Relational Adaptation

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Abstract

Economic performance depends crucially on how parties adapt to changing circumstances. We therefore study how the organization of economic activity can facilitate such adaptation. Where spot transactions would produce inefficient adaptation, we ask how governance structures (allocations of control) can facilitate relational contracts that improve on spot adaptation. We show that the optimal governance structure for implementing a given relational contract minimizes the maximum aggregate reneging temptation created by that relational contract. We thus explore how formal governance structures support self-enforcing relationships—principally in contracts between firms, but also in "forbearance" within firms and relational contracting in "hybrid" governance structures.

Key words: relational contract, governance structure, adaptation, forbearance

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Relational Adaptation

by George Baker, Robert Gibbons, and Kevin J. Murphy

1. Introduction

Adaptation to changing circumstances is a fundamental goal of economic systems. This issue has long been explored in the context of markets—e.g., Arrow (1953), Debreu (1959), and Grossman (1981)—but surfaces as importantly in other settings. For example, Barnard (1938: 6) argued that "The survival of an organization depends upon the maintenance of an equilibrium of complex character in a continuously fluctuating environment." We see Barnard's observation applying not only within firms but also to contracts and other managed transactions between them.

In this paper, we consider an economic environment in which a sequence of states, s_t, arises and corresponding decisions, $d(s_t)$, are taken. For most of our analysis, we assume that decisions are non-contractible ex post: the parties cannot write an enforceable contract on d during the short window between the realization of the state and the need to take the decision. What the parties can do, however, is facilitate adaptation by choosing the ex ante assignment of decision rights (hereafter, the *governance structure*).

In a one-shot setting where decisions are non-contractible, the parties with decision rights play a Nash equilibrium, choosing state-dependent decisions that maximize their respective spot payoffs. Such *spot adaptation* is typically not efficient (i.e., it does not maximize the sum of the parties' payoffs). In this sense, our model explores a central issue emphasized by Williamson (2000: 605), who summarized decades of informal theory by arguing that "maladaptation in the contract execution interval is the principal source of inefficiency."

Given this inefficiency under spot adaptation, we use the theory of repeated games to explore how the parties can use *relational contracts* (i.e., self-enforcing agreements governed by the parties' concerns about the future) to improve their expected payoffs.[1] Of course,

[1] See Baker, Gibbons, and Murphy (2002) for citations concerning (a) the general importance of relational contracts both within firms and between and (b) some specific roles of informal agreements in ostensibly formal processes (such as transfer pricing within organizations and alliances between them).

holding the governance structure constant, the parties can do at least as well under relational adaptation as under spot. Our contribution is to explore whether the parties can achieve further improvements by choosing a different governance structure than would have been optimal in a spot setting.

Our model revisits an important problem first studied by Simon (1951): how to achieve adaptation as uncertainty is resolved. Simon considered two parties, a boss and a subordinate, both of whom care about a decision, d, that can be taken after a state, s, is realized. The efficient decision in state s is d*(s), but the parties cannot write the contract d*(•) ex ante and enforce it ex post. Instead, Simon assumed that the parties' options are either to lock in a decision, d_0, before the state is realized or to allow the boss to choose her self-interested decision, $d_b(s)$, after the state is realized.

For our purposes, it is important to note that Simon also briefly mentioned two additional ideas: an alternative allocation of control (namely, letting the subordinate decide, p. 304) and the possibility of repeated interaction (p. 302). Our version of Simon's model compares self-interested decision-making by the boss to self-interested decision-making by the subordinate (rather than to a decision locked in ex ante).[2] We extend Simon's model by allowing an arbitrary number of parties and an arbitrary number of decision rights, each of which can be allocated to any party. Furthermore, we explore the interaction between Simon's two additional ideas by analyzing how the prospect of an ongoing relationship affects the optimal allocation of control.

Our focus on how the possibility of relational contracting affects the optimal allocation of control allows us to study issues that Klein and Williamson have long argued are central to contract design.[3] In particular, our model is consistent with Klein's (2000: 68) observation that, although Macaulay (1963) was certainly correct that many business relationships are self-enforced, "transactors are not indifferent regarding the contract terms they choose to govern their self-enforcing relationships." That is, parties to relational contracts often sign formal contracts that both limit the parties' reneging temptations in some states of the world and exacerbate these temptations in others. Our model thus analyzes how parties should

2 Our formulation thus resolves an implicit tension in Simon's analysis: Simon does not explain why, if the decision is contractible ex ante, it is not also contractible ex post. If the decision were contractible ex post, then the parties could renegotiate the boss's self-interested decision ex post and the allocation of decision rights ex ante would be immaterial.

3 See, for example, Klein and Murphy (1988), Klein (1996, 2000) and Williamson (1971, 1975, 1991).

structure contracts that start when they sign them, rather than contracts that are done when they sign them (such as a contract to trade at a given price).

None of these theoretical ideas—from Simon to Williamson to Klein—requires or even includes specific investments. These ideas thus complement those of Williamson (1971, 1979), Klein, Crawford, and Alchian (1978), Grossman and Hart (1986), and Hart and Moore (1990) that emphasize not only the existence of specific investments but also the efficiency of these investments as a key determinant of optimal governance structures. Our model takes the former approach, studying difficulties in adaptation ex post rather than in investments ex ante.

Two growing empirical literatures also study optimal governance structures in the absence of specific investments. The first closely parallels our model, analyzing *contracting for control*, in which parties use formal contracts to allocate decision rights across fixed firm boundaries. For example, Lerner and Merges (1998) analyze 25 decision rights that can be allocated to either partner in contracts between pharmaceutical firms and biotechnology companies, such as the right to control patent litigation or the right to manufacture the final product. Similarly, Arrunda, Garicano, and Vasquez (2001) study the allocation of 33 decision rights in contracts between auto manufacturers and their dealers, such as the right to determine the size and qualifications of the sales force, or the right to set prices.[4] In the spirit of Stinchcombe's (1985) and Pirrong's (1993) early work (which studied contracting but not specifically contracts for control), many recent empirical papers on contracting for control explicitly note that the classic drivers of transaction costs—such as site, physical-asset, and human-asset specificities—are conspicuously absent from the environments they study. In short, both in our model and in many empirical settings, the parties are designing governance structures in the absence of specific investments.

A second empirical literature analyzes the classic make-or-buy problem, in which the allocation of control changes when parties alter firm boundaries. Early contributions such as Masten, Meehan, and Snyder (1991) introduced determinants of firm boundaries in addition to specific investments.[5] More recently, many contributions to the empirical literature on the

4 See also Elfenbein and Lerner (2003), Kaplan and Stromberg (2003), Robinson and Stuart (2007), Ryall and Sampson (2009), and Lerner and Malmendier (2010).

5 In particular, to motivate the possibility of lock-in even in the absence of specific investments, Masten, Meehan, and Snyder (1991: 9) described "temporal specificity" as follows. "Where timely performance is critical, delay becomes a potentially effective strategy for extracting price concessions. … Even though the

make-or-buy problem have almost or entirely ignored specific investments.[6] While the direct application of our model is to contracting for control, we extend the model to describe assets as well as contracts. In so doing, we develop a theory of firm boundaries in the absence of specific investments. In fact, by allowing both contracts and assets in our extended model, we encompass not just the classic alternatives of integration and non-integration, but also some of the "hybrid" governance structures (such as networks, consortia, and so on) emphasized from Blois (1972) and Richardson (1972) through Powell (1990) to Ménard (2012). Our extended model thus begins to address the rich set of observed governance structures—from contracts to firms to hybrids—that parties use to ameliorate Williamson's "maladaptation in the contract execution interval," even in the absence of specific investments.

In a separate extension of our main model, we depart from our assumption that decisions are non-contractible ex post, assuming instead that contracts can be written and enforced ex post but at a cost. Partly, this extension is a robustness check: we show that allowing for such costly contracting preserves the main insights from our main model. But we also conduct a related analysis to formalize Williamson's (1991) discussion of "forbearance" (in which contracts between firms have standing in court but contracts within firms do not). In this analysis, we define non-integration to have finite costs of contracting ex post but integration to have infinite costs (i.e., firms are contract-free zones, consistent with the discussions in Hansmann (2012) and Kornhauser and MacLeod (2012)). Because non-integration has lower costs of contracting, it outperforms integration for spot transactions. We show, however, that certain relational contracts are feasible under integration but not under non-integration, because integration can reduce the contract's maximum reneging temptation. In short, we build on Williamson's observation that contract law may be different within firms versus between them, thus exploring both which kinds of transactions will then be conducted under integration versus non-integration and how we should then expect firms to differ from markets.

In addition to these connections to the theoretical ideas of Simon, Klein, and Williamson and to empirical work on optimal governance structures in the absence of

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skills and assets necessary to perform the task may be fairly common, the difficulty of identifying and arranging to have an alternative supplier in place on short notice introduces the prospect of strategic holdups."

6 See Baker and Hubbard (2003, 2004), Nickerson and Silverman (2003), Gonzalez-Diaz, Arruñada and Fernandez (2004), Forbes and Lederman (2009, 2010), and Gil and Hartmann (2009).

specific investments, our model also relates to two streams of formal theory. First, because most of our analysis assumes that decisions are not contractible even after the state is realized, we join a recent literature in departing from the efficient bargaining ex post assumed in early incomplete-contract models such as Grossman and Hart (1986) and Hart and Moore (1990).[7] In this earlier literature, control affects how the benefits from a decision are divided among the parties, but control does not affect the decision itself (because efficient bargaining results in the efficient decision, regardless of the governance structure). In our model and this recent literature, in contrast, control matters because it will be exercised (self-interestedly, and hence perhaps inefficiently), rather than because it creates a threat point for efficient bargaining.

Second, in studying relational adaptation, we draw on earlier work on relational contracts under fixed governance structures (e.g., MacLeod and Malcomson (1989) and Levin (2003)). In our setting, like theirs, a decision rule can be implemented by a relational contract if and only if the decision rule creates sufficient surplus above the expected total payoff from optimal spot governance. The innovation in our setting is that the governance structure is endogenous, and this has consequences both on and off the equilibrium path. Specifically, the parties can choose their governance structure not only today, which influences reneging opportunities, but also tomorrow, which affects the surplus the relationship can produce and hence the relational contracts that can be sustained.

The paper is organized as follows. In Section 2 we analyze an arbitrary number of decision rights that can be allocated among an arbitrary number of parties. In Section 3 we apply our main results in a simple setting (two parties and one decision right) and we illustrate a central tradeoff in our model: in choosing a second-best decision rule, the parties would like to both reduce reneging temptation and avoid losing surplus, but these two goals often conflict. In Section 4, we relax our assumption that decisions are not contractible during the short window between the realization of the state and the need to take the decision, both as a robustness check and to study forebearance.

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7 Examples of such departures include: Masten (1986), Skaperdas (1992), and Rajan and Zingales (2000) on battles for control; Dewatripont and Tirole (1994), Hart and Moore (2005), and Van den Steen (2010) on orchestrating control; Dessein (2002), Alonso, Dessein, and Matouscheck (2008), and Rantakari (2008) on communication and control; Milgrom and Roberts (1988), Aghion and Tirole (1997), and Prendergast (2002) on incentives and control; and Hart and Moore (2008), Hart (2009), and Hart and Holmstrom (2010) on "aggrievement" and control.

In Section 5, we enrich our analyses in two ways. First, we extend the simple setting from Section 3 to two decision rights and show that the allocation of control of different decisions can have important interactions across parties even if the parties' preferences are separable across decisions. Second, we enrich the model from Section 2 by adding payoff rights and assets (defining the latter as bundles of inextricable decision rights and payoff rights), and we discuss how one might define a firm in terms of asset ownership, thereby producing a relational-adaptation theory of the firm in the absence of specific investments. Section 6 concludes.

2. Contracting for Control

In this section we analyze governance structures that allocate decision rights to parties (or, in a more concrete interpretation, contracts that move decision rights across fixed firm boundaries). We begin with the simple case of two parties and one decision right. We then enrich the model to include an arbitrary number of parties and decision rights.[8] We analyze spot adaptation in Section 2.1 and relational adaptation in Section 2.2.

2.1. Spot Adaptation

As a simple example (to which we return in Section 3), consider a single decision right that can be assigned to either of two parties, A or B. The parties are risk-neutral and have private (inalienable) benefits, π_A and π_B. These private benefits depend on the state of nature, drawn from the finite set S according to the probability density f(s), and also on the decision d, chosen from the finite set D after the state is revealed. First-best state-dependent decision-making therefore solves

(1) $$d^{FB}(s) = \arg\max_{d \in D} \pi_A(d,s) + \pi_B(d,s),$$

which produces total payoff in state s of

(2) $$V^{FB}(s) = \pi_A(d^{FB}(s),s) + \pi_B(d^{FB}(s),s).$$

[8] As we discuss below, while our analysis applies to many parties, some of our assumptions are more palatable when there are only two.

We assume that the state is observable to both parties but is not verifiable to third parties. In addition, until Section 4, we assume that (a) the parties cannot write an enforceable contract on d during the short window between when the state is observed and when the decision needs to be taken and (b) the parties also cannot transfer the decision right during this window. On the other hand, throughout the paper, we assume that it is costless to write and enforce a contract that allocates the decision right to one party ex ante (i.e., in the long span of time from the beginning of the transaction until the state is revealed).

In a spot setting, if party i (i = A, B) holds the decision right and observes state s, then party i will choose the decision that maximizes its own private benefit, without regard to the private benefit of party j:

(3) $$d_i^*(s) = \underset{d \in D}{\arg\max}\, \pi_i(d,s),$$

which produces total payoff in state s of

(4) $$V^i(s) = \pi_A(d_i^*(s),s) + \pi_B(d_i^*(s),s).$$

Which party should own the decision right in a spot setting? If decision rights could be reallocated after the state is revealed (but before the decision must be taken), then party A should hold the decision right in all states where $V^A(s) > V^B(s)$, and B should hold the decision right when $V^B(s) > V^A(s)$. Because decision rights must be assigned before the state is revealed (and cannot be reallocated afterwards), however, party A should hold the right if $E_s[V^A(s)] > E_s[V^B(s)]$, and B should hold the right if $E_s[V^B(s)] > E_s[V^A(s)]$.

This simple example is easily extended to a richer model with an arbitrary number of parties and decision rights.[9] With some abuse of notation, suppose there are I parties denoted $i \in I = \{1, ..., I\}$ and K decision rights denoted $k \in K = \{1, ..., K\}$. Party $i \in I$ receives inalienable private benefit $\pi_i(\mathbf{d},s)$, where $\mathbf{d} = (d_1, \dots, d_K)$ is the vector of decisions chosen from the set $D = \Pi_{k \in K} D_k$. (It is straightforward to incorporate inalienable decision rights $\delta_i \in \Delta_i$ for each $i \in I$. All the results in this section continue to hold. We simplify notation by omitting such decision rights from the formal model, but we discuss them informally below.)

Let $\mathbf{d}^{FB}(s)$ denote the first-best decisions in state s, given by

[9] Note, however, that our assumption that all parties observe the state (and, in the repeated game below, also the decisions) may be more likely to be satisfied for small groups than large.

(5) $$\mathbf{d}^{FB}(s) = \arg\max_{\mathbf{d}\in D} \sum_{i\in I} \pi_i(\mathbf{d},s),$$

producing the first-best total payoff in state s

(6) $$V^{FB}(s) = \sum_{i\in I} \pi_i(\mathbf{d}^{FB}(s),s).$$

Define $V^{FB} = E_s[V^{FB}(s)]$ as the expected total payoff produced by the first-best decision rule.

For this environment, we define a *governance structure* to be an assignment of decision rights to parties.[10] We assume that each feasible governance structure g: K → I assigns each decision right k ∈ K to exactly one party i ∈ I. That is, there is no joint control of any decision right and there is no decision right that is left uncontrolled. Let $G = I^K$ denote the set of feasible governance structures.

Given governance structure g ∈ G, let K(i,g) ⊆ K denote the set of decision rights held by party i and $D_{ig} = \Pi_{k\in K(i,g)} D_k$ denote the decision space for party i, where $\mathbf{d}_{ig}$ is a typical element of D_{ig}. We assume that, for each governance structure g and each state s, there is a unique Nash equilibrium decision vector, $\mathbf{d}_g^{NE}(s)$, in the one-shot game where each party simultaneously chooses $\mathbf{d}_{ig} \in D_{ig}$. That is, for each party i, $\mathbf{d}_{ig}^{NE}(s)$ solves:

(7) $$\max_{\mathbf{d}_{ig}\in D_{ig}} \pi_i((\mathbf{d}_{ig},\mathbf{d}_{-ig}^{NE}(s)),s).$$

The payoff to party i in a spot transaction under governance structure g in state s is then $\pi_{ig}^{NE}(s) = \pi_i(\mathbf{d}_g^{NE}(s), s)$, with expectation $V_{ig}^{NE} = E_s\left[\pi_{ig}^{NE}(s)\right]$, so the expected total payoff from a spot transaction under governance structure g is $V_g^{NE} = \sum_{i\in I} V_{ig}^{NE}$. The optimal governance structure for a spot transaction is therefore

(8) $$g^{SP} = \arg\max_{g\in G} V_g^{NE}.$$

Let the decision rule implemented by optimal spot governance, $\mathbf{d}_{g^{SP}}^{NE}(\cdot)$, be denoted by $\mathbf{d}^{SP}(\cdot)$ and the expected total payoff $V_{g^{SP}}^{NE}$ by V^{SP} with the associated expected payoff V_i^{SP} to party i.

[10] We consider a richer environment in Section 5.2 and give an analogous definition of a governance structure there.

We assume that no governance structure achieves the first-best decision vector in every state, so $V^{SP} < V^{FB}$.

2.2 Relational Adaptation

Because the decisions under spot adaptation are inefficient ($V^{SP} < V^{FB}$), it is natural to ask whether relational adaptation can improve on the payoffs that the parties achieve under the optimal governance structure for spot adaptation, g^{SP} in (8). More specifically, in a repeated game, we ask three questions: (a) can relational contracting improve on the parties' spot payoffs if they persist in using g^{SP}; (b) can the parties achieve further improvements in their payoffs if they switch to another governance structure (and, if so, which one); and (c) can the parties ever implement the first-best decision rule (and, if so, under what governance structure)?

We begin by establishing a familiar result that answers question (a): under a given governance structure, a state-dependent decision rule can be implemented by a relational contract if and only if the decision rule creates sufficient surplus above the expected total payoff from optimal spot governance (V^{SP}). Our main focus is then on questions (b) and (c): how can the parties choose a governance structure to improve their payoffs under relational contracting? Compared to analyses of single governance structures (such as MacLeod and Malcomson (1989) and Levin (2003)), one new feature of our three analyses (even (a)) is that the parties can change governance structures after any period (a possibility that may be especially relevant if there is reneging on the relational contract).

Our argument proceeds as follows. First, we specify our stage game (as an enriched version of the spot transaction in Section 2.1, now allowing for payments between the parties at several points) and discuss our solution concept (subgame-perfect equilibrium, with a renegotiation-proofness assumption on the governance structure after reneging). Then we discuss the necessary and sufficient condition for a decision rule to be implemented in a relational contract (i.e., for the parties' decision and payment strategies to be an equilibrium of the repeated game), but we relegate most of this analysis to Appendix 1. Finally, we prove our main results: first, the optimal governance structure for implementing a given decision rule minimizes the maximum aggregate reneging temptation that the decision rule creates; and second, this optimal governance structure often differs from the governance structure that maximizes the parties' expected total payoff in a spot setting (g^{SP}). We also determine whether the first-best decision rule can be implemented and, if so, what governance structure implements the first-best when the parties are least patient.

Consider a stage game in which the spot-adaptation model in Section 2.1 is enriched to allow payments at three different times. (These payments can be positive or negative—i.e., they can be paid to or paid by a given party.) First, the payments might be non-contingent *wages*, denoted by t_{ig} and paid after the governance structure is chosen but before the state or any decisions are observed. Second, the payments might be state-contingent *bribes*, denoted by $\tau_{ig}(s)$ and paid after the state is observed but before the parties make their decisions. Third, the payments might be state- and decision-contingent *bonuses*, denoted by $T_{ig}(\mathbf{d}, s)$ and paid depending on whether the ultimate decisions are appropriately tailored to the state. Figure 1 illustrates the timing of these potential payments within each period, relative to when the governance structure is chosen, the state observed, and the decisions taken.

Now consider the repeated version of this stage game, where all parties discount payoffs according to discount rate r. This is a repeated game of complete and perfect information, so we analyze subgame-perfect Nash equilibria. We impose the following renegotiation-proofness assumption on the parties' choice of governance structure at the start of each period: if any party reneges (on a payment or a decision), the parties engage in optimal spot governance in all future periods.[11] Unless the parties were already operating under the optimal spot governance structure g^{SP}, implementing optimal spot governance requires reallocating control to g^{SP}, which typically requires a side-payment P_{ig} to party i (or from party i if P_{ig} is negative). We impose two weak constraints on these side-payments: balance and individual rationality. Thus, after reneging, each party receives P_{ig}, control of the decision rights is reallocated to g^{SP}, and the expected total payoff is V^{SP} per period thereafter.[12]

Let $\mathbf{d}^{RC}(\cdot)$ be a state-contingent decision rule that produces a higher expected total payoff than the optimal spot governance structure produces. That is, define

[11] Like our assumption that all parties observe the state and the decisions, this assumption (of efficient spot governance after reneging) is more plausible for two parties than for larger groups. For example, imagine that there are four parties who care about two decisions: parties A and B care about decision 1, C and D about 2. One could imagine that reneging by A or B on decision 1 would not prevent relational contracting by C and D over decision 2 (e.g., one couple's divorce may not disrupt another's marriage).

[12] It may seem strange that we allow renegotiation of control after reneging and yet rule out such renegotiation during the short window between when the state is observed and when the decision must be taken, but there is no inconsistency here. Again, our assumption is that the latter window is short, and reallocating control would take some time, so this is why there is no renegotiation during the window, but there is plenty of time before the next period's state is observed.

(9) $$V(\mathbf{d}^{RC}(\cdot)) = E_s\left[\sum_{i\in I}\pi_i(\mathbf{d}^{RC}(s),s)\right]$$

and suppose that $V(\mathbf{d}^{RC}(\cdot)) > V^{SP}$.

Our first task is to determine whether, if the parties begin the game under a particular governance structure $g \in G$, there exist payment rules t_{ig}, $\tau_{ig}(\cdot)$, and $T_{ig}(\cdot,\cdot)$ such that the decision and payment strategies $\{\mathbf{d}^{RC}(\cdot), t_{ig}, \tau_{ig}(\cdot), T_{ig}(\cdot,\cdot); i \in I\}$ are a subgame-perfect equilibrium of the repeated game (given our assumption of efficient spot governance after reneging). If so, we say that these strategies are a *relational contract* under governance structure g. If such a relational contract exists, we say that it *implements* this decision rule under governance structure g.

For such a relational contract to exist, there are many reneging constraints that must be satisfied: each party i must be willing to pay (or receive) t_{ig}, pay (or receive) $\tau_{ig}(s)$, take decisions $\mathbf{d}_{ig}^{RC}(s)$, and pay (or receive) $T_{ig}(\mathbf{d}, s)$. In Appendix 1 we show that all these constraints can be simplified to one necessary and sufficient condition: given a governance structure, a decision rule can be implemented via a relational contract if and only if the decision rule's maximum aggregate reneging temptation under that governance structure is less than the present value of the surplus that the decision rule creates (relative to optimal spot governance). To state this result formally, we introduce the following notation:

$\pi_i^{RC}(s) = \pi_i(\mathbf{d}^{RC}(s),s)$	Payoff to party i (excluding transfers) from relational-contract decisions in state s
$\mathbf{d}_{ig}^{BR}(s) = \underset{\mathbf{d}_{ig}\in D_{ig}}{\arg\max}\, \pi_i((\mathbf{d}_{ig},\mathbf{d}_{-ig}^{RC}(s)),s)$	Party i's best response in state s under governance structure g to relational-contract decisions by all other parties
$\pi_{ig}^{BR}(s) = \pi_i((\mathbf{d}_{ig}^{BR}(s),\mathbf{d}_{-ig}^{RC}(s)),s)$	Payoff to party i (excluding transfers) from best response in state s under governance structure g, when all other parties take relational-contract decisions

Given $\mathbf{d}^{RC}(\cdot)$, let $R_{ig}(s\,|\,\mathbf{d}^{RC}(\cdot)) = \pi_{ig}^{BR}(s) - \pi_{ig}^{RC}(s)$ denote party i's reneging temptation under governance structure g in state s, and define $R_g(\mathbf{d}^{RC}(\cdot)) = \max_s \sum_i R_{ig}(s\,|\,\mathbf{d}^{RC}(\cdot))$ as the maximum aggregate reneging temptation created by $\mathbf{d}^{RC}(\cdot)$ under g. Appendix 1 shows that there exist payment rules t_{ig}, $\tau_{ig}(\cdot)$, and $T_{ig}(\cdot,\cdot)$ such that all the reneging constraints are satisfied if and only if

$$(10) \qquad R_g(\mathbf{d}^{RC}(\cdot)) \le \tfrac{1}{r}\Big[V(\mathbf{d}^{RC}(\cdot)) - V^{SP}\Big] .$$

In other words, if a decision rule $\mathbf{d}^{RC}(\cdot)$ satisfies (10), then there are payment rules such that $\{\mathbf{d}^{RC}(\cdot); t_{ig}, \tau_{ig}(\cdot), T_{ig}(\cdot,\cdot)\}$ is a relational contract under governance structure g.

Readers content with the argument at this level of detail can skip to Proposition 1 below, as well as to the illustration in Section 3 intended to build intuition. For those desiring the complete argument, we offer the following formal statements of the reneging constraints, as well as the remainder of the analysis in Appendix 1. To simplify the formal statements of the reneging constraints, we introduce the following notation (using U to denote payoffs including transfers, reserving V for payoffs without transfers as above):

$U_{ig}^{RC}(s) = t_{ig} + \tau_{ig}(s) + T_{ig}(\mathbf{d}^{RC}(s),s) + \pi_i^{RC}(s)$	Payoff to party i (including transfers) from relational-contract decisions in state s under governance structure g
$U_{ig}^{RC} = E_s\Big[U_{ig}^{RC}(s)\Big]$	Expected payoff to party i (including transfers) from relational-contract decisions under governance structure g

Recall also the notation $\pi_{ig}^{NE}(s)$ and V_{ig}^{NE} associated with (7) above.

The constraint that each party i be willing to pay (or accept) its wage payment, t_{ig}, can now be stated as

$$(11) \qquad \left(1+\tfrac{1}{r}\right)U_{ig}^{RC} \ge V_{ig}^{NE} + P_{ig} + \tfrac{1}{r}V_i^{SP}$$

for all i. The left-hand side of (11) is the expected present value of party i's payoffs on the equilibrium path, where all parties honor the relational contract. The right-hand side is the expected present value from reneging on the wage payment. If party i reneges on the wage payment, then the relational contract is broken, so no further payments (bribes or bonuses) will be made this period by any party, all parties will take Nash equilibrium decisions in this period (generating expected payoff V_{ig}^{NE}), control of decision rights will be reallocated (with payment P_{ig}), and optimal spot governance will ensue forever after (generating expected present value $\frac{1}{r}V_i^{SP}$).

The constraint that each party i be willing to pay (or accept) its bribe, $\tau_{ig}(s)$, in each state s becomes

$$(12) \quad [\tau_{ig}(s) + \pi_{ig}^{RC}(s) + T_{ig}(\mathbf{d}^{RC}(s),s)] + \tfrac{1}{r}U_{ig}^{RC} \geq \pi_{ig}^{NE}(s) + P_{ig} + \tfrac{1}{r}V_i^{SP}$$

for all i and s. There are two differences between (11) and (12): in (12), t_{ig} has already been paid, so it does not appear in this period's payoffs (the terms in square brackets) on the left-hand side, and the state s has already been realized, so this period's payoffs (on both sides of the inequality) are contingent on s, not expectations.

The constraint that each party i be willing to take its relational-contract decisions, $\mathbf{d}_{ig}^{RC}(s)$, in each state becomes

$$(13) \quad [\pi_{ig}^{RC}(s) + T_{ig}(\mathbf{d}^{RC}(s),s)] + \tfrac{1}{r}U_{ig}^{RC} \geq \pi_{ig}^{BR}(s) + P_{ig} + \tfrac{1}{r}V_i^{SP}$$

for all i and s. The left-hand side of (13) is the same as (12) except that $\tau_i(s)$ is omitted, because it has already been paid. The right-hand side of (13) is the same as (12) except that $\pi_{ig}^{BR}(s)$ replaces $\pi_{ig}^{NE}(s)$, because now party i is deviating from $\mathbf{d}_{ig}^{RC}(s)$ to $\mathbf{d}_{ig}^{BR}(s)$, while the other parties choose $\mathbf{d}_{-ig}^{RC}(s)$.

Finally, the constraint that each party i be willing to pay (or accept) its bonus, $T_{ig}(\mathbf{d}, s)$, in each state becomes

$$(14) \quad T_{ig}(\mathbf{d}^{RC}(s),s) + \tfrac{1}{r}U_{ig}^{RC} \geq P_{ig} + \tfrac{1}{r}V_i^{SP}$$

for all i and s.

To summarize, if the decision and payment strategies satisfy (11) through (14) then we say that $\{\mathbf{d}^{RC}(\cdot), t_{ig}, \tau_{ig}(\cdot), T_{ig}(\cdot,\cdot); i \in I\}$ is a *relational contract* that *implements* the decision rule $\mathbf{d}^{RC}(\cdot)$ under governance structure g. In Appendix 1, we show that the inequality (10) is necessary and sufficient for satisfying constraints (11) through (14), leading to the following result:

Proposition 1: The decision rule $\mathbf{d}^{RC}(\cdot)$ can be implemented under governance structure g if and only if (10) holds.

Our Proposition 1 parallels results in MacLeod and Malcomson (1989) and Levin (2003). But those models allow just one governance structure, whereas we allow multiple governance structures and so focus on two further questions. First, what governance structure best facilitates a given relational contract? And second, what governance structure facilitates the best feasible relational contract? Furthermore, because we allow the parties to renegotiate their governance structure each period, there is a new feature throughout our analysis, even in Proposition 1: the optimal spot governance structure g^{SP} is implicit in the expected total payoff V^{SP} on the right-hand side of (10), so the opportunity to change governance structures affects the surplus the relationship can produce and hence the relational contracts that can be sustained.

To answer the first question, note that the right-hand side of (10)—the present value of the surplus that the decision rule $\mathbf{d}^{RC}(\cdot)$ creates, relative to optimal spot governance—is independent of g. (This independence follows from our assumption that, if any party reneges, then all parties engage in optimal spot governance thereafter.) Therefore, the optimal governance structure for implementing the decision rule $\mathbf{d}^{RC}(\cdot)$ minimizes the left-hand side of (10), so that $\mathbf{d}^{RC}(\cdot)$ can be implemented for the highest value of r. We therefore have:

Proposition 2: The optimal governance structure for implementing the decision rule $\mathbf{d}^{RC}(\cdot)$ is

(15) $$g^*(\mathbf{d}^{RC}(\cdot)) = \arg\min_{g \in G} R_g(\mathbf{d}^{RC}(\cdot)).$$

Proposition 2 determines the optimal governance structure for implementing a given decision rule, but it does not determine what decision rule should be implemented. If the first-best decision rule can be implemented, however, then the optimal governance structure is the one that implements the first-best at the highest value of r. We therefore have:

Corollary 1: The optimal governance structure for implementing the first-best decision rule $\mathbf{d}^{FB}(\cdot)$ is

(16a) $$g^*(\mathbf{d}^{FB}(\cdot)) = \arg\min_{g \in G} R_g(\mathbf{d}^{FB}(\cdot)).$$

And writing g^{FB} for $g^*(\mathbf{d}^{FB}(\cdot))$, we have:

Corollary 2: The first-best decision rule $\mathbf{d}^{FB}(\cdot)$ can be implemented if and only if

(16b) $$r \leq \frac{V^{FB} - V^{SP}}{R_{g^{FB}}(\mathbf{d}^{FB}(\cdot))} \ .$$

If the discount rate violates (16b) then the first-best cannot be achieved under any governance structure, but the parties may still be able to implement a decision rule that outperforms optimal spot governance. A decision rule-governance structure pair ($\mathbf{d}(\cdot)$, g) is *second-best* if it maximizes the parties' expected total payoff subject to (10). Formally, ($\mathbf{d}^{SB}(\cdot)$, g^{SB}) must satisfy:

(17a) $R_{g^{SB}}(\mathbf{d}^{SB}(\cdot)) \leq \frac{1}{r}\left[V(\mathbf{d}^{SB}(\cdot)) - V^{SP}\right]$ and

(17b) there does not exist ($\mathbf{d}^{RC}(\cdot)$, g′) such that $V(\mathbf{d}^{RC}(\cdot)) > V(\mathbf{d}^{SB}(\cdot))$ and $R_{g'}(\mathbf{d}^{RC}(\cdot)) \leq \frac{1}{r}\left[V(\mathbf{d}^{RC}(\cdot)) - V^{SP}\right]$.

For intermediate values of r (i.e., above the bound in (16b) but not too high), the second-best decision rule-governance structure pair ($\mathbf{d}^{SB}(\cdot)$, g^{SB}) may outperform optimal spot governance: $V(\mathbf{d}^{SB}(\cdot)) > V^{SP}$. In this case, the second-best entails non-zero reneging temptations (in particular, $R_{g^{SB}}(\mathbf{d}^{SB}(\cdot)) > 0$). For high values of r, however, optimal spot governance will be second-best and there will be no reneging temptations.

At this section's level of generality, these propositions and corollaries are what we can say about when or why different governances structures achieve first- or second-best relational adaptation. To say more, we next impose more structure on the problem.

3. Illustration

Consider the simplest possible setting: there are two parties (i ∈ {A, B}) and one decision right, so there are two possible governance structures (denoted g = A and g = B). Define $d_i(s) \in D$ as the decision that party *i* prefers in state s. Suppose that the environment is *effectively binary*, in the following sense: *i* receives a private benefit of $\pi_i(d_i(s), s) > 0$ from the decision preferred by *i*, a private benefit of $\pi_i(d_j(s), s) = 0$ from the decision preferred by *j*, and a negative private benefit from any decision besides $d_i(s)$ and $d_j(s)$.[13] For simplicity, where no confusion will result, we write d_i for $d_i(s)$ and $\pi_i(s)$ for $\pi_i(d_i(s), s)$, but we emphasize that our focus is on adaptation: the decisions of interest depend on the state. For example, this setting can be interpreted as assuming that if s differs from s′ then $d_i(s)$ differs from $d_i(s')$ for both players.

To fix ideas, suppose that $s \in [0, 1]$ with atomless density $f(s) > 0$ for all s and that $\pi_i(s)$ is continuous and increasing for each party (i.e., the parties always disagree about which of their two preferred decisions to take and the size of their disagreement, as indicated by $\pi_A(s)$ and $\pi_B(s)$, increases with s). Suppose also that $\pi_B(0) > \pi_A(0)$ and $\pi_A(1) > \pi_B(1)$ and the benefit functions cross once, at $s^* \in (0, 1)$. The first-best decision rule is then to take decision d_A when $s > s^*$ (that is, when $\pi_A(s) > \pi_B(s)$) and decision d_B when $s < s^*$. Figure 2 shows an example.

To analyze whether the parties can achieve the first-best using relational adaptation, we first ask what would happen under spot adaptation. The expected payoff from assigning the decision right to *i* under spot governance is $\int_0^1 \pi_i(s) f(s) ds$. The optimal spot governance structure, assigns the decision right to party *B* if $\int_0^1 \pi_B(s) f(s) ds > \int_0^1 \pi_A(s) f(s) ds$. For purposes of illustration, suppose that $g^{SP} = B$.

Of course, neither governance structure achieves the first-best under spot adaptation. Equation (10) implies, however, that a relational contract with the decision right assigned to party *i* can achieve the first-best if $R_i(s \mid \mathbf{d}^{FB}(\cdot)) \leq \frac{1}{r}(V^{FB} - V^{SP})$ for all s, where $R_i(s \mid \mathbf{d}^{FB}(\cdot))$ is *i*'s temptation in state s to renege on the first-best decision rule.

Suppose that party A controls the decision. Party A's reneging temptation is zero for $s \geq s^*$ (because in these states the first-best decision is the decision that A prefers) and is $\pi_A(s)$ when $s < s^*$ (because in these states the first-best decision is the decision that B prefers, and by taking this decision A foregoes the benefit $\pi_A(s)$). Because $\pi_A(s)$ is increasing in s, A's maximum reneging temptation under the first-best decision rule is $\pi_A(s^*)$. Therefore, assigning the decision right to A will achieve the first best if $\pi_A(s^*) \leq \frac{1}{r}(V^{FB} - V^{SP})$.

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[13] While negative payoffs from a decision besides $d_i(s)$ and $d_j(s)$ could occur in a given period, it is easy to imagine that, at the beginning of each period, either party can unilaterally accept an outside option, in which case both parties receive payoffs that period that we normalize to zero.

Alternatively, suppose that party B controls the decision. Party B's reneging temptation is zero for $s \leq s^*$ (because d_B is first-best) and is $\pi_B(s)$ when $s > s^*$, so B's maximum reneging temptation under the first-best decision rule is $\pi_B(1)$, and assigning control to B will achieve the first best if $\pi_B(1) \leq \frac{1}{r}(V^{FB} - V^{SP})$. Thus, at sufficiently low discount rates, the first-best can be achieved under either governance structure. Because $\pi_B(1) > \pi_A(s^*) > 0$, however, there is a range of higher discount rates where assigning control to A achieves the first-best, while assigning control to B does not, illustrating Corollary 1. In this sense, the optimal governance structure for relational adaptation allocates control to A, whereas the optimal governance structure for spot adaptation allocates control to B.

At sufficiently high discount rates (namely, those exceeding the bound given in Corollary 2), even first-best adaptation does not create enough expected surplus, $V^{FB} - V^{SP}$, to allow the first-best to be implemented under either governance structure. When the first-best cannot be achieved, the parties may still be able to implement a decision rule that outperforms optimal spot governance. In Appendix 2, we show that the second-best decision rule for the setting assumed in this section takes the intuitive form depicted in Figure 3. In particular, control is assigned to A (as was optimal under first-best but not spot) and the decision rule implements d_A unless $s < s'$ (where $s' < s^*$). By setting s' below s^*, A's maximum reneging temptation falls to $\pi_A(s') < \pi_A(s^*)$, but the expected total payoff falls to $V(s') < V^{FB}$ where $V(s')$ is the expected total payoff when d_A is chosen unless $s < s'$. If s' is sufficiently close to s^*, however, this loss in payoff (illustrated by the shaded region of Figure 3) is small relative to the reduction in reneging temptation (because, just below s^*, $\pi_A(s)$ is only slightly below $\pi_B(s)$), so (10) may be satisfied. The second-best decision rule therefore involves the highest s' satisfying (10), thereby maximizing the parties' expected total payoff, subject to A's reneging constraint. Of course, as noted above, if r is sufficiently high then no such value of s' exists and optimal spot governance is second-best.

This simple example illustrates three results that are much more general.[14] First, formal governance structures and relational contracts interact, in the sense that the set of feasible relational contracts can depend on the formal governance structure the parties choose. For example, the first-best may be feasible if A has control but not if B does. Given this first result, it is a short step to a second: the optimal choice of formal governance structure can

[14] For examples of these three results in other relational-contracting settings, see Baker, Gibbons, and Murphy (1999, 2001, and 2002).

depend on whether the parties have access to relational contracts (or, as a continuous variable, on the value of the parties' discount rate, r). For example, even when the first-best requires A to have control, B may optimally have control for spot transactions. Finally, it is impossible to use relational contracts under one governance structure to mimic spot governance under an alternative governance structure. For example, when A has control, it is not possible to implement optimal spot governance (here, $d = d_B$ for all s), since this would make the right-hand side of (10) equal zero but the left-hand side positive. This third result shows that there are limits to what can be achieved by relational contracting and these limits depend on the governance structure.

4. Contracting in the Decision Window

4.1. Costly Contracting Ex Post

We now relax the assumption that decisions are not contractible ex post. We do this partly as a robustness check, to show that our main insights do not disappear once costly contracting is introduced. In addition, the analysis in this sub-section produces interesting comparative-static results about how relational contracting responds to costly contracting. Finally, in the next sub-section we analyze a related model to explore Williamson's idea of "forebearance." We emphasize, however, that this sub-section provides only a simple analysis of a stylized model; see the Conclusion for discussion of richer models that would be interesting to analyze in future work.

To model costly contracting ex post, we add the following move to the timing in Figure 1: just after the parties learn the state, the party who does not have control can, at cost $c > 0$, make a take-it-or-leave-it offer (d, p) to the party with control. If the offer is accepted then the party in control must take decision d and the other party must pay p to the party with control; if the offer is rejected (or if no offer is made) then the period continues as in Figure 1. In this section we add this new move to the simple setting from Section 3 (i.e., there are two parties and a single decision right that is effectively binary, and the benefit functions $\pi_i(s)$ are continuous, increasing, and cross once). In addition, for expositional simplicity, we assume that $\pi_A(s) - \pi_B(s)$ is increasing in s, as was illustrated in Figure 2.

Before analyzing this model, we note three things. First, our earlier analyses can be interpreted as c being infinite. Second, because the decision is effectively binary (in particular, given the state, only two decisions are of interest, and each is the preferred decision of one party), it would be equivalent to assume that paying the cost c after the state is observed allows a change of control rather than a specification of the decision. Third, as will become clear, this new model is equivalent to revising the model in Section 3 so that the benefit functions are $\tilde{\pi}_i(s) = \max\{\pi_i(s), \pi_j(s) - c\}$, which leaves the first-best decision rule unchanged but can affect spot adaptation, reneging temptations, and first- and second-best relational adaptation.

Figure 4 enriches Figure 2 to illustrate states where it is efficient to pay c to contract on d under spot adaptation. For example, suppose that A has control. If $c < \pi_B(0) - \pi_A(0)$ then there exists an s (indicated by $s_A(c)$ in Figure 4) such that for all $s < s_A(c)$ it is efficient for A to pay c but charge B the price $\pi_B(s)$ for implementing $d = d_B$, because in these states $\pi_B(s) - c > \pi_A(s)$. Similarly, if B has control and $c < \pi_A(1) - \pi_B(1)$, then there exists an $s_B(c)$ such that for all $s > s_B(c)$ it is efficient for B to pay c but charge A the price $\pi_A(s)$ for implementing $d = d_A$, because in these states $\pi_A(s) - c > \pi_B(s)$. In the high-cost case where $c > \max\{\pi_B(0) - \pi_A(0), \pi_A(1) - \pi_B(1)\}$, there is no state in which is efficient to pay c, regardless of which party is in control, so the analysis from Section 3 is unchanged.

We now summarize the results for spot, first-best, and second-best relational adaptation for this model. For simplicity, we describe the low-cost cost case where $c < \min\{\pi_B(0) - \pi_A(0), \pi_A(1) - \pi_B(1)\}$, as shown in Figure 4. Proofs (for all values of c) are in Appendix 3.

Spot adaptation with A in control yields the following: decision d_A without incurring contracting costs for $s > s_A(c)$, and decision d_B with contracting cost c for $s < s_A(c)$. Likewise, spot adaptation with B in control will yield decision d_B without incurring contracting costs for $s < s_B(c)$ and decision d_A with contracting cost c for $s > s_B(c)$. Let $V^{SP}(c)$ denoted the expected total payoff from the optimal spot governance structure.

First-best relational adaptation broadly parallels the results in Section 3: for low enough values of r, the first-best decision rule satisfies (10) with either party in control, but for somewhat higher values of r, the first-best can be achieved only if A is in control. However, while this qualitative result for first-best adaptation is the same as in Section 3, the quantitative results differ for two reasons. First, because $c < \pi_A(1) - \pi_B(1)$, allowing costly contracting increases B's maximum reneging temptation from $\pi_B(1)$ to $\pi_A(1)$-c, so the critical value of r at which B can implement the first-best falls. Second, regardless of who has control, $V^{SP}(c)$ weakly increases as c falls, so the highest value of r at which either party can implement the first-best (at which (10) holds with equality) weakly decreases as c falls. In particular, the first-best decision rule $\mathbf{d}^{FB}(\cdot)$ can be implemented when A has control if and only if

$$(18) \qquad r \leq \frac{V^{FB} - V^{SP}(c)}{\pi_A(s^*)} \ .$$

Since $V^{SP}(c)$ approaches V^{FB} as c approaches zero, improving contracting (by reducing c) can harm welfare (by rendering first-best relational contracting infeasible).[15]

Second-best relational adaptation also broadly parallels Section 3: A should have control, and the second-best decision rule involves A choosing d_A in states below s^*. Because $c < \min\{\pi_B(0) - \pi_A(0), \pi_A(1) - \pi_B(1)\}$, however, $V^{SP}(c)$ here is now larger than V^{SP} was in Figure 3 (where c could be interpreted as infinite). As a result, the surplus from relational contracting (the right-hand side of (10)) is smaller than it was in Figure 3. Thus, if r is too high to allow first-best adaptation, then A's maximum reneging temptation (the left-hand side of (10)) must be reduced, which can occur in one of two ways: c is never paid on the equilibrium path, or c is paid on the equilibrium path.

Figure 5 depicts a situation where A is not asked to take decision d_B unless $s < s''(c)$ (where $s''(c) < s' < s^*$), so A's maximum reneging temptation is $\pi_A(s''(c)) < \pi_A(s')$. As in Figure 3, allowing A to take decision d_A for $s''(c) < s < s^*$ reduces the expected payoff V, so there may not be a value of $s''(c)$ satisfying (10). For appropriate parameters, however, not only does such an $s''(c)$ exist, but we also have $s''(c) > s_A(c)$, as shown in Figure 5, in which case the second-best relational contract does *not* involve enforceable contracting on the equilibrium path (but the value of c nonetheless affects what relational contracts are feasible because it affects $V^{SP}(c)$).

Figure 6 depicts a slightly different decision rule than Figure 5: A is again not asked to take decision d_B unless $s < s''(c)$, but now $s''(c) < s_A(c)$, so enforceable contracts *are* used on the equilibrium path for $s \in (s''(c), s_A(c)]$ and A's maximum reneging temptation is therefore $\pi_B(s''(c)) - c > \pi_A(s''(c))$. The logic again parallels Figure 3: the parties allow A to take decision d_A for $s > s_A(c)$, which reduces A's reneging temptation but also reduces the expected payoff V.

15 For other examples where imperfect formal contracting can harm welfare by hindering relational contracting, see Baker, Gibbons, and Murphy (1994), Kranton (1996), Prendergast and Stole (1999), Di Tella and MacCulloch (2002), and Dhillon and Rigolini (2011).

Figure 7 shows how the optimal governance structure (g) and expected total payoff (V) vary with both the interest rate (r) and the cost of ex post contracting (c). To compute explicit solutions, we analyze a linear-uniform version of Figure 4, where s is uniform on [0, 1], $\pi_A(s) = 2s$, and $\pi_B(s) = s + b$, where $b \in (½, 1)$. As in Section 3, optimal spot governance then gives control to B, whereas optimal relational governance gives control to A. Furthermore, in this linear-uniform case, the second-best decision rule is as in Figure 5, not Figure 6 (i.e., c is not paid on the equilibrium path). Calculations for this example are in Appendix 4.

Three features of Figure 7 are worth noting. First, the optimal governance structure can vary with the cost of contracting. At sufficiently low contracting costs, relational adaptation is not feasible and control is therefore optimally assigned to B under spot adaptation. But, at sufficiently high contracting costs (coupled with sufficiently low interest rates), relational adaptation is feasible and party A should have control.

Second, the relation between expected total payoff and contracting costs is not monotonic: V falls initially, when contracting costs are small, so $V = V^{SP}(c)$, but V then increases in c (if the discount rate is low enough) after $V^{SP}(c)$ falls enough to allow relational governance. As shown in the figure, V eventually stops increasing with c, when V achieves either V^{FB} or the second-best level achieved in Section 3 (where c can be interpreted as infinite).

Third, imperfect spot governance can supplant superior relational governance. For example, fixing $r = r_2$, a decrease in c from just above c_2 to just below makes relational contracting infeasible, thus reducing the parties' expected total payoff. Here, a small reduction in c moves the parties from second-best relational contracting to spot governance, analogous to our observation after (18) that a small reduction in c could prevent first-best relational contracting. A related result appears in Figure 3 of Baker, Gibbons, and Murphy (1994).

4.2. Firms as Contract-Free Zones

In the spirit of Hansmann (2012) and Kornhauser and MacLeod (2012), we now follow contract law by assuming that (a) a contract has standing in court only if the parties are legal persons and (b) a firm is a legal person but, for most purposes, most units within the firm are not. For example, a division is not a legal person, and an employee is not a legal person except for employment contracts with the employer. Thus, contracts between divisions, such as about transfer pricing, typically cannot be enforced in a court, although an employment contract between the firm and an employee can. In this sense, firms are contract-free zones (employment contracts aside).

One way to model these issues is to reinterpret the model from Section 4.1 so that ex post contracts *between* firms can be enforced by a court (at cost c), but ex post contracts *within* firms cannot be enforced (i.e., c can be interpreted as infinite). We thereby provide a first step towards formalizing Williamson's (1991) discussion of "forbearance" as a difference in contract law within firms versus between them. Given this difference, we then explore what kinds of transactions will be conducted under integration versus non-integration and how we should expect firms to differ from markets. As in Section 4.1, however, here we provide only an initial analysis; see the Conclusion for further possibilities.

Formally, consider the following thought experiment based on the model from Section 4.1. Given a transaction between firms A and B (i.e., under non-integration) with parameters c and r, would the parties prefer to integrate (i.e., have c become infinite)? This thought experiment is not the same as comparing different values of c in Figure 7, because Section 4.1 envisions c being fixed and equal across all governance structures. Instead, we are now considering whether the parties might choose a new governance structure because it entails a new value of c. It is important to note, however, that the parties' choice of c could last for as little as one period. For example, if there is reneging on a relational contract under integration, then the parties could switch back to non-integration (finite c) to achieve optimal spot governance thereafter—a possibility not allowed in Figure 7, with its assumption that c is fixed and equal across all governance structures.

We will show that the parties might choose integration (infinite c) if doing so would reduce the maximum reneging temptation created by the optimal relational contract under non-integration. A necessary condition for the parties to choose integration for this reason is thus that the maximum reneging temptation under non-integration occurs where the party in control is tempted to defect by paying c and making a take-it-or-leave-it offer (d, p). Thus, a further necessary condition is that, in the optimal relational contract under non-integration, the party in control pays c on the equilibrium path (as in Figure 6), as follows.

Suppose that $c < \min\{\pi_B(0) - \pi_A(0), \pi_A(1) - \pi_B(1)\}$, so that non-integration outperforms integration for spot adaptation. If the parties are sufficiently patient, then relational contracting is feasible under non-integration: as in Sections 3 and 4.1, A should have control, but the second-best could take the form of either Figure 5 or Figure 6 (i.e., c might or might not be paid on the equilibrium path). If the second-best relational contract under non-integration takes the form of Figure 5 then the same relational contract is second-best under integration, so the parties are indifferent between non-integration and integration. Thus, a necessary condition for the parties to strictly prefer integration to non-integration is that the second-best under non-integration take the form of Figure 6 instead of Figure 5 (i.e., c is paid on the equilibrium path). In this case, party A's maximum reneging temptation under non-integration is $\pi_B(s''(c)) - c > \pi_A(s''(c))$, so switching from non-integration to integration can reduce A's maximum reneging temptation. That is, the role of the integration decision here is to reduce this period's reneging temptation, $R_g(\mathbf{d}^{RC}(\cdot))$ on the lefthand side of (10), not to influence the payoff from optimal spot governance after reneging occurs, $V^{SP}(c)$ on the righthand side of (10).

For example, consider the new relational contract shown in Figure 8 under integration, which is a modification of the relational contract shown in Figure 6 under non-integration. In Figure 6, party A chooses d_A for $s > s_A(c)$ and d_B for $s < s_A(c)$, incurring contracting cost c for $s \in [s''(c), s_A(c)]$. In Figure 8, party A chooses d_A for $s > s^{**}$ and d_B for $s < s^{**}$, never incurring contracting cost c. For simplicity, s^{**} is chosen to equate party A's maximum reneging temptations under the two contracts: $\pi_B(s''(c)) - c = \pi_A(s^{**})$. The relational contract in Figure 8 is not feasible under non-integration, so if it produces larger expected total payoff than the relational contract in Figure 6 then the parties will prefer integration over non-integration (even if the relational contract in Figure 8 is not the optimal relational contract under integration). The advantage of Figure 8 over Figure 6 arises because c is not paid for $s \in (s''(c), s^{**}]$, but the disadvantage arises because party A chooses d_A rather than d_B at cost c for $s \in (s^{**}, s_A(c)]$. Clearly, for convenient choices of the distribution f(s), the former can dominate the latter, in which case "forbearance" is a motive for integration.

We expect that a full-fledged analysis along this line could produce interesting comparisons between integration and non-integration. For example, Figures 6 and 8 describe identical behavior for integration and non-integration in high and low states: d_B without contracting costs for $s < s''(c)$ and d_A without contracting costs for $s > s_A(c)$. The difference in behavior is in the middle states, where in some states—namely, $s \in (s^{**}, s_A(c)]$—parties under integration make worse decisions than parties under non-integration, but in other states—namely, $s \in (s''(c), s^{**}]$—parties under integration make efficient decisions relationally rather than with contracting costs. To us, this comparison seems plausible: integration differs from non-integration by sometimes giving the boss her own way but other times avoiding costly contracts—here, for $s \in (s^{**}, s_A(c)]$ and $s \in (s''(c), s^{**}]$, respectively.

5. Richer Settings

5.1. Two Decision Rights

In this sub-section, we extend the model in Section 3 from one to two decision rights, so $\mathbf{d} = (d_1, d_2)$. When there is more than one decision, some governance structures may cause more than one party to be tempted to renege in a given state, so we must consider the aggregate reneging temptation in each state s, $\sum_i R_{ig}(s \mid \mathbf{d}^{RC}(\cdot))$ defined above (10). Our interest in this sub-section is in exploring the determinants of this maximum aggregate reneging temptation. Our analysis illustrates three points about multi-decision settings. First, analogous to multi-market contact explored by Bernheim and Whinston (1990) and multi-employee contact explored by Levin (2002), incentive constraints can be pooled across decisions. Second, because of the adaptation aspect of our model, reneging temptations can be separated across states (with only one state ultimately mattering). And third, because of the governance-choice aspect of our model, the optimal governance structure minimizes the maximum aggregate reneging temptation. Here we apply these three ideas to show that the optimal governance structure for multiple decisions can differ from what would arise by considering each decision separately, even when the parties' benefits are separable across decisions. In the Conclusion, we discuss other issues one might explore in models with multiple decision rights.

To establish the three points of this sub-section, it suffices to restrict attention to implementing the first-best decision rule, which allows us to rely on Corollaries 1 and 2. Suppose that each party's payoff is additively separable in the two decisions: $\pi_i(d_1, d_2, s) = \pi_{i1}(d_1, s) + \pi_{i2}(d_2, s)$. As in Section 3, each decision is effectively binary: the decision party i prefers in state s is $d_{ik}(s)$ for $k \in \{1, 2\}$, with $\pi_{ik}(d_{ik}(s), s) > 0$, $\pi_{ik}(d_{jk}(s), s) = 0$, and $\pi_{ik}(d_k, s)$ very negative for other choices of d_k. As illustrated in Figure 9, the benefit functions $\pi_{ik}(s)$ are continuous and increasing in s for both parties and for both decision rights. For each decision, suppose that the benefit functions cross at one point, denoted s_k^* for decision k. The first-best then entails taking A's preferred decision for d_1 when $s < s_1^*$ and B's when $s > s_1^*$, together with taking A's preferred decision for d_2 when $s < s_2^*$ and B's when $s > s_2^*$.

To illustrate the first point (on pooling incentive constraints), note that in Figure 9, if decision 1 were the only decision then Corollary 2 would imply that a relational contract with the decision right assigned to A can achieve the first-best if $\pi_{A1}(s_1^*) \le \frac{1}{r}[V_1^{FB} - V_1^{SP}]$, using the natural notation for first-best and spot total expected payoffs from decision 1. Similarly, if decision 2 were the only decision then Corollary 2 would imply that a relational contract with the decision right assigned to A can achieve the first-best if $\pi_{A2}(s_2^*) \le \frac{1}{r}[V_2^{FB} - V_2^{SP}]$. However, it could be that one of these inequalities fails but the sum of the two holds,

$$(19) \qquad \pi_{A1}(s_1^*) + \pi_{A2}(s_2^*) \le \tfrac{1}{r}[V_1^{FB} - V_1^{SP}] + \tfrac{1}{r}[V_2^{FB} - V_2^{SP}],$$

in which case a relational contract covering both decisions could achieve the first-best even though single-decision relational contracts would fail to achieve the first-best for one of the decisions.

To illustrate the second point (on determining reneging temptations by state), note that what matters in Figure 9 is not the sum of the maximum reneging temptations as suggested by the left-hand side of (20), but rather the maximum of the sum: $R_g(\mathbf{d}^{FB}(\cdot)) = \max_s \sum_i R_{ig}(s \mid \mathbf{d}^{FB}(\cdot))$, which occurs in a single state. For example, suppose party A holds both decision rights (denoted by g = AA). When $s \in [0, s_1^*)$, A is tempted to renege on both decisions and has a maximum reneging temptation for $s \in [0, s_1^*)$ of $\pi_{A1}(s_1^*) + \pi_{A2}(s_1^*)$. When $s \in (s_1^*, s_2^*)$, A is not tempted to renege on decision 1 but has a reneging temptation of $\pi_{A2}(s)$ for decision 2, so A's maximum reneging temptation for $s \in (s_1^*, s_2^*)$ is $\pi_{A2}(s_2^*)$. Finally, when $s \in (s_2^*, 1]$, A is not tempted to renege on either decision. Therefore, A's maximum reneging temptation is $\text{MAX}\{\pi_{A1}(s_1^*) + \pi_{A2}(s_1^*), \pi_{A2}(s_2^*)\}$. Thus, the first-best decision rule can be implemented when A controls both decisions if and only if:

$$(20) \qquad MAX\{\pi_{A1}(s_1^*) + \pi_{A2}(s_1^*), \pi_{A2}(s_2^*)\} \le \tfrac{1}{r}[V_1^{FB} - V_1^{SP}] + \tfrac{1}{r}[V_2^{FB} - V_2^{SP}].$$

Note that, as long as $s_1^* \ne s_2^*$ (i.e., the maximum reneging temptation for each decision occurs in different states), the left-hand side of (20) is strictly less than the left-hand side of (19).

Therefore, it is possible that first-best is achievable with multiple decisions, even if the first-best is not achievable for either decision in a single-decision setting.

Finally, to illustrate the third point (on the choice of governance structures), consider the maximum aggregate reneging temptation when A still controls decision 1 but now B controls decision 2 (denoted g = AB). When $s \in [0, s_1^*)$, A is tempted to renege on decision 1 but B is not tempted to renege on decision 2, so the maximum aggregate reneging temptation for $s \in [0, s_1^*)$ is $\pi_{A1}(s_1^*)$, which is less than the corresponding temptation when A controlled both decisions, $\pi_{A1}(s_1^*) + \pi_{A2}(s_1^*)$. When $s \in (s_1^*, s_2^*)$, neither party is tempted to renege on the decisions under their control. Finally, when $s \in (s_2^*, 1]$, A is not tempted to renege on decision 1, but B's reneging temptation on decision 2 is $\pi_{B2}(s)$, which reaches a maximum of $\pi_{B2}(1)$. Therefore, the maximum aggregate reneging temptation is $\text{MAX}\{\pi_{A1}(s_1^*), \pi_{B2}(1)\}$, and the first-best can be implemented under this new governance structure if and only if:

$$(21) \qquad MAX\{\pi_{A1}(s_1^*), \pi_{B2}(1)\} \leq \tfrac{1}{r}[V_1^{FB} - V_1^{SP}] + \tfrac{1}{r}[V_2^{FB} - V_2^{SP}]\ .$$

Comparing (21) to (20) suggests a trade-off: assigning the right to decision 2 to B rather than A reduces the aggregate reneging temptation over the range $s \in [0, s_2^*)$ but increases the reneging temptation for $s \in (s_2^*, 1]$. For the case depicted in Figure 9, where $\pi_{A1}(s_1^*) + \pi_{A2}(s_1^*) > \pi_{A1}(s_1^*) > \pi_{B2}(1) > \pi_{A2}(s_2^*)$, the maximum aggregate reneging temptation for g=AB in (21) is less than the maximum aggregate reneging temptation for g=AA in (20), even though A would optimally control each decision in single-decision settings.

In short, by combining an analogy to multi-market contact with the adaptation and governance-structure aspects of our model, we have uncovered a new determinant of the optimal allocation of control: minimizing the maximum aggregate reneging temptation in a multi-decision setting may produce a different governance structure than would considering each decision separately, even when the parties' benefits are additively separable across decisions.

5.2. Firms as Decision and Payoff Rights

In Sections 2, 3, and 4 we analyzed what we called "contracting for control," where parties use formal contracts to allocate decision rights across fixed firm boundaries. As a complement to our main focus on contracting for control, we now enrich the model from

Section 2 by adding payoff rights and assets, discussing how one might define a firm in terms of asset ownership. In this sub-section we only develop the model; in the Conclusion we discuss how one might use such a model to produce a relational-adaptation theory of firms' boundaries in the absence of specific investments.

Following Baker, Gibbons, and Murphy (2008), we first introduce payoff rights and then define an asset to be an inextricable bundle of one or more decision rights and one or more payoff rights. Roughly speaking, the owner of a payoff right receives the payoff $\pi(\mathbf{d},s)$ in addition to the owner's private benefit. In the spirit of Section 2's treatment of decision rights, we allow transfers of both assets and payoff rights before the state is revealed, but we assume that the parties cannot transfer assets or payoff rights during the short window between when the state is revealed and when decisions must be taken.

To illustrate the idea and effect of assets and payoff rights in our model, consider again the simple case with two parties (A and B) with inalienable private benefits $\pi_A(d,s)$ and $\pi_B(d,s)$ and a single decision right. Unlike in Sections 2.1 and 3, we now temporarily suppose that the decision right is inextricably tied to a payoff right (i.e., the two together are an asset) that can be assigned to either party. Whichever party owns the asset holds the decision right and receives the payoff $\pi(d,s)$ (in addition to the private benefits). Under spot adaptation, if party i owns the asset, then in state s party i will take decision

$$(22) \qquad d_i^*(s) = \underset{d \in D}{\arg\max}\, \pi_i(d,s) + \pi(d,s),$$

which produces total payoff in state s of

$$(23) \qquad V^i(s) = \pi_A(d_i^*(s),s) + \pi_B(d_i^*(s),s) + \pi(d_i^*(s),s).$$

Equations (22) and (23) are analogous to equations (3) and (4), respectively. Efficient spot asset ownership involves assigning the (decision right, payoff right) pair so as to produce the highest expected payoff: party A should own the asset if and only if $E_s[V^A(s)] > E_s[V^B(s)]$.

Now suppose that there are two decision rights, d_1 and d_2, and two payoff rights, π_1 and π_2. If the associated decision rights and payoff rights are inextricable, then this is a world with two assets: (d_1, π_1) and (d_2, π_2). This two-asset world has two kinds of governance structures (ignoring permutations):

g^1: Party A owns (d_1, π_1); Party B owns (d_2, π_2).

g^2: Party A owns (d_1, π_1) and (d_2, π_2); Party B owns nothing.

It seems natural to call g^1 "non-integration" and g^2 "integration." But now imagine that the decision rights and the payoff rights are freely separable from each other. There are then four kinds of governance structures:

g^1: Party A owns d_1 and π_1; Party B owns d_2 and π_2.

g^2: Party A owns all four rights; Party B owns nothing.

g^3: Party A owns d_1, d_2, and π_1; Party B owns π_2.

g^4: Party A owns d_1, π_1, and π_2; Party B owns d_2.

It may still be natural to call g^1 "non-integration" and g^2 "integration," but then what should we call g^3 and g^4 and how do they relate to integration? One prominent definition of integration and non-integration comes from the Grossman-Hart-Moore (GHM) property-rights model, which assumes that the parties' payoff functions are fixed and defines integration from the allocation of decision rights. By this definition, g^1 could be non-integration and g^3 integration, or g^4 could be non-integration and g^2 integration, but g^1 and g^2 do not hold the parties' payoff functions fixed and so do not fit the GHM definition.

In Baker, Gibbons, and Murphy (2008) we develop a static model with assets, decision rights, and payoff rights and we relate the resulting governance structures to alliances, acquisitions, divestures, licensing, and royalty arrangements. These and other governance structures can be viewed as "hybrid" organizational forms that are "neither market nor hierarchy" (Powell, 1990), perhaps formalizing Blois' (1972) idea of "quasi-integration," Richardson's (1972) "dense network of co-operation and affiliation," or Eccles' (1981) "quasifirms."

Whether one views these governance structures—defined by different allocations of assets, decision rights, and payoff rights—as firms, markets, or hybrids, the relational analysis of this enriched model goes through as in Section 2. Indeed, just as Section 2 moved from two parties and one decision right to many of each, so too here can one move from one payoff right to many (with some perhaps inextricable from decision rights and others not). An Appendix enriching Section 2 in this way is available upon request.

6. Conclusion

Both between firms and within, opportunities may arise suddenly and require rapid responses. It is therefore important to understand whether the organization of economic activity can facilitate such adaptation.

In modeling adaptation, we assume that decisions are not costlessly contractible during the short interval between when the state is realized and the decision taken. This assumption allows us to focus on features of not only contract execution but hence also contract design that Klein and Williamson have long argued are central. In accord with growing empirical literatures on both contracting between firms and vertical integration, our model offers a theory of optimal governance structures in the absence of specific investments (or where specific investments exist but are contractible, so that governance structures need not be chosen to influence these investments).

In our model, a governance structure is an allocation of decision rights. Our primary application is "contracting for control" (moving control rights across firm boundaries), but we extend our model to other governance structures between as well as within firm boundaries, such as vertical integration, joint ventures, and other hybrid organizations.

Since spot governance produces "maladaptation in the contract-execution interval," we study how relational contracts can improve efficiency. In particular, we explore how choosing a different governance structure than would be optimal in a spot setting allows the parties to achieve the best feasible relational adaptation.

We see several opportunities for further work along the lines we have initiated here, including in each of the last four sub-sections (4.1 through 5.2), as follows.

Costly contracting: The model in Section 4.1 is an extremely simple way to introduce costly contracting ex post, but more could be done. For example, in that model, contracting on the decision ex post is equivalent to contracting on control ex post, because only two decisions are relevant in each state. Extending the analysis to more than two decisions could create interesting interactions between the ex ante allocation of control and ex post contracting. Furthermore, one could then allow contracting on control ex post (say, at cost k rather than c), instead of or in addition to allowing contracting on decisions. Finally, having allowed contracting ex post, one could also do so ex ante (say, at cost $c' < c$ for ex ante contracts on decisions and at cost $k' < k$ for ex ante contracts on control, where we have here implicitly assumed $k' = 0$).

Forebearance: We think the model in Section 4.2 is a plausible and tractable way to formalize a difference in contract law within firms versus between them, and we like that our relational analysis gives not only a reason to prefer the non-contractibility of integration (even though the costly contracting of non-integration would be weakly dominant in spot settings) but also a description of how behavior should differ within firms versus between them (with the boss inefficiently indulging her own preferences in some states but making efficient decisions without costly contracting in others). Again, though, more could be done. For example, by assuming that contracts are not feasible under integration (i.e., $c = \infty$), we are ignoring employment contracts. It would be interesting to explore how formal employment contracts interact with necessarily relational contracts on other issues within firms. Furthermore, while our model may have captured Williamson's assertion that contract law differs within firms versus between them, we certainly have not fully explored his ideas about the consequences of "forebearance" for internal organization. For example, one could compare non-integration between firms A and B to integration where headquarters C oversees transfer pricing between divisions A and B.

Choice versus Implementation: While Section 2 proves some results for a general model with many decision rights, we build much of our intuition in Section 3 using a model with only one decision right. It is therefore important to know whether Section 3 conveys all the main ideas, and Section 5.1 shows that it does not: the optimal governance structure for multiple decisions can differ from what would arise by considering each decision separately, even if the parties' benefits are separable across decisions. But by assuming that benefits are separable across decisions, we forsake many interesting applications, such as the difference between choice versus implementation (such as where the first task is to choose a project and the second is to carry it out). One could explore this topic using a model like Section 5.1's, where both decision rights are alienable (i.e., can be assigned to any party), or one could imagine that some tasks can be conducted only by some people, as noted in Section 2.1's brief discussion of inalienable decision rights $\delta_i \in \Delta_i$ for each $i \in I$.

Assets and Firms' Boundaries: We intend Sections 2 through 4 to address contracting for control, where firms use contracts to move decision rights across fixed firm boundaries. In the world, however, there are at least three basic governance structures—non-integration, integration, and contracting for control—so it is important to have one model that can express and evaluate all three options. For example, while empirical papers such as Lerner and Merges (1998) productively utilize a GHM model to compare non-integration to contracting for control, and empirical papers such as Woodruff (2002) productively utilize such a model to compare non-integration to integration, it is difficult for these authors to consider biases from the governance structure they omit because a theory of two governance structures cannot speak to this issue. We therefore see Section 5.2 not only as the basis for a relational-adaptation theory of integration versus non-integration (with firms' boundaries defined by asset ownership, even in the absence of specific investments), but also as a way to analyze all three of these governance options at once (and various "hybrids" as well).

Aggrievement in continuation equilibria: Finally, moving beyond the four sub-sections just discussed, we think that enriching our model to include inalienable decision rights $\delta_i \in \Delta_i$ for each $i \in I$ could provide an interesting complement to the static models by Hart and Moore (2008), Hart (2009), and Hart and Holmstrom (2010). Much like our relational approach, these static models explore interactions between ex ante choices of formal governance structures and possibly inefficient ex post decisions (whether about adaptation or, as we called it above, implementation). These static models avoid the need for relational analysis by positing a novel behavioral theory of entitlement, aggrievement, and shading. It would be interesting to explore parallel ideas under conventional assumptions. For example, to what extent is shading akin to a punishment continuation in a relational contract, and what are the implications for optimal governance structures?

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Figure 1 Timing of payments in a Relational Contract

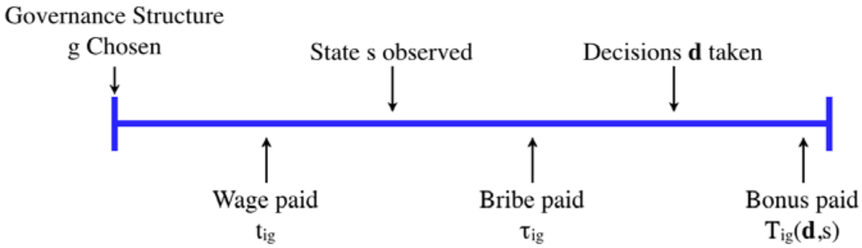
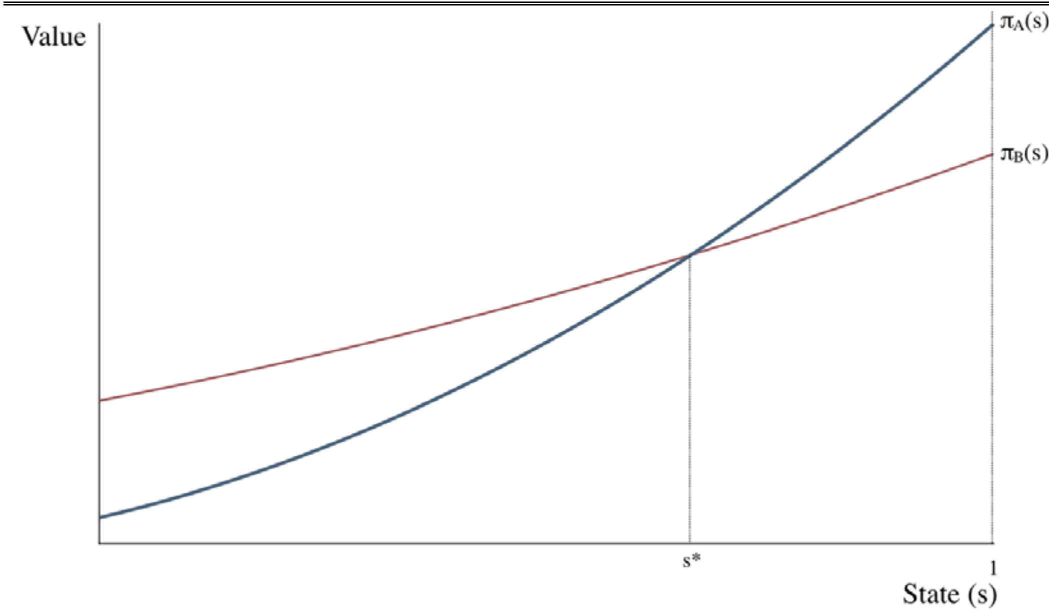
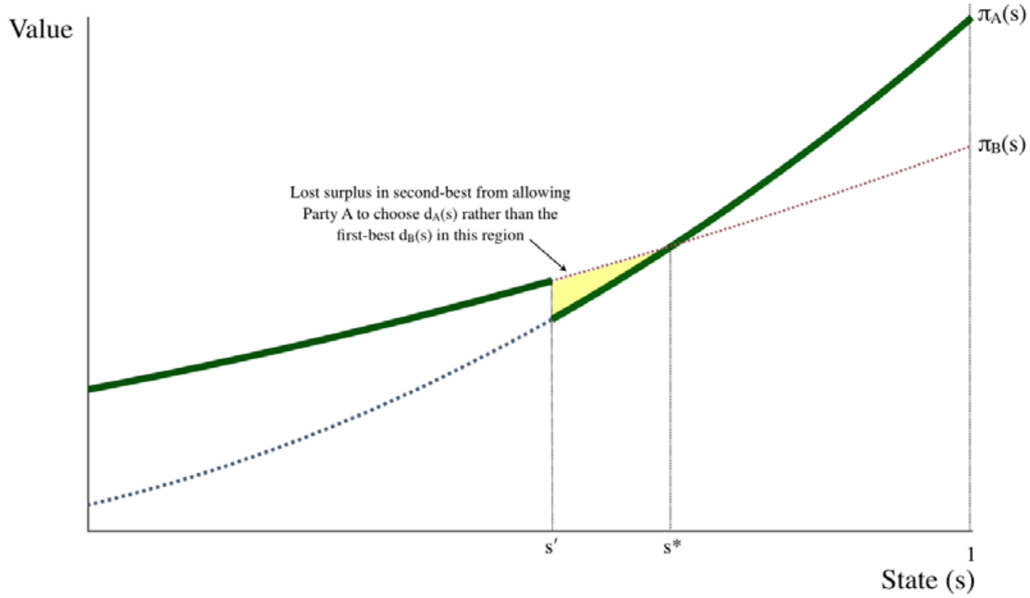


Figure 2 Illustration of private benefits for two parties with one decision right



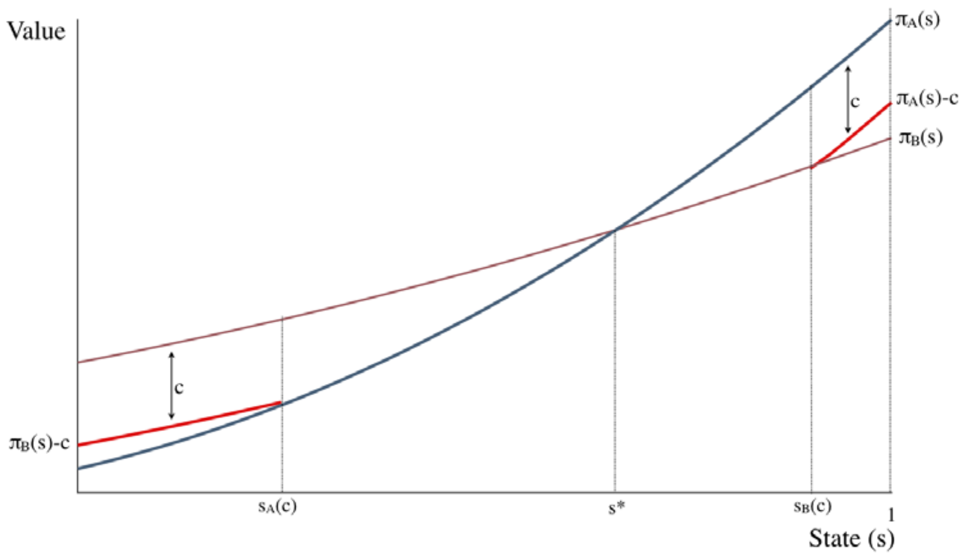
Note: The figure shows the private benefits for Parties A and B ($\pi_A(s)$ and $\pi_B(s)$, respectively) for a decision that is effectively binary (as defined in the text). The first-best decision rule is to implement the decision preferred by Party A when $s > s^*$ (that is, when ($\pi_A(s) > \pi_B(s)$) and to implement the decision preferred by Party B when $s < s^*$.

Figure 3 Second-best decision rule for two parties with one decision right



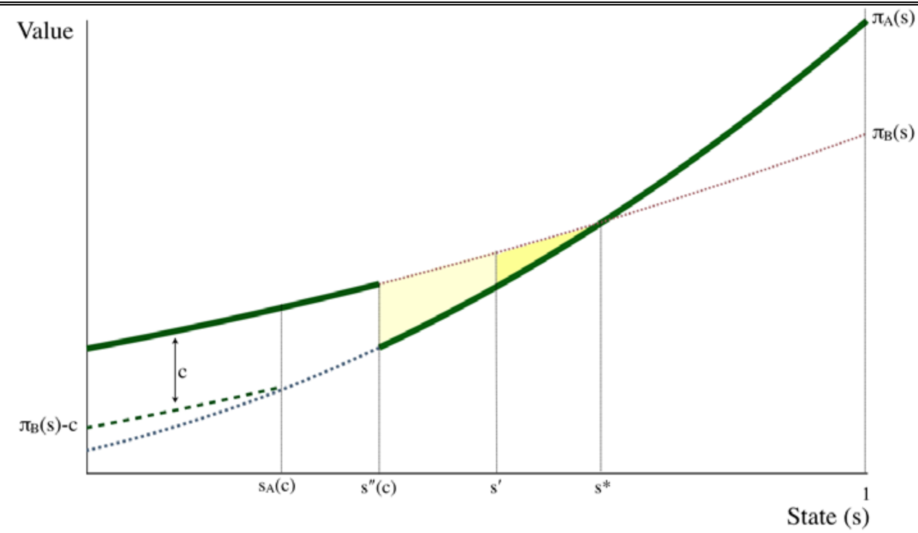
Note: The figure shows the private benefits for Parties A and B. For intermediate values of r, the second-best has Party A in control, taking the decision preferred by Party B when $s < s'$ and the decision preferred by Party A when $s > s'$, where $s' < s^*$. The critical value s′ maximizes the parties' expected total payoff, subject to Party A's reneging constraint.

Figure 4 States where it is efficient to pay c to contract on d under spot adaptation



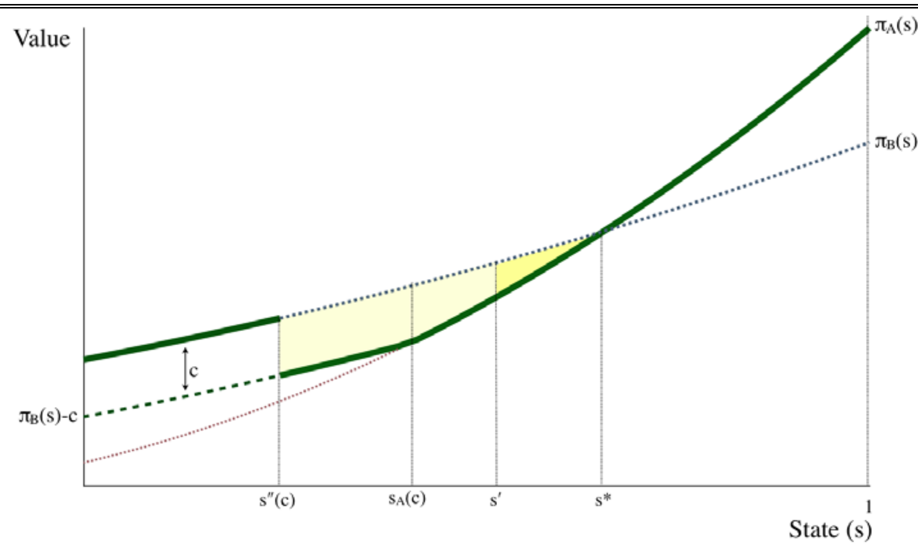
Note: The figure shows states where it is efficient to pay c to contract on d after the state is realized. Because $\pi_B(0) - \pi_A(0) > c$, for states $s < s_A(c)$ if A were in control then it would be efficient to contract on $d = d_B$ rather than allow A to choose d_A (where $s_A(c)$ solves $\pi_A(s) = \pi_B(s) - c$). Because $\pi_A(1) - \pi_B(1) > c$, for states $s > s_B(c)$ if B were in control then it would be efficient to contract on $d = d_A$ rather than allow B to choose d_B (where $s_B(c)$ solves $\pi_B(s) = \pi_A(s) - c$).

Figure 5 Second-best relational adaptation in the shadow of enforceable contracts



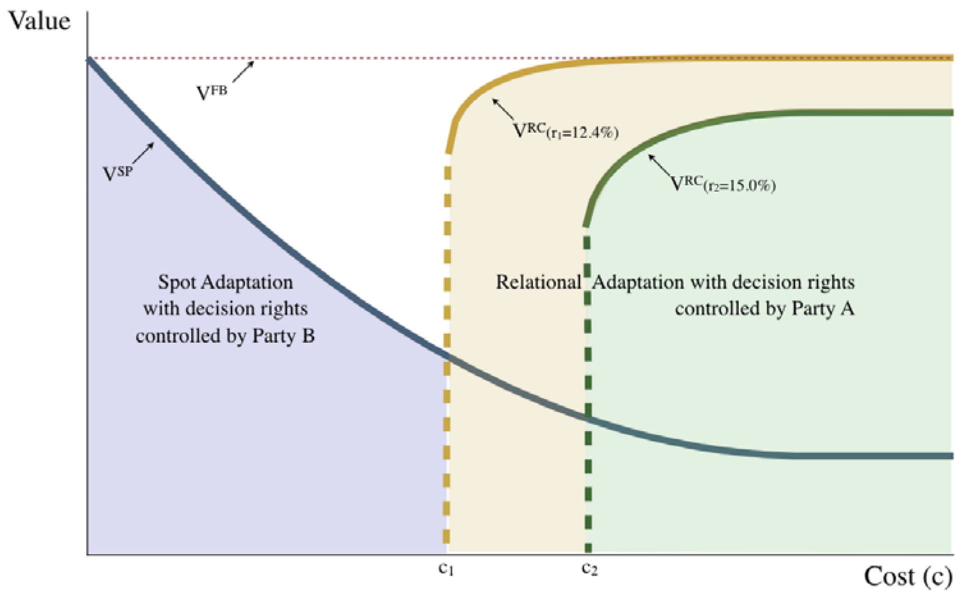
Note: The figure depicts a potential second-best relational contract where A chooses to implement $d = d_A$ for $s \geq s''(c)$ and $d = d_B$ for $s < s''(c)$. Since $s''(c) < s' < s^*$, the contract results in less surplus than first-best (where $d = d_B$ for $s < s^*$) or second best when ex post contracting is prohibited (where $d = d_B$ for $s < s'$). Also, since $s_A(c) < s''(c)$, the second-best relational contract illustrated here does not involve ex post contracting even though it is feasible at cost c.

Figure 6 Second-best relational adaptation involving enforceable contracts



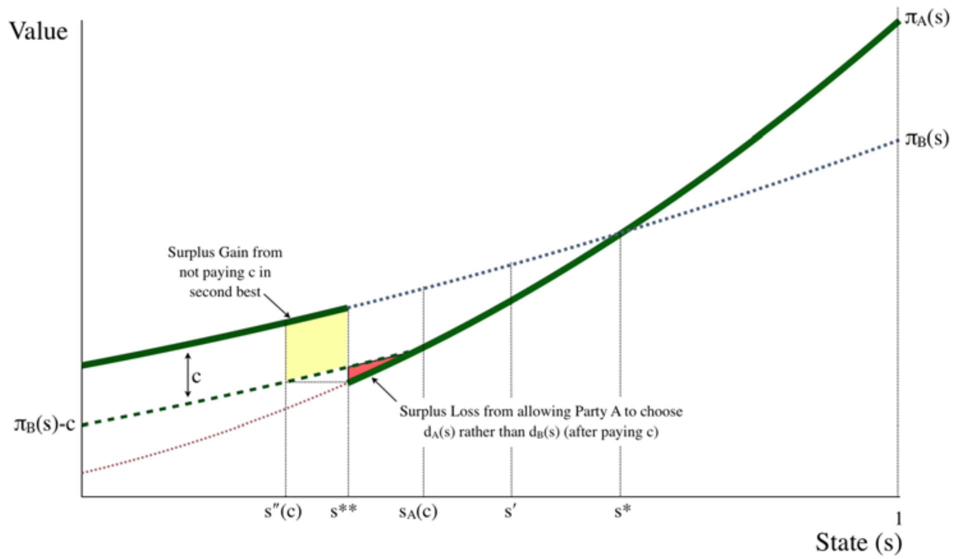
Note: The figure depicts a potential second-best relational contract where A chooses to implement $d = d_A$ for $s \geq s''(c)$ and $d = d_B$ for $s < s''(c)$. Since $s''(c) < s' < s^*$, the contract results in less surplus than first-best (where $d = d_B$ for $s < s^*$) or second best when ex post contracting is prohibited (where $d = d_B$ for $s < s'$). Also, since $s_A(c) > s''(c)$, the second-best relational contract illustrated here does involve B paying c to implement $d = d_B$ for $s''(c) < s' < s_A(c)$.

Figure 7 Optimal governance structures and total payoff as with ex post contracting



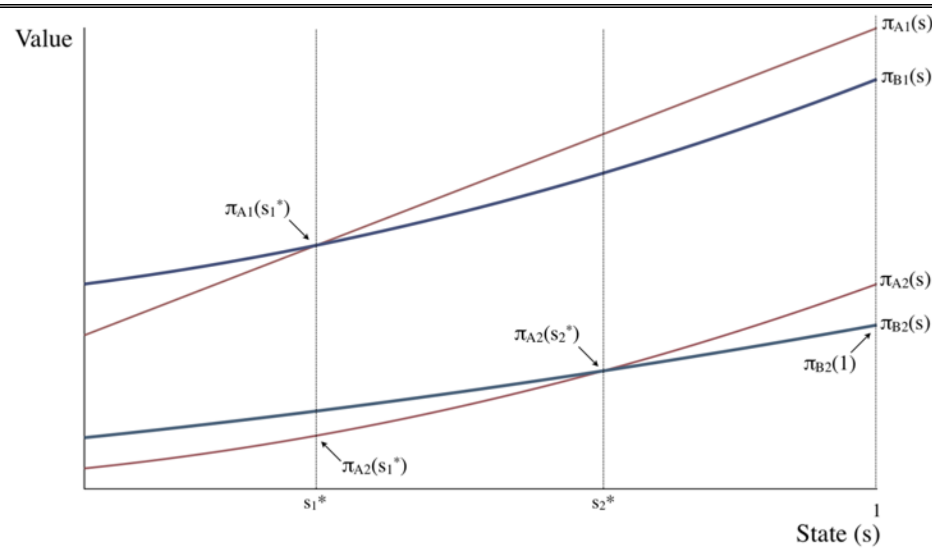
Note: The figure shows how the optimal governance structure and expected total payoff vary with the cost of ex post contracting, c. The figure assumes that $\pi_A(s) = 2s$, $\pi_B(s) = s + b$, s is uniform on [0, 1], and b=.501. As shown in Appendix 4, these assumptions imply that control is optimally allocated to B under spot adaptation and optimally allocated to A under relational adaptation. The figure depicts optimal governance under two different interest rates, r=12.4% and r=15.0%. At sufficiently low contracting costs, only spot adaptation is feasible (indeed, when c=0 spot adaptation achieves first-best). When c exceeds c_1 (for r=12.4%) or c_2 (for r=15%), relational contracting (with A control) is feasible and produces discretely higher payoff than spot adaptation. Indeed, for sufficiently large costs, relational contracting achieves first-best when r<12.4%; whereas for r=15% the relational contract is always second-best as c increases.

Figure 8 Formal Contracting under Non-integration but not under Integration



Note: The figure depicts the difference in surplus between (a) a non-integrated relational contract, shown in Figure 6, where A pays $c < \infty$ to contract on d_B when $s''(c) < s < s_A(c)$, versus (b) an integrated relational contract, shown in bold green here, where A chooses d_B below s** and d_A above, but A never pays $c = \infty$. The cutoff s** is chosen such that A's maximum reneging temptation is identical in the two relational contracts: $\pi_A(s^{**}) \equiv \pi_B(s''(c)) - c$. The gain from integrating is from avoiding paying c for $s''(c) < s < s^{**}$. The loss from integrating is that A chooses d_A instead of d_B for $s^{**} < s < s_A(c)$, whereas under non-integration A pays c and chooses d_B in these states. For convenient choices of f(s), the former dominates the latter.

Figure 9 Private benefits for two parties with two decision rights



Note: The figure shows the private benefits for Parties A and B for two decision rights. The first-best entails taking A's preferred decision for d_1 when $s < s_1^*$ and B's when $s > s_1^*$, together with taking A's preferred decision for d_2 when $s < s_2^*$ and B's when $s > s_2^*$. When A controls both decisions, the maximum aggregate reneging temptation is $\text{MAX}\{\pi_{A1}(s_1^*) + \pi_{A2}(s_1^*),\ \pi_{A2}(s_2^*)\}$. When A controls decision 1 and B controls decision 2, the maximum aggregate reneging temptation is $\text{MAX}\{\pi_{A1}(s_1^*), \pi_{B2}(1)\}$.

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APPENDIX 1

The purpose of this Appendix is to show that, given a decision rule $\mathbf{d}^{RC}(\cdot)$, there exist payment rules t_{ig}, $\tau_{ig}(\cdot)$, and $T_{ig}(\cdot,\cdot)$ such that the reneging constraints (11) through (14) are satisfied if and only if (10) holds. That is, (10) is both necessary and sufficient for implementing the state-contingent decision rule $\mathbf{d}^{RC}(\cdot)$ through a relational contract.

We adopt the convention that a positive value of t_{ig}, $\tau_{ig}(s)$, or $T_{ig}(\mathbf{d}, s)$ is a payment to Party i, and a negative value a payment from Party i. Furthermore, we require that these payments balance: $\Sigma_{i\in I}\, t_{ig} = 0$, $\Sigma_{i\in I}\, \tau_{ig}(s) = 0$ for all s, and $\Sigma_{i\in I}\, T_{ig}(\mathbf{d}, s) = 0$ for all $\mathbf{d}$ and s, which implies that $\sum_{i\in I} U_{ig}^{RC} \equiv V_g^{RC} \equiv V^{RC}$.

Since (11) through (14) hold for each $i \in I$, they also must hold for the sum across i. Summing over $i \in I$ yields the necessary conditions

(11') $\left(1+\frac{1}{r}\right)V^{RC} \geq V_g^{NE} + \frac{1}{r}V^{SP}$,

(12') $\frac{1}{r}V^{RC} + \sum_i \pi_{ig}^{RC}(s) \geq \sum_i \pi_{ig}^{NE}(s) + \frac{1}{r}V^{SP}$ for all s,

(13') $\sum_i \pi_{ig}^{RC}(s) + \frac{1}{r}V^{RC} \geq \sum_i \pi_{ig}^{BR}(s) + \frac{1}{r}V^{SP}$ for all s, and

(14') $\frac{1}{r}V^{RC} \geq \frac{1}{r}V^{SP}$.

We can restrict attention to relational contracts satisfying $V^{RC} > V^{SP}$, and we have $V^{SP} \geq V_g^{NE}$ by (8), so (11') and (14') are trivially satisfied. Similarly, we can restrict attention to relational contracts satisfying $\sum_i \pi_{ig}^{RC}(s) \geq \sum_i \pi_{ig}^{NE}(s)$, because a relational contract that failed this inequality could be improved by setting $\mathbf{d}_{ig}^{RC}(s) = \mathbf{d}_{ig}^{NE}(s)$ for any state in which $\sum_i \pi_{ig}^{RC}(s) < \sum_i \pi_{ig}^{NE}(s)$, so (12') is also trivially satisfied. Since (13') must hold for all s it must be that $\max_s \sum_i (\pi_{ig}^{RC}(s) - \pi_{ig}^{BR}(s)) \equiv R_g(\mathbf{d}^{RC}(\cdot)) \le \frac{1}{r}(V^{RC} - V^{SP})$, which implies that (10) is a necessary condition for constraints (11') through (14').

To establish the sufficiency of (10), we show that if (10) holds then there exist payments t_{ig}, $\tau_{ig}(s)$, and $T_{ig}(\mathbf{d}_{RC}(s), s)$ that satisfy (11) through (14), with $\Sigma_{i\in I}\ t_{ig} = 0$, $\Sigma_{i\in I}\ \tau_{ig}(s) = 0$ for all s, and $\Sigma_{i\in I}\ T_{ig}(\mathbf{d}, s) = 0$ for all $\mathbf{d}$ and s. In particular, consider the following specifications of the bonus, bribe, and wage:

$$\text{(A1)} \quad T_{ig}(\mathbf{d}^{RC}(s), s) = \begin{cases} \pi_{ig}^{BR}(s) - \pi_{ig}^{RC}(s) - \frac{1}{r}U_{ig}^{RC} + P_{ig} + \frac{1}{r}V_i^{SP} & i \in I \ne j \\ -\sum_{i \ne j} T_{ig}(\mathbf{d}^{RC}(s), s) & i = j \end{cases}$$

$$\text{(A2)} \quad \tau_{ig}(s) = \begin{cases} \pi_{ig}^{NE}(s) + P_{ig} + \frac{1}{r}V_i^{SP} - [\pi_{ig}^{RC}(s) + T_{ig}(\mathbf{d}^{RC}(s), s) + \frac{1}{r}U_{ig}^{RC}] & i \in I \ne j \\ -\sum_{i \ne j} \tau_{ig}(s) & i = j \end{cases}$$

$$\text{(A3)} \quad t_{ig} = 0, \ i \in I$$

Since $\pi_{ig}^{BR}(s) > \pi_{ig}^{RC}(s)$, if (13) holds then (14) must hold. Similarly, under our assumption that $t_{ig} = 0$ for all i, if (12) holds for all s then (11) must hold. To see this latter result, note that the left hand side of (12) can be written as $U_{ig}^{RC}(s) + \frac{1}{r}U_{ig}^{RC}$ (when $t_{ig} = 0$). Taking expectations of (12) with respect to s (and recalling that $E_s[\pi_{ig}^{NE}(s)] \equiv V_i^{NE}$) yields (11). Therefore, to establish sufficiency of (10) given our candidate payments (A1)-(A3), we need only show that these payments satisfy (12) and (13).

By construction, $T_{ig}(\mathbf{d}_{RC}(s), s)$ in (A1) is defined so that (13) is satisfied with equality for all i≠j. For i=j, substitution from (A1) implies that (13) is satisfied if:

$$\sum_{i \in I} \left(\pi_{ig}^{RC}(s) + \frac{1}{r}U_{ig}^{RC} - \pi_{ig}^{BR}(s) + P_{ig} + \frac{1}{r}V_i^{SP} \right) \ge 0$$

for all s, which reduces to

$$\text{(13")} \quad \sum_{i \in I} \left(\pi_{ig}^{BR}(s) - \pi_{ig}^{RC}(s) \right) \le \frac{1}{r}(V^{RC} - V^{SP}).$$

The left-hand side of (13") is the aggregate reneging temptation in state s. Since we know from (10) that (13") is satisfied in the state yielding the maximum aggregate reneging temptation, $R_g(\mathbf{d}^{RC}(\cdot))$, it follows that (13") (and hence (13) and (14)) are satisfied as long as (10) holds.

Similarly, $\tau_{ig}(s)$ is defined by construction in (A2) so that (12) is satisfied with equality for all i≠j. For i=j, substitution from implies that (12) is satisfied if:

$$\sum_{i\in I}\left(\pi_{ig}^{RC}(s)+T_{ig}(\mathbf{d}^{RC}(s),s)+\tfrac{1}{r}U_{ig}^{RC}-\pi_{ig}^{NE}(s)-P_{ig}-\tfrac{1}{r}V_i^{SP}\right)\geq 0 \text{ for all s,}$$

which reduces to

$$\text{(12")}\quad \sum_{i\in I}\left(\pi_{ig}^{NE}(s)-\pi_{ig}^{RC}(s)\right)\leq \tfrac{1}{r}(V^{RC}-V^{SP}), \text{ for all s.}$$

As before, we restrict attention to relational contracts satisfying $V^{RC} > V^{SP}$, and also to contracts satisfying $\sum_i \pi_{ig}^{RC}(s) \geq \sum_i \pi_{ig}^{NE}(s)$, because a relational contract that failed this second inequality could be improved by setting $\mathbf{d}_{ig}^{RC}(s)=\mathbf{d}_{ig}^{NE}(s)$ for any state in which $\sum_i \pi_{ig}^{RC}(s) < \sum_i \pi_{ig}^{NE}(s)$. Given these assumptions, the left-hand side of (12") is negative and the right-hand side is positive, and therefore (12"), (12) and (11) are satisfied.

APPENDIX 2

Lemma 1 shows that, given our assumptions in Section 3 a second-best outcome that is superior to optimal spot governance will never involve assigning control to party B.

Lemma A1: Suppose $\pi_i(s)$ is continuous and increasing for each party, $\pi_B(0) > \pi_A(0)$, $\pi_A(1) > \pi_B(1)$, and the benefit functions cross once. Suppose the first-best is not feasible but ($d^{SB}(\cdot)$, g^{SB}) is second-best, with $V(d^{SB}(\cdot)) > V^{SP}$. Then B does not have control in the second-best (i.e., $g^{SB} \neq B$).

Proof: Suppose $g^{SB} = B$. For $s < s^*$, we must have $d^{SB}(s) = d_B$ almost everywhere, because if $d^{SB}(s) = d_A$ for a positive measure of states then we could change to $d^{SB}(s) = d_B$, thereby increasing $V(d^{SB}(\cdot))$ and not increasing $R_B(d^{SB}(\cdot))$, violating (17b). Since $V(d^{SB}(\cdot)) > V^{SP}$, there exists a positive measure of states $s > s^*$ where $d^{SB}(s) = d_A$. Let $s_A = \sup \{s: d^{SB}(s) = d_A\}$. Then $R_B(d^{SB}(\cdot)) = \pi_B(s_A)$, so $\pi_B(s_A) \leq \frac{1}{r}\left[V(d^{SB}(\cdot)) - V^{SP}\right]$ by (17a). Since π_B is increasing, we have

$$R_A(d^{FB}(\cdot)) = \pi_A(s^*) = \pi_B(s^*) < \pi_B(s_A) \leq \tfrac{1}{r}\left[V(d^{SB}(\cdot)) - V^{SP}\right] < \tfrac{1}{r}\left[V^{FB} - V^{SP}\right],$$

violating (17a). QED

Lemma A1 implies that if the second-best has $V(d^{SB}(\cdot)) > V^{SP}$ then party A has control. Proposition A2 then establishes how A exercises that control: the second-best involves allowing A's preferred decision for states $s' < s < s^*$ (where B's preferred decision would have been first-best).

Proposition A2: Suppose $\pi_i(s)$ is continuous and increasing for each party, $\pi_B(0) > \pi_A(0)$, $\pi_A(1) > \pi_B(1)$, and the benefit functions cross once. Suppose the first-best is not feasible but ($d^{SB}(\cdot)$, g^{SB}) is second-best with $V(d^{SB}(\cdot)) \in (V^{SP}, V^{FB})$. Then $g^{SB} = A$ and there exists $s' \in (0, s^*)$ such that $d^{SB}(\cdot)$ specifies decision d_B when $s < s'$ and d_A when $s > s'$. Furthermore, s' is the largest value satisfying (17a).

Proof: From Lemma A1, $g^{SB} = A$. For $s > s^*$, we must have $d^{SB}(s) = d_A$ almost everywhere, because if $d^{SB}(s) = d_B$ for a positive measure of states then we could change to $d^{SB}(s) = d_A$, thereby increasing $V(d^{SB}(\cdot))$ and not increasing $R_A(d^{SB}(\cdot))$, violating (17b). Let $s' = \inf\{s: d^{SB}(s) = d_A\}$. Because $V(d^{SB}(\cdot)) < V^{FB}$, there exists a positive measure of states $s < s^*$ where $d^{SB}(s) = d_A$, so $s' < s^*$. Then for $s \in (s', s^*)$ we must have $d^{SB}(s) = d_A$ almost everywhere, because if there exists a positive measure of states $s'' \in (s', s^*)$ with $d^{SB}(s'') = d_B$, then $R_A(d^{SB}(\cdot)) \geq \pi_A(s'')$ for all such s'', and since π_A is increasing we could change the decision in a positive measure of these states (starting with s') to $d^{SB}(s'') = d_B$, thereby increasing $V(d^{SB}(\cdot))$ and not increasing $R_A(d^{SB}(\cdot))$, violating (17b). Since $V(d^{SB}(\cdot)) > V^{SP}$, there exists a positive measure of states $s < s^*$ where $d^{SB}(s) = d_B$, so we have $d^{SB}(s) = d_B$ for almost all $s < s'$ and d_A for almost all $s > s'$. In fact, since $R_A(d^{SB}(\cdot))$ is state-specific rather than an expectation, we have that $d^{SB}(s) = d_B$ for all $s < s'$ and d_A for all $s > s'$. Given this form for $d^{SB}(\cdot)$, $V(d^{SB}(\cdot))$ is increasing in s', so the second-best s' is the largest value satisfying (17a). QED

APPENDIX 3

This appendix analyzes spot, first-best, and second-best relational adaptation in the model from Section 4.

To handle all values of c with unified notation, define $s_A(c)$ and $s_B(c)$ as follows: if $\pi_B(0) - \pi_A(0) \leq c$ then $s_A(c) = 0$, otherwise $s_A(c)$ solves $\pi_A(s) = \pi_B(s) - c$; and if $\pi_A(1) - \pi_B(1) \leq c$ then $s_B(c) = 1$, otherwise $s_B(c)$ solves $\pi_B(s) = \pi_A(s) - c$. Following the notation introduced above (8), we can then write the expected total payoff from spot adaptation when A has control as

$$V_A^{NE} = \int_{s=0}^{s_A(c)} [\pi_B(s) - c] f(s) ds + \int_{s=s_A(c)}^{1} \pi_A(s) f(s) ds$$

and the expected total payoff from spot adaptation when B has control as

$$V_B^{NE} = \int_{s=0}^{s_B(c)} \pi_B(s) f(s) ds + \int_{s=s_B(c)}^{1} [\pi_A(s) - c] f(s) ds,$$

so the expected total payoff from spot adaptation is $V^{SP} = \max\{V_A^{NE}, V_B^{NE}\}$. Note that if $c < \min\{\pi_B(0) - \pi_A(0), \pi_A(1) - \pi_B(1)\}$ then V^{SP} depends on c. In particular, as c approaches zero, $s_A(c)$ and $s_B(c)$ approach s^* and V^{SP} approaches V^{FB}.

To derive when the first-best is feasible, we need to compute the parties' reneging temptations. Suppose B has control. For $s \in (s^*, s_B(c)]$, B's reneging temptation is $\pi_B(s) > \pi_B(s^*)$, and for $s \in (s_B(c), 1]$, B's reneging temptation is $\pi_A(s) - c > \pi_B(s) > \pi_B(s^*)$. Thus, B's maximum reneging temptation is $\pi_A(1) - c > \pi_B(s^*)$. Alternatively, suppose A has control. For $s \in [s_A(c), s^*)$, A's temptation is $\pi_A(s) < \pi_A(s^*)$, and for $s \in [0, s_A(c))$, A's temptation is $\pi_B(s) - c \in (\pi_A(s), \pi_A(s^*))$. Thus, we have the same qualitative result as in Section 3: because A's maximum temptation is $\pi_A(s^*)$, which is less than B's maximum temptation $\pi_A(1) - c$, A should have control to achieve the first-best at the highest discount rates.

Second-best relational adaptation also parallels Section 3, in two respects: A should have control, and the second-best decision rule may take the form shown in Figure 3 (i.e., without any use of enforceable contracts on the equilibrium path). The former follows from a slight modification of the proof of Lemma A1, where B's reneging temptation is now

$\tilde{\pi}_B(s) = \max\{\pi_B(s), \pi_A(s) - c\}$ instead of $\pi_B(s)$. Since $V(d^{SB}(\cdot)) > V^{SP}$, there exists either $s \in (s^*, s_B]$ where $d^{SB}(s) = d_A$ (rather than d_B under spot adaptation) or $s \in (s_B, 1]$ where $d^{SB}(s) = d_A$ (without paying c as under spot adaptation). In the first case, $R_B(d^{SB}(\cdot)) \geq \pi_B(s) > \pi_B(s^*)$; in the second, $R_B(d^{SB}(\cdot)) \geq \pi_A(s) - c > \pi_B(s^*)$. The remainder of the proof of Lemma A1 then applies.

To see the latter, recall the argument behind the second-best decision rule in Figure 3 (where c can be interpreted as infinite): because r is too high for the first-best to be feasible, the second-best decision rule must reduce A's reneging temptation by not specifying that A take decision d_B unless $s < s'$ (where $s' < s^*$), so that A's maximum reneging temptation becomes $\pi_A(s') < \pi_A(s^*)$. Of course, allowing A to take decision d_A for $s' < s < s^*$ also reduces the expected payoff $V(d^{SB}(\cdot))$, so there may not be a value of s' satisfying (10).

APPENDIX 4

This Appendix supplies calculations for the example underlying Figure 7.

Since s is uniform on [0, 1], $\pi_A(s) = 2s$, and $\pi_B(s) = s + b$, where $b \in (0, 1)$, we have $\pi_A(s) = \pi_B(s)$ at s* = b, and the first-best decision rule produces expected total payoff

$$V^{FB} = \int_0^{s^*} [s+b]ds + \int_{s^*}^1 2s\,ds = 1 + \tfrac{1}{2}b^2.$$

Under spot adaptation, if A has control then it is efficient for B to pay c to implement d = d_B whenever s < $s_A(c)$ = max{0, b-c}. Similarly, when B has control, it is efficient for A to pay c to implement d = d_A whenever s > $s_B(c)$ = min{1, b+c}. The expected total payoff under spot adaptation when party i has control is then:

$$V_A^{SP} = \int_0^{s_A(c)} [s+b-c]ds + \int_{s_A(c)}^1 2s\,ds = 1 + \tfrac{1}{2}(b-c)^2,$$

if c < b and $V_A^{SP} = 1$ otherwise; and

$$V_B^{SP} = \int_0^{s_B(c)} [s+b-c]ds + \int_{s_B(c)}^1 2s\,ds = 1 + \tfrac{1}{2}(b+c)^2 - c.$$

if c < 1-b and $V_B^{SP} = \tfrac{1}{2} + b$ otherwise.

It is straightforward to show that $V_A^{SP} > V_B^{SP}$ whenever b < ½ and $V_A^{SP} < V_B^{SP}$ whenever b > ½. Therefore, the optimal governance structure under spot adaptation is for A to control when b < ½, and for B to control when b > ½. For the remainder of this analysis, we will assume that b > ½ so that g^{SP} = B.

As shown in Appendix 3, first- and second-best relational adaptation are best achieved by giving A control. From (18), party A's maximum reneging temptation under the first-best decision rule is $\pi_A(s^*) = 2b$, so the first-best can be implemented if and only if $2b \le \tfrac{1}{r}[V^{FB} - V^{SP}]$. Thus, the critical value of r below which the first-best can be achieved with A in control (denoted r_A^{FB}) does change if the opportunity to contract on d changes V^{SP} (as it does when c < 1-b). In particular, (18) yields

$$r_A^{FB} = \begin{cases} \dfrac{(1-b)^2}{4b} & \text{if } c \geq 1-b \\ \dfrac{c(1-b-\frac{1}{2}c)}{2b} & \text{if } c < 1-b \end{cases}.$$

Naturally, r_A^{FB} falls to zero with c because contracting on d then achieves almost the first-best decisions at almost no cost, so V^{SP} approaches V^{FB} and there is little surplus from conducting the relationship.

Turning to the second-best, as discussed above in connection with Figure 6, this example's assumptions of linear benefits and a uniform state ensure that second-best relational contracting does not involve formal contracting (at cost c) on the equilibrium path: the second-best relational contract has $s''(c) > s_A(c)$ as in Figure 5 rather than $s''(c) < s_A(c)$ as in Figure 6, where

$$s''(c) = \begin{cases} b-2r+\sqrt{(b-2r)^2-2b+1} & \text{if } c \geq 1-b \\ b-2r+\sqrt{(b-2r)^2-(b+c)^2+2c} & \text{if } c < 1-b \end{cases}, \text{ and}$$

When the first-best is not feasible, expected total payoff under second-best relational governance is

$$V^{SB} = \int_0^{s''(c)} [s+b]ds + \int_{s''(c)}^1 2s\,ds = 1 + bs''(c) - \tfrac{1}{2}s''(c)^2,$$

The critical value for r that implements a second-best relational contract with $V^{RC} > V^{SP}$ with A control is

$$r_A^{SB} = \begin{cases} \frac{1}{2}\left(b-\sqrt{2b-1}\right) & \text{if } c \geq 1-b \\ \frac{1}{2}\left(b-\sqrt{(b+c)^2-2c}\right) & \text{if } c < 1-b \end{cases}.$$