternate measures including the variance-to-mean ratio of daily department runs—a relative measure of volatility.

[19]This measure is constructed as the annual sum of the time between the first alarm and the resolution of each incident multiplied by the number of firefighters assigned to each incident.

[20]Annual fire department budget data is available in the Government Finance Statistics series compiled by the U.S. Census. Fire department operating budgets are measured with operating expenditures on fire protection by local governments. However, this series is not complete and so analysis controlling for

of partner resources received is the obligation to provide help which results in aid given. This variable is likely to be correlated with both performance and partner resources. Correspondingly, this variable is included as a control and is calculated symmetrically as the count of firefighter runs given by the focal organization to its mutual aid partners in year t.

Instrumental variables. The following partner characteristics should be uncorrelated with focal department performance because they occur in other jurisdictions: interactions among common network partners ($z^1_{d,t}$), distance travelled to incidents ($z^2_{d,t}$), border fires ($z^3_{d,t}$), and total fires ($z^4_{d,t}$). However, because mutual aid and formal contracting are determined by the returns to both focal departments and their partners characteristics that shift the costs and benefits to one party will affect the realizations for the other.[21]

Establishing an alliance contract involves planning and negotiating the rights and obligations of the departments involved. This process requires common knowledge as well as a mutual understanding of the interdependencies that extend beyond their partnership. Departments are embedded in networks of relations in which relevant information arises and is circulated. Interactions among partners are occasions for gathering and transmitting information. Network flow increases the likelihood that information will be circulated to all the nodes. Network flow is measured with the number of recent interactions among a department's ego-centric network partners (i.e. intra-network aid). I expect more intra-network aid to positively influence the use of alliance contracts. But, I do not expect these interactions—which occur beyond department borders—to affect

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these budgets is included in the appendix that is not for publication. The results are qualitatively very similar.

[21]After interacting these variables with uncertainty there are eight instruments for four endogenous variables: four for the main effects of partner resources and alliance contracts and an additional four for interactions with uncertainty. In the notation above, the instrument vector $Z^{main}_{d,t} = \{z^1_{d,t}, z^2_{d,t}, z^3_{d,t}, z^4_{d,t}\}$ for the vector of potentially endogenous variables $W^{main}_{d,t} = \{\text{alliance contracts, partner resources}\} \in (main)_{d,t}$ and the instrument vector $Z^{interaction}_{d,t} = \{z^1_{d,t} \times uncertainty, z^2_{d,t} \times uncertainty, z^3_{d,t} \times uncertainty, z^4_{d,t} \times uncertainty\}$ for the vector of potentially endogenous variables $W^{interaction}_{d,t} = \{\text{alliance contracts} \times \text{uncertainty, partner resources} \times \text{uncertainty}\} \in (interaction)_{d,t}$.

performance within the department's jurisdiction.

Alliance contracts are intended to enhance the coordination of resources by both reducing the time it takes to decide what resources to deploy and whether to deploy them. When partners have to travel farther to interact the time compression benefits of these contracts are reduced. As a result, I expect the distance partners travel on aid calls to decrease use of alliance contracts. However, because I measure partner distance by excluding those runs involving the focal department this variable should not affect the performance of the focal department.

Similarly, inter-department collaboration is more feasible when the services can be delivered over smaller distances. As a result, I expect a partners with a larger distribution of fires close to their political borders to place take more steps to engage in collaborations with their proximate partners. I do not expect a larger number of border fires to influence performance–except through partner resources. I measure border fires with the count of fires among a department's partner network that occur at a distance that is greater than the 80^{th} percentile of all runs in the sample window from headquarters.

Incidents generate opportunities to collaborate. Therefore, an increase in incidents will increase the benefits of using aid and investing in costly contracts to organize interactions. Because I measure partner fires by excluding the aid departments give to their partners I do not expect this variable to influence focal department performance.[22]

Consistent with the literature estimating production functions, all continuous measures are transformed with a logarithmic function. This transformation simplifies interpretation because the coefficients in log-log models can be read as percent changes or elasticities. All variables are described and summarized in table 4.1.

[22] However, if the data generating process for fires is based in large part on weather then performance and partner fires will be correlated. I deal with this in two ways. First, I control for broad regional effects that change over time with state-year interactions and higher-order terms in the main specifications. Second, I use county-year interactions and higher order terms as stronger controls for more narrowly defined regional trends as a robustness check in table .

4.3.4 Data and sample

The dataset from which I draw a sample is an unbalanced panel including 24,211 U.S. fire departments. The dataset covers about 80 percent of the population, and includes observations in the period between 1999 and 2006. The sample was collected by the USFA through individual fire department efforts to record information using the National Fire Incident Reporting System (NFIRS)—a standardized reporting format. NFIRS was first established in 1974 to gather and analyze information on the magnitude of the nation's fire problem, but only gained broad adoption in the last decade. The USFA provides a public-release format of data available since the the most current NFIRS version was introduced in January 1999. This version represents the most comprehensive reporting format since the system began, and it marks the point at which participation took off. The regression sample includes 7,202 departments with a total of 29,714 department-year observations.[23]

Automatic aid arrangements spread throughout sample departments—rising from about 3% to 75%—over the observation window between 1999 and 2006. At the same time these departments increased the frequency of interactions with partners. The average number of fire department runs involving aid increased from roughly 5 runs per year to more than 20 (see figure 4.1).

4.4 Results

This research asks: How do alliances affect organization performance? I begin by presenting the results from models where performance is measured by property damage. These estimates are more stable, consistent, and straightforward than those from models where

[23]Most of the missing values result from departments not reporting department personnel information: a loss of 12,726 out of 24,211 departments. Another 1,243 of the remainder only appear in the sample for one year. And, the remaining 3,040 departments are excluded from the sample because they are missing data for at least one department-year on regression variables or measures with degenerate values.

performance is measured with casualties. First, I describe the results regarding the link between organizational slack and property damage. Next, I describe the results regarding the link between alliance contracts and property damage. Then, I present a comparison of the property damage results with the results where performance is measured with casualties. Finally, I discuss two additional robustness checks.

Table 4.2 provides a summary of the estimates in comparison with the predictions of the hypotheses and an assessment of the consistency between the theory and evidence. The full regression results are reported in table 4.3 for property damage and table 4.4 for casualties. The first two columns of tables 4.3 and 4.4 report the OLS regression results for fixed effect (model 1) and distributed lag (model 2) models. The next two columns report the IV regression results for fixed effect (model 3) and distributed lag (model 4) models.

The first stage regressions provide strong evidence that the instruments are relevant (see table 4.5 in the Appendix). The estimates have the expected signs and are statistically significant in almost all of the specifications, and the F-statistics for the excluded instruments are significantly larger than 10 in all specifications.[24] There is also evidence that the instruments are exogenous. Because there are more instruments than endogenous variables it is possible to test whether the instruments are correlated with error term in the main model. Tables 4.3 and 4.4 report p-values for the Hansen J tests which in all but one case suggest that the instruments employed are valid. Furthermore, given the large sample sizes it is surprising to get non-rejection results (evidence of valid instruments) at all.

[24]Furthermore, the instruments explain a meaningful amount of the total variation in the endogenous variables: the Shea Partial R^2 estimates of about 2.2% and 4.5% for partner resources and alliance contracts, respectively.

4.4.1 Organizational slack and property damage

The estimates of the moderating effect of internal resources on the link between uncertainty and property damage affirm H1. Specifically, the estimated coefficients for the interaction between internal resources and uncertainty are negative and statistically significant in all models where property damage is the dependent variable (see table 4.3). The results are also economically meaningful. The IV estimates in models 3 and 4 imply that a 10% increase in staff firefighters relative to expected peak-loads decreases property damage by about 3-4% when uncertainty increases 10% above the mean value.[25] That is equivalent to a decrease in property damage of between $9,500 and $12,900 per year per department.[26]

The estimates of the moderating effect of partner resources on the link between uncertainty and property damage affirm H2. Specifically, the estimated coefficients on the interaction between partner resources and uncertainty are negative and statistically significant in all models where property damage is the dependent variable (again see table 4.3). The results are also economically meaningful. The estimates in models 3 and 4 imply that a 10% increase in resources received from partners decreases property damage by about 10-11% when uncertainty increases 10% above the mean value. That is equivalent to a savings in property damage of roughly between $34,000 and $40,000 per year per department.[27]

Because partner resources are associated with less control than internal resources—and so yield increased coordination costs—the performance effect of partner resources should exert a stronger moderating effect on demand uncertainty than internal resources. This is consistent with the trade-off between control and flexibility I argue is associated

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[25] The mean effect of a 10% increase over the average value of both variables is calculated as $(1.1)(1.1)^{\beta} - 1$

[26] Extrapolated to the national level this represents a reduction of $290-390M annually—of course, these estimates are indicative not definitive.

[27] Extrapolated to the national level this represents a reduction of $1,000-1,200M annually—of course, these estimates are indicative not definitive.

with resources that are shared rather than owned. Exchanges with partners involve more severe coordination challenges than organizing increased resources internally. Consequently, the costs of collaborating are more likely to swamp the benefits when conditions are more stable and regular. There are two pieces of evidence consistent with this argument. First, the magnitude of the effect of partner resources is substantially larger than the estimated effect of internal slack: a factor difference of more than two times and a statistical difference that is significant at a p-value smaller than 0.01. Second, the main effect of partner resources on performance—interpreted as the effect of partner resources in absence of uncertain demand—is negative. This implies that greater reliance on partner resources is associated with more property damage, and it provides evidence of coordination problems for which alliance governance is so important.

4.4.2 Alliance contracts and property damage

The estimated effects of alliance contracts on property damage provides partial support H3. Specifically, the estimated coefficient on the main effect of alliance contracts is negative in both the OLS and IV models (see tables 4.3). Alliance contracts improve performance when measured by property damage; however, the estimates are only statistically significant in the distributed lag models. A cautious interpretation places the true value somewhere in the range between the fixed effect and distributed lag. The distributed lag estimates form an upper boundary. The estimate in model 4 of table 4.3 implies that organizing exchange in an alliance with a formal written contract decreases property damage by about 4.2% when fire demand arrives in a perfectly predictable manner—that is, in the absence of uncertainty. The effect of alliance contracts relative to informal alliances is equivalent to a reduction in property damage of up to $14,000 per year per department or up to $440M nationally.

The results provide partial support for H4. Specifically, the sign of the estimated coefficient on the interaction between alliance contract and uncertainty is positive in all models for which property damage is the dependent variable. Although the point estimates are qualitatively similar only two coefficients are statistically different from zero.[28] The effects are also economically meaningful. The estimate in model 3 implies that the use of an alliance contract increases property damage by up to 8% when uncertainty increases 10% above the mean value. That suggests a small increase in uncertainty is sufficient to wipe out the coordination gains from using alliance contracts when demand is completely predictable.

4.4.3 Trade-offs between property damage and casualties

A strong empirical regularity emerged in the results which suggests a more nuanced set of effects than originally conceived. The evidence implies that internal resources, partner resources, and alliance contracts exert different effects on property damage than on casualties. The effects for models in which property damage is the dependent variable are consistently larger on a percentage basis than the effects for models in which casualties is the dependent variable. Many of the estimated effects on casualties are not statistically distinguishable from zero. In fact, none of the IV estimates with fixed effects are statistically significant.

On the whole these organizational designs are more consequential for property damage than casualties, and of greater consequence the results suggest the presence of trade-offs among objectives. Specifically, while a 10% increase in staff firefighters relative to expected peak-loads decreases property damage by about 3-4% when uncertainty increases 10% above the mean value it does so at the expense of an increase in casualties of up to 0.6%.[29] While a 10% increase in partner resources from partners decreases property damage by about 10-11% when uncertainty increases 10% above the mean value it does so at

[28]The use of IVs in a fixed effect model is very demanding on the variation in the data which is aggregated temporally to the department year.

[29]Nationally equivalent to 140 casualties per year.

the expense of an increase in casualties of up to 2%.[30] While alliance contracts decrease property damage by up to 4.2% they do not have a statistically significant on casualties. Finally, while alliance contracts increase property damage by up to 8% when uncertainty increases 10% above the mean value they decrease casualties by up to 2.2%.[31]

4.4.4 Robustness

From an empirical standpoint, the hypotheses are broadly supported under rigorous controls: in particular, time-invariant differences between departments and feedback from past performance. Furthermore, after purging estimates of endogenous variation in two key explanatory variables the point estimates increase in magnitude; however, so too do the standard errors and not all coefficient estimates are statistically significant.[32] Nonetheless, this paper employs multiple research designs, each with different strengths and limitations, in an attempt more reliably assess the predictions offered above.

The preceding analysis does not account for differences in changes that occur at the county level over time. Of particular concern is that each county—in which there are multiple departments—follows a different learning and upgrade trajectory for its 911 call center in which alliance contracts are made operational. To control for these differences, the analysis was re-run on a sub-sample of the regression sample to include only departments from the nine states with the largest number of observations. Half the data was effectively thrown out for this analysis–substantially reducing the statistical power.

The results are presented in table 4.6 for the OLS and IV estimates with property damage as the dependent variable. The results are qualitatively very similar to the results

[30]Nationally equivalent to 440 casualties per year.

[31]Nationally equivalent to -490 casualties per year.

[32]The application of instrumental variables in this research design is very demanding: first, the instruments must provide time-series as well as cross-sectional variation; second, the variation must be sufficient to be partitioned according to differences in uncertainty (the two-way interactions with the endogenous regressors).

on the full regression sample that only incorporates state-time trends. In fact, the OLS estimates of the FE and LD models deliver very tight bounds on the effects. The IV estimates produce similar point estimates to the models on the full sample but with larger standard errors and a loss of statistical significance on the coefficient for H3.

4.5 Discussion and implications

In the first part of the analysis, this study shows that fire departments with more organizational slack perform relatively better overall than those with more lean resource profiles, but only when demand uncertainty is high.[33] This implies that for fire departments slack enables organizations to better adapt to irregular conditions. In this setting, these conditions are distinguished by the unevenness of fire arrivals over time. These results are broadly consistent with existing theory on the fit between the design of the organization and its environment. However, by distinguishing the effects of slack (i) from two different sources (ii) on two different outcomes this study sheds light on the way in which fitness generates superior performance in more precise terms.

Specifically, I conceive of and find evidence consistent with the operation of two sets of mechanisms linking choices about resources owned by the organization, the services of resources borrowed from partners, and organization performance. First, this study attributes the influence of internal resources on performance to twin pressures from trade-offs between the risks of breaking constraints and the risks of idling resources. The relative responsiveness of these pressures to demand uncertainty determines the directional effect of internal resources on performance. When the risks of idling resources are greater than the risks of exceeding capacity constraints an increase in internal resources will worsen performance. In this setting, the risks of breaking constraints and failing to control fires are more severe than the risks of idling personnel and so an increase in internal resources

[33] These results reflect the cost controlled effectiveness of an increase in personnel relative to peak expected demand.

reduces property damage when conditions are volatile and irregular.

Second, while managers make commitments to particular resources they also incorporate the services of resources that are owned by partners. This study shows that partner resources influence performance even after controlling for internal resources. The estimated effects are attributed to competing mechanisms. On one hand, partner resources relieve the tensions associated with internal resources under uncertainty. On the other hand, the services of partner resources are less controllable and so are subject to more serious coordination problems than internal resources. Effective firefighting occurs when departments rapidly deploy the right combination of resources for a particular incident. When working with alliance partners fire departments must contend with different norms and understandings, different operating procedures, and different technical interfaces. These differences impede the ability to deploy resources across organization borders.

This study also shows that resource allocation choices exert forces that work in different directions for different outcomes. Why would fire departments experience conflicting effects from the same design decisions for multiple aspects of performance? One explanation follows from the nature of production of fire services. Departments with more firefighters—whether alone or in conjunction with partners—may be able to produce higher average quality of services by providing better backing coverage, better resource combinations, and faster responses. However, departments that raise service levels by employing more firefighters increase their exposure to risks of casualty at the same time.

Consider for instance how four firefighters might be able to attack a structure fire more effectively than two firefighters. Doubling the number of firefighters may improve effectiveness, but it does so by exposing twice as many individuals to risk of injury or death. This suggests that some organizational goals come into conflict. Furthermore, combining the efforts of four firefighters is a harder coordination task than combining the efforts of two firefighters—particularly, when these individuals are from separate organizations. The results are consistent with this stylized example and suggest that an increase in firefighters relative to expected peak-loads reduce property damage while increasing the number of casualties by a small amount. This implies that an increase in organizational slack may be more effective but also more risky for fire departments.

For managers in general, these findings imply that although alliances relieve tensions that arise from commitments to strategic resources under conditions of uncertain demand they can involve a loss of control and sharper goal conflict at the same time. The loss of control generates coordination costs and goal conflict leads to discrimination across outcomes. Therefore, managers must be cognizant of these challenges when designing the organization in conjunction with alliance partners.

In the second part of the analysis, this study recognizes that the effects of resources on performance are not independent of the structures linking them. It shows that the transition from informal arrangements with alliance partners to formal written contracts improves performance when measured by property damage but not by casualties. There are at least two explanations for why we might observe this result.

First, alliance contracts provide structure that constrains the actions of each partner in episodes of collaboration. As predicted, this structure can generate misfit between designs *ex ante* and requirements *ex post* leading to worse outcomes when conditions are less certain predictable. However, the trade-off between property damage and casualties suggest that alliance contracts may also provide structure with which to enforce activities that contribute differentially to organizational priorities. Under this interpretation, although more structure introduces rigidities that reduce some aspects of performance it may do so as a way of coordinating actions towards the pursuit of greater priorities.

Second, alliance contracts may resolve *ex post* motivation problems (Hart and Moore 2008). That is, they may induce different trade-offs for different objectives because these objectives may be associated with different incentive problems. On incidents involving risks to life partners are likely to deliver consummate performance, but on incidents involving only risks to property partners may have incentives to free-ride. That is because firefighters will go to the mat to protect a fellow firefighter but not necessarily a structure that in all likelihood is insured—particularly in another jurisdiction. Considered this way, the results imply that alliance contracts may also be needed to reduce incentive problems in this setting. When conditions are stable and regular alliance contracts will be more complete and induce cooperation more effectively. When conditions are unstable and irregular and alliance contracts are less complete and so serve as less effective instruments for inducing cooperation. In these situations alliance contracts may act as focal points for partners to comply with the agreement without discharging their duties in a manner consistent with the intention of the agreement (Hart and Moore 2008). In this way, the results of this study suggest that alliance contracts are needed against a backdrop of incentive problems—when only property is at risk.

They also suggest that informal arrangements are sufficient to deliver consummate performance against a backdrop of muted incentive problems—when lives are also at risk. When conditions are uncertain and partners have greater difficulty coordinating actions alliance contracts provide structures that make the actions each partner will take more predictable. Therefore, on outcomes which generate incentives to deliver consummate performance observed improvements in performance from using contracts are attributed to improvements in coordinating activities. These explanations imply that contracts may serve different purposes for different outcomes. By comparing results across property damage and casualties this study examines how alliance contracts serve these different functions: as devices for coordinating activities, as devices for ensuring cooperation consistent with the spirit of the relationship, and as devices for delineating among organizational priorities.

What do these results imply for managers in other industries? Again consider the passenger airline industry. These organizations pursue multiple goals that are sometimes incompatible. Alliances are prevalent in this industry, and these agreements relate to several aspects of the business. Airlines use automatic re-booking systems to manage passengers that miss connections on their flights. Airlines that extend these programs to include the flights of alliance partners can benefit from accessing the resources of their partners while achieving high levels of coordination. While these arrangements may improve the way that airlines can handle missed connections and work with partners they may also introduce incentive problems for partners that would rather free-ride on the system of exchange. One way that this arises is in the way these airlines handle tickets of different priority. Partners may rather use higher-valued seats for their own customers than those of their partners. In these circumstance, automatic re-booking systems must be designed to incorporate trade-offs among the competing goals of connection efficiency and that benefit from enhanced coordination and those that benefit from enhancing partner cooperation.

Finally, this study examines an empirical setting in which relations between organizations proceed from informality to formality. This is an atypical progression; however, it provides an opportunity to examine alliances in both states. In this way the study provides evidence that many organizations work together under informal arrangements before ever formalizing relations. Interactions that occur prior to formalizing a relationship may be very meaningful to the performance of participating organizations.

Furthermore, these interactions provide information for partners that affects the design of arrangements within the working relationship. For instance, for alliances with a history of successful interactions formalizing the relationship may be more symbolic than alliances with a history of poor unsuccessful interactions who formalize the relationship to remedy cooperative problems. These difference suggest that the nature of informal relations can materially influence the selection into contract, the design of these arrangements, and how they are linked with performance. So, if an alliance is considered to have begun at the point that an organization establishes a formal tie a history of exchange may be overlooked that has consequence for success of the relation. This suggests that we may observe a dynamic phenomenon where formal alliances are just the most recent arrangements in a long history of interactions.

4.6 Conclusion

Managers are faced with ongoing decisions about the amount, kind, and structure of organizational resources. These decisions establish patterns of activity that constitute organizational architecture. The results of this study demonstrate how a set of architectural choices for working in alliances affect organization performance. From a theoretical standpoint, this paper contributes to our understanding of the mechanisms by which alliances influence the performance of participating organizations. Decisions about organizational slack (how much and from where?) and the structure of arrangements for working with alliance partners (formal or informal?) are the focus of the analysis. From a practical standpoint, this study has important implications for managers in designing their organizational architecture in conjunction with alliance partners. This study shows that the influence of alliances on performance differs according to the amount of demand uncertainty and the aspect of performance being considered.

These results have implications for the coordination of activities and ultimate success of partnered organizations in a wide variety of industries. First, the design considerations raised by this study are particularly important in industries where organizations are enmeshed in relations with other organizations involving obligations and entitlements. This includes electricity and other utilities suppliers who participate in pooling arrangements. It also includes transportation suppliers such as airline, rail, and shipping companies who participate in code-sharing, interconnection, and loyalty program alliances.

Second, these design considerations are also important to organizations participating in industries where demand is fleeting and arrives unevenly, and where resource investments must be made before demand is revealed. This includes the apparel business where firms commit to products and quantities, and where the tastes are changeable and difficult to predict. It includes the hotel and resort businesses where capacity is fixed in the short-run, where demand is largely seasonable, and where major attractions can create excessive demand. It also includes healthcare services where organizations rely on highly trained staff and specialized equipment that is difficult to find and replace, and where demand for services and urgent. Organizations in these industries are regularly faced with capacity decisions that entail substantial uncertainty and risk as well as the possibility of engaging in alliances to address these resource problems.

Overall many of the hypotheses developed in this study are supported. Distinguishing between internal resources and the services of partner resources leads to a more precise understanding of the ways in which the allocation of resources contributes to performance. Both internal and partner resources moderate the negative effect of demand uncertainty on organization performance. The presence of both effects is attributed (i) to the relief provided by partner resources to the twin costs of internal resources when demand is volatile and irregular, and (ii) to the coordination costs associated with working more intensely with alliance partners when demand is stable and regular. This suggests that failure to consider the simultaneous investment in resources within the organization and across alliances may lead to incorrect interpretations of how design is linked with performance. Future research should directly consider the precise connections between internal and partner resources. In this study I suggest ways in which internal and partner resources may be both substitutes and complements. Distinguishing the conditions under which complementarity or substitution arise will inform how design of resources with an alliance operate and jointly determine success.

Distinguishing between when alliances are informally arranged and when they are structured with formal contracts leads to different outcomes. Formal contracts directly improve performance when measured by property damage but not by casualties. The negative effect on property damage is attributed to the stronger contractual controls that facilitate coordination between alliance partners and that ensure partners are not free-riding. In contrast, informal arrangements are sufficient to deliver consummate performance on casualties. This suggests that failure to consider multiple aspects of organization performance can produce different results.

Future research should be careful to distinguish between features of alliance contracts that contribute to performance in different ways. In cases where the same contract design considerations yield congruent effects on multiple aspects of performance this is not problematic; however, the results of this study suggest ways in which the effects may be more nuanced.

Finally, distinguishing between formal and informal alliances suggests that researchers need to be careful about what constitutes an alliance. If an alliance is considered to begin with a formal agreement the history of interactions may create very different reasons for adopting formal contracts and the content of these agreement may vary substantially. Future research should explore how qualitative differences in the history of interactions preceding the use of formal contracts influence the adoption and design of alliance contracts.

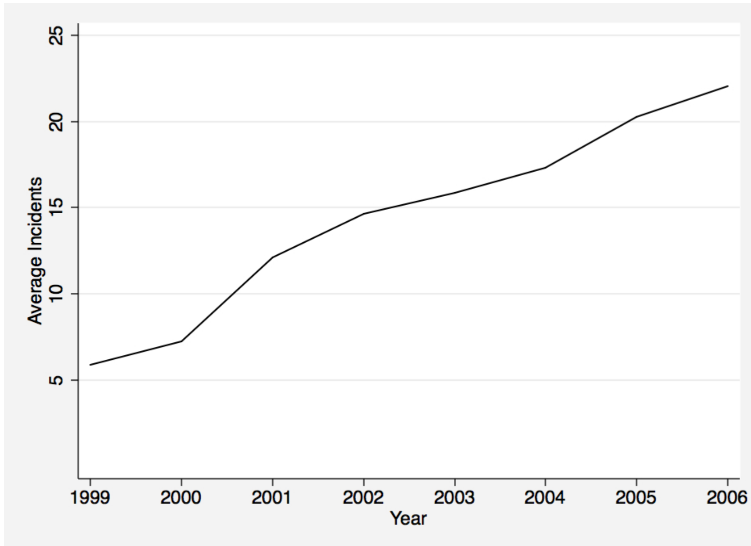

Figure 4.1: Aid interactions per department

This graph depicts the rise in aid interactions per department from roughly 5 runs per department in 1999 to more than 20 runs in 2006 for 7,202 sampled departments.

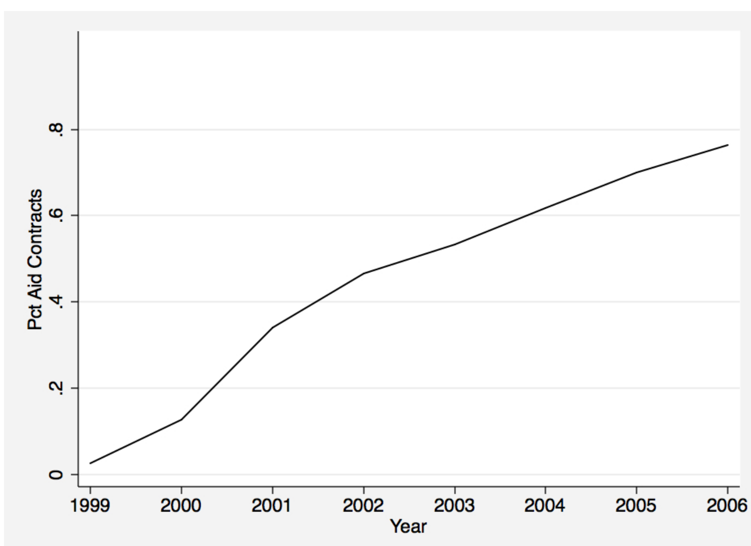

Figure 4.2: Spread of aid contracts

This graph depicts the spread of automatic aid for sampled departments for 7,202 sampled departments.

Table 4.1: Summary statistics

Dependent Variables	Description	Mean	Std. Dev.	N
Property damage	US$ loss of property (deflated)$_{d,t}$	353,249	1,593,092	29,714
Casualties	# civilian and firefighter injuries and deaths$_{d,t}$	1.39	4.99	29,714
Independent Variables	**Description**	**Mean**	**Std. Dev.**	**N**
Uncertainty	SD(daily firefighter runs)$_{d,t}$	1.62	0.63	29,714
Internal resources	Ratio of # firefighters$_{d,t}$ to $p95^{th}$ daily firefighter runs$_{d,t-1}$	2.32	12.69	29,714
Partner resources	# firefighter runs received from partners$_{d,t}$	76.31	158.65	29,714
Alliance contract	Indicator for presence of automatic aid$_{d,t}$	0.57	0.49	29,714
Aid given	# firefighter runs given to partners$_{d,t}$	52.26	105.79	29,714
Firefighter hours	# firefighter hours spent fighting fires$_{d,t}$	92,159	6,195,245	29,714
Apparatus hours	# Apparatus hours deployed fighting fires$_{d,t}$	40,421	2,463,159	29,714
Residential structure fires	# fires in residential buildings$_{d,t}$	13.32	40.85	29,714
Non-residential structure fires	# fires in non-residential buildings$_{d,t}$	8.15	15.48	29,714
Outside fires	# non-structure fires	38.66	98.58	29,714
Year		2004	1.93	29,714
Instrumental Variables	**Description ($\mathcal{F}_d \equiv$ partner set for department d)**	**Mean**	**Std. Dev.**	**N**
Intra-network aid	$\sum_{p \neq d, p \in \mathcal{F}_d} \sum_{k=0}^{1}$ interactions$_{p,t-k}$	78.59	251.13	29,714
Partner distance	$\sum_{p \neq d, p \in \mathcal{F}_d}$ # miles travelled$_{p,t}$ excluding aid to d	1256	3581	29,714
Border fires	$\sum_{p \neq d, p \in \mathcal{F}_d}$ # fires $> p80^{th}$ distance from headquarters$_{p,t}$	147.05	280.91	29,714
Partner fires	$\sum_{p \neq d, p \in \mathcal{F}_d}$ # own fires$_{p,t}$	445.85	695.61	29,714

Table 4.2: Summary of results compared to predictions

		IV estimates		Expected?	Supported?	
Dep Var	Variable (× uncertainty)	FE	LD	Sign	Sign	Signif.
Property Dam.	Internal slack	-0.144***	-0.196***	(−)	Yes	Yes
	Partner resources	-0.623***	-0.538***	(−)	Yes	Yes
	Alliance contract (main)	-1.021	-4.171***	(−)	Yes	Mixed
	Alliance contract	0.793**	0.891	(+)	Yes	Mixed
Casualties	Internal slack	0.003	0.030***	(−)	No	Mixed
	Partner resources	0.022	0.101***	(−)	No	Mixed
	Alliance contract (main)	0.037	0.050	(−)	No	No
	Alliance contract	-0.027	-0.231**	(+)	No	Mixed

Note: Estimates are from tables 4.3 and 4.4. $^{+}$ $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, n=29,714

Table 4.3: Property damage regression results

	(1)	(2)	(3)	(4)
DV	Property damage	Property damage	Property damage	Property damage
Model	FE	LD	FE	LD
Estimator	OLS	OLS	2SLS	2SLS
Uncertainty	0.648***	0.510***	0.779**	1.141***
	(0.104)	(0.086)	(0.390)	(0.292)
Internal slack	0.204***	0.369***	0.213**	0.480***
	(0.074)	(0.056)	(0.102)	(0.089)
Partner resources	0.725***	0.563***	2.789***	1.534***
	(0.046)	(0.038)	(0.421)	(0.349)
(H1) Internal slack	-0.078**	-0.136***	-0.144***	-0.196***
× uncertainty	(0.038)	(0.029)	(0.053)	(0.059)
(H2) Partner resources	-0.150***	-0.125***	-0.623***	-0.538***
× uncertainty	(0.023)	(0.019)	(0.152)	(0.160)
	F(1) = 2.75	F(1) = 0.1	$\chi^2(1)$=12.6	$\chi^2(1)$=6.8
	p = 0.09	p = 0.74	p = 0.00	p = 0.01
(H3) Alliance contract	-0.295	-0.555***	-1.021	-4.171***
	(0.189)	(0.145)	(1.571)	(1.279)
(H4) Alliance contract	0.117	0.176**	0.793**	0.891
× uncertainty	(0.096)	(0.079)	(0.384)	(0.656)
Department FE	Yes	No	Yes	No
Lagged DV	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes
State-time trends	Yes	Yes	Yes	Yes
Controls	F(6)=54.5	F(6)=131.6	$\chi^2(6)$=112.1	$\chi^2(6)$=371.3
R^2	0.110	0.461	n/a	n/a
Hansen J-test (p-value)	n/a	n/a	0.355	0.003

Note: instruments include intra-network aid, partner distance, partner fires, border fires. Controls not displayed include aid given, man hours, apparatus hours, residential structure fires, commercial structure fires, and outside fires tested with composite linear hypotheses. State-time trends include first and second order terms. Robust standard errors in parentheses clustered on 7,202 departments. $^{+}$ $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, n=29,714.

Table 4.4: Casualties regression results

	(1)	(2)	(3)	(4)
DV	Casualties	Casualties	Casualties	Casualties
Model	FE	LD	FE	LD
Estimator	OLS	OLS	2SLS	2SLS
Uncertainty	-0.023***	-0.028**	-0.055	-0.178***
	(0.008)	(0.013)	(0.045)	(0.042)
Internal slack	-0.009	0.005	-0.013	-0.022+
	(0.005)	(0.006)	(0.009)	(0.011)
Partner resources	-0.011***	-0.042***	-0.016	-0.128**
	(0.004)	(0.006)	(0.029)	(0.051)
(H1) Internal slack × uncertainty	0.001	0.010**	0.003	0.030***
	(0.003)	(0.004)	(0.005)	(0.008)
(H2) Partner resources × uncertainty	0.010***	0.021***	0.022	0.101***
	(0.002)	(0.004)	(0.018)	(0.024)
	F(1) = 6.0	F(1) = 6.6	$\chi^2(1)$=1.8	$\chi^2(1)$= 12.0
	p = 0.01	p = 0.01	p = 0.18	p = 0.00
(H3) Alliance contract	0.021	0.004	0.037	0.050
	(0.013)	(0.017)	(0.117)	(0.165)
(H4) Alliance contract × uncertainty	-0.007	-0.007	-0.027	-0.231**
	(0.008)	(0.012)	(0.043)	(0.090)
Department FE	Yes	No	Yes	No
Lagged DV	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes
State-time trends	Yes	Yes	Yes	Yes
Controls	$\chi^2(6)$=112.1	$\chi^2(6)$=371.3	$\chi^2(6)$=17.0	$\chi^2(6)$=217.5
R^2	0.661	0.830	n/a	n/a
Hansen J-test (p-value)	n/a	n/a	0.785	0.647

Note: instruments include intra-network aid, partner distance, partner fires, border fires. Controls not displayed include aid given, man hours, apparatus hours, residential structure fires, commercial structure fires, and outside fires tested with composite linear hypotheses. State-time trends include first and second order terms. Robust standard errors in parentheses clustered on 7,202 departments. $^{+}$ $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, n=29,714.

4.7 Appendix

Table 4.5: First-stage results: aggregate annual performance

	(1)	(2)	(3)	(4)
Dep Var	Partner resources	Partner resources	Contract	Contract
Model	FE	DL	FE	DL
Estimator	OLS	OLS	OLS	OLS
Uncertainty	0.648***	0.493***	-0.020***	-0.029***
	(0.026)	(0.0277)	(0.005)	(0.007)
Intra-network aid	0.019+	0.169***	0.023***	0.025***
	(0.011)	(0.010)	(0.003)	(0.003)
Aid distance	-0.057***	-0.107***	-0.021***	-0.001
	(0.021)	(0.026)	(0.005)	(0.007)
Border fires	0.247***	0.057***	0.012+	0.002
	(0.027)	(0.022)	(0.007)	(0.006)
Partner fires	0.049***	0.119***	0.001	0.019***
	(0.015)	(0.013)	(0.003)	(0.003)
Year FE	Yes	Yes	Yes	Yes
State-time trends	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
R^2	0.28	0.34	0.42	0.35
F-stat (excluded instruments)	24	184	18	62

Note: controls not displayed include aid given, man hours, apparatus hours, residential structure fires, commercial structure fires, and outside fires tested with composite linear hypotheses. State-time trends include first and second order terms. Robust standard errors in parentheses clustered on 7,202 departments. $^{+}$ $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, n=29,714.

$^{+}$ $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4.6: County-time trends: aggregate annual performance

	(1)	(2)	(3)	(4)
Dep Var	Property damage	Property damage	Property damage	Property damage
Model	FE	LD	FE	LD
Estimator	OLS	OLS	2SLS	2SLS
Unit of analysis	d,t	d,t	d,t	d,t
Uncertainty	0.620***	0.448***	0.977	0.459
	(0.134)	(0.120)	(0.756)	(0.348)
Internal slack	0.300***	0.460***	0.342+	0.475***
	(0.094)	(0.078)	(0.206)	(0.107)
Partner resources	0.740***	0.616***	1.574	1.616***
	(0.062)	(0.056)	(1.028)	(0.490)
(H1) Internal slack	-0.150***	-0.170***	-0.199**	-0.161**
× uncertainty	(0.046)	(0.042)	(0.077)	(0.066)
(H2) Partner resources	-0.157***	-0.138***	-0.447**	-0.314+
× uncertainty	(0.031)	(0.027)	(0.212)	(0.172)
(H3) Alliance contract	-0.450+	-0.619***	-0.194	-4.061**
	(0.256)	(0.213)	(1.517)	(1.591)
(H4) Alliance contract	0.259**	0.254**	0.796	0.338
× uncertainty	(0.130)	(0.115)	(0.661)	(0.468)
Department FE	Yes	No	Yes	No
Lagged DV	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes
County-time trends	Yes	Yes	Yes	Yes
Controls	F(6) = 34.8	F(6) = 79.4	$\chi^2(6)$=60.9	$\chi^2(6)$=121.2
Observations	15217	15217	15217	15217
Obs - Parameters	14512	14503	14512	14503
# Departments	3430	3430	3430	3430
R^2	0.199	0.514	n/a	n/a

Note: Sample restricted to departments from 9 states with most number of observations from the sample above. Controls not displayed include aid given, man hours, apparatus hours, residential structure fires, commercial structure fires, and outside fires tested with composite linear hypotheses. Instruments include intra-network aid, partner distance, partner fires, border fires. State-time trends include first and second order terms. Unit of analysis: d = focal department, t = year. Robust standard errors in parentheses clustered on departments. $^{+}$ $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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