

# THE QUARTERLY JOURNAL OF ECONOMICS

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Vol. CXXIII

February 2008

Issue 1

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## CONTRACTS AS REFERENCE POINTS\*

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We argue that a contract provides a reference point for a trading relationship: more precisely, for parties' feelings of entitlement. A party's *ex post* performance depends on whether he gets what he is entitled to relative to outcomes permitted by the contract. A party who is shortchanged shades on performance. A flexible contract allows parties to adjust their outcomes to uncertainty but causes inefficient shading. Our analysis provides a basis for long-term contracts in the absence of noncontractible investments and elucidates why "employment" contracts, which fix wages in advance and allow the employer to choose the task, can be optimal.

### I. INTRODUCTION

What is a contract? Why do people write (long-term) contracts? The classical view held by economists and lawyers is that a contract provides parties with a set of rights and obligations,

\*An early version of this paper was entitled "Partial Contracts." We are particularly indebted to Andrei Shleifer and Jeremy Stein for useful comments and for urging us to develop Section V. We would also like to thank Philippe Aghion, Jennifer Arlen, Daniel Benjamin, Omri Ben-Shahar, Richard Craswell, Stefano DellaVigna, Tore Ellingsen, Florian Englmaier, Edward Glaeser, Elhanan Helpman, Ben Hermalin, Louis Kaplow, Emir Kamenica, Henrik Lando, Steve Leider, Jon Levin, Bentley MacLeod, Ulrike Malmendier, Sendhil Mullainathan, Al Roth, Jozsef Sakovics, Klaus Schmidt, Robert Scott, Jonathan Thomas, Jean Tirole, Joel Watson, Birger Wernerfelt, two editors, and three referees for helpful suggestions. In addition, we have received useful feedback from audiences at the Max Planck Institute for Research on Collective Goods in Bonn, the Harvard-MIT Organizational Economics Seminar, the University of Zurich, the 2006 Columbia University Conference on the Law and Economics of Contracts, Cornell University (Center for the Study of Economy & Society), Yale University Law School (where part of the text formed the first author's Raben Lecture), Edinburgh University, the London School of Economics, the American Law and Economics Association Meetings (where part of the text formed the first author's Presidential address), the Copenhagen Business School, the University of Stockholm, the Stockholm School of Economics, and the European Economic Association 2006 Annual Congress (where part of the text formed the second author's Schumpeter Lecture). We are grateful to Paul Niehaus for excellent research assistance. We acknowledge financial support from the U.S. National Science Foundation through the National Bureau of Economic Research and from the UK Economic and Social Research Council.

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*The Quarterly Journal of Economics*, February 2008

and that these rights and obligations are useful, among other things, to encourage long-term investments.<sup>1</sup> In this paper we present an alternative and complementary view. We argue that a contract provides a reference point for the parties' trading relationship: more precisely for their feelings of entitlement. We develop a model in which a party's *ex post* performance depends on whether the party gets what he is entitled to relative to the outcomes permitted by the contract. A party who is shortchanged shades on performance, which causes a deadweight loss. One way the parties can reduce this deadweight loss is for them to write an *ex ante* contract that pins down future outcomes very precisely, and that therefore leaves little room for disagreement and aggrievement. The drawback of such a contract is that it does not allow the parties to adjust the outcome to the state of the world. We study the trade-off between rigidity and flexibility. Our analysis provides a basis for long-term contracts in the absence of noncontractible relationship-specific investments and throws light on why simple "employment" contracts can be optimal.

To motivate our work, it is useful to relate it to the literature on incomplete contracts. A typical model in that literature goes as follows. A buyer and seller meet initially. Because the future is hard to anticipate, they write an incomplete contract. As time passes and uncertainty is resolved, the parties can and do renegotiate their contract, in a Coasian fashion, to generate an *ex post* efficient outcome. However, as a consequence of this renegotiation, each party shares some of the benefits of prior (noncontractible) relationship-specific investments with the other party. Recognizing this, each party underinvests *ex ante*. The literature studies how the allocation of asset ownership and formal control rights can reduce this underinvestment.<sup>2</sup>

Although the above literature has generated some useful insights about firm boundaries, it has some shortcomings.<sup>3</sup> Three that seem particularly important to us are the following. First, the emphasis on noncontractible *ex ante* investments seems overplayed: although such investments are surely important, it is hard to believe that they are the sole drivers of organizational form. Second, and related, the approach is ill suited to studying the internal organization of firms, a topic of great interest and importance. The

1. For up-to-date syntheses of the classical view, see Bolton and Dewatripont (2005) and Shavell (2004).

2. See, for example, Grossman and Hart (1986) and Hart and Moore (1990).

3. For a discussion, see Holmstrom (1999).

reason is that the Coasian renegotiation perspective suggests that the relevant parties will sit down together *ex post* and bargain to an efficient outcome using side payments: given this, it is hard to see why authority, hierarchy, delegation, or indeed anything apart from asset ownership matters. Finally, the approach has some foundational weaknesses.<sup>4</sup>

We believe that to develop more general and compelling theories of contracts and organizational form it is essential to depart from a world in which Coasian renegotiation always leads to *ex post* efficiency.<sup>5</sup> The purpose of our paper is to move in this direction. To achieve this goal, we depart from the existing literature in two key ways. First, we drop the assumption made in almost all of the literature that *ex post* trade is perfectly contractible. Instead, we suppose that trade is only partially contractible.<sup>6</sup> Specifically, we distinguish between perfunctory performance and consummate performance, that is, performance within the letter of the contract and performance within the spirit of the contract.<sup>7</sup> Perfunctory performance can be judicially enforced, whereas consummate performance cannot.<sup>8</sup> Second, we introduce some important behavioral elements. We suppose that a party is happy to provide consummate performance if he feels that he is getting what he is entitled to, but will withhold some part of consummate performance if he is shortchanged—we refer to this as “shading.” An important assumption we will make (for most of the paper) is that a party’s sense of entitlement is determined by the contract he has written. This is the sense in which a contract is a “reference point.” A companion assumption, also significant, is that the contract in question is negotiated under relatively competitive conditions. A final element of the story is that there is no reason that parties’ feelings of entitlement should be consistent. In particular, when the contract permits more than one outcome, each party may feel entitled to a different outcome.

4. See, for example, Maskin and Tirole (1999) and the response in Hart and Moore (1999).

5. One obvious possibility is to introduce asymmetric information. To date such an approach has not been very fruitful in the theory of the firm. But see Matouschek (2004).

6. We do not go as far as some of the recent incomplete contracting literature that supposes that *ex post* trade is not contractible at all (see, e.g., Baker, Gibbons, and Murphy [2006]). One problem with supposing that *ex post* trade is noncontractible is that it is unclear how one party gets an action carried out except by doing it himself. As will be seen, our approach does not suffer from this difficulty.

7. The perfunctory and consummate language is taken from Williamson (1975, p. 69).

8. For a discussion and examples, see Goldberg and Erickson (1987, p. 388).

These ingredients yield the above-described trade-off between flexibility and rigidity. A flexible contract has the advantage that parties can adjust the outcome to the state of the world, but the disadvantage that any outcome selected will typically cause at least one party to feel aggrieved and shortchanged, which leads to a loss of surplus from shading. An optimal contract trades off these two effects. Our theory explains not only why parties will write somewhat rigid contracts, but also the nature of the rigidity. The parties are more likely to put restrictions on variables over which there is an extreme conflict of interest, such as price, than on variables over which conflict is less extreme, such as the nature or characteristics of the good to be traded. Among other things, our model shows why simple employment contracts, which fix price (wage) in advance and allow the employer to choose the task, can be optimal. (More generally, the model explains why the wage should vary with the task if some tasks are systematically costlier than others.)

For most of the paper we suppose that parties' feelings of entitlement are controlled entirely by the contracts they have written. In reality, other influences on entitlements are sometimes important. For example, parties may look to related transactions to determine whether they are being fairly treated. This consideration allows a rich new set of possibilities; we examine these briefly in Section V. Although our analysis is preliminary, we show that external measures of entitlement can interfere with an *ex ante* contract and that it may therefore be optimal for the parties to postpone contracting; that is, the optimal *ex ante* contract may be "no contract."

The behavioral assumptions on which our analysis is based are undoubtedly strong, and although they are broadly consistent with a number of ideas in the literature, there is no single model or experiment that we can appeal to that supports precisely what we do. In future work it would therefore be highly desirable to see whether our assumptions can be validated by experiment. At the same time, we should make it clear that we are not wedded to a particular set of behavioral assumptions. In addition, and relatedly, we see the behavioral approach adopted here as something of a means to an end; the end is the development of a tractable model of contracts and organizational form that exhibits *ex post* inefficiency and that can explain simple contracts observed in reality, such as the employment contract. From this perspective, the costs of flexibility that we focus on—shading costs—can be viewed

as a shorthand for other kinds of transaction costs, such as rent-seeking, influence, and haggling costs. We return to this theme in the conclusions.

The paper is organized as follows. Section II presents the model, discusses our key assumptions, and lays out a simple example. In Section III we analyze a case where there is uncertainty about value and cost but not about the type of good to be traded. In Section IV we consider a second case where there is uncertainty about the nature of the good. This section also discusses the employment relationship. Section V allows for the possibility of influences on entitlements other than the initial contract. In Section VI we discuss renegotiation. Finally, Section VII concludes. The Appendix considers a more general class of contracts than those studied in the text and includes proofs of propositions.

## II. THE MODEL

We consider a buyer B and a seller S who are engaged in a long-term relationship. The parties meet at date 0 and can trade at date 1. We assume a perfectly competitive market for buyers and sellers at date 0, but that competition is much reduced at date 1: in fact, for the most part we suppose that B and S face bilateral monopoly at date 1. In other words, there is a “fundamental transformation” in the sense of Williamson (1985).

We do not model why this fundamental transformation occurs. It could be because the parties make relationship-specific investments, but there may be other, more prosaic reasons. For example, imagine that B is organizing a wedding for his daughter. S might be a caterer. Six months before the wedding, say, there may be many caterers that B can approach and many weddings that S can cater. But it may be very hard for B or S to find alternative partners a week before the wedding. Although there are no very obvious relationship-specific investments here, the fundamental transformation seems realistic, and the model applies.

It would be easy to fit relationship-specific investments explicitly into the analysis, but we would then suppose that these investments were contractible. That is, an important feature of our model is that it does not rely on noncontractible investments.

We make some standard assumptions. Any uncertainty at date 0 is resolved at date 1. There is symmetric information throughout, and the parties are risk-neutral and face no wealth constraints.



FIGURE I

We now come to the two assumptions that represent significant departures from the literature. First, we suppose that *ex post* trade is only partially contractible. Specifically, although the broad outlines of *ex post* trade are contractible, the finer points are not. As noted in the Introduction, we distinguish between perfunctory and consummate performance, that is, performance within the letter of the contract and performance within the spirit of the contract. Perfunctory performance is enforceable by a court, whereas consummate performance can never be judicially enforced.

For instance, in the wedding example, a judge can determine whether food was provided but not the quality of the cake or whether the host was friendly to the catering staff.

Before we describe our second (set of) assumption(s), it is useful to provide a timeline; see Figure I. The parties meet and contract at date 0. At this stage there may be uncertainty, and so the parties typically choose to write a flexible contract that admits several outcomes. At date 1 the uncertainty is resolved and the parties refine the contract; that is, they decide which outcome to pick. After this, trade occurs and the degree of consummate performance is determined.<sup>9</sup>

We now come to our second key departure from the literature. We make a number of assumptions—some behavioral—about the determinants of consummate performance. First, we suppose that consummate performance does not cost significantly more than perfunctory performance: either it costs slightly more or it costs slightly less, that is, a party may actually enjoy providing consummate performance. In what follows, to simplify matters, we assume that a party is completely indifferent between providing consummate and perfunctory performance.

9. Because a court can determine whether trade took place, any payments that B has promised S conditional on trade must be made: if not, S would sue for breach of contract. In other words, payments are part of perfunctory performance. (The speed with which payments are made, however, may be part of consummate performance.)

Given this indifference, we take the view that a party will be willing to provide consummate performance if he is “well treated,” but not if he is “badly treated.”<sup>10</sup> We make the crucial assumption that a party is “well treated” if and only if he receives what he is entitled to, and that the date 0 contract acts as a reference point for entitlements. In fact, for most of the paper we suppose that the contract is the *sole* reference point for entitlements (but see Section V). What we mean by this is that a party does not feel entitled to more than the best outcome permitted by the contract. So, for example, if the date 0 contract specifies just one outcome, then each party will feel that he is getting exactly what he is entitled to if that outcome occurs.<sup>11</sup> We discuss the assumption that the contract acts as a reference point further below. As we shall make clear, this assumption is linked to a companion assumption that the contract is negotiated under relatively competitive conditions.<sup>12</sup>

Matters become more complicated if the contract specifies more than one outcome. Now we take the view that the parties may no longer agree about what they are entitled to. In particular, if the contract says that either outcome a or outcome b can occur,

10. This idea is consistent with the large behavioral economics literature that has examined altruism, reciprocity, and retaliation. For example, in the ultimatum game (see, e.g., Guth, Schmittberger, and Schwarze [1982]), a suggested split of surplus by the proposer that is seen as “greedy” will often elicit retaliation in the form of rejection by the responder, even though this is costly for the responder. See Camerer and Thaler (1995) for a discussion and Andreoni, Castillo, and Petrie (2003) for experimental evidence for the case where the responder can scale back the level of trade rather than rejecting trade entirely. Other important works on reciprocity and retaliation include Akerlof (1982); Akerlof and Yellen (1990); Rabin (1993); Fehr, Gächter, and Kirchsteiger (1997); Bewley (1999); and Fehr and Schmidt (1999). For surveys see Fehr and Gächter (2000) and Sobel (2005). MacLeod (2003) models the role of retaliation in sustaining accurate assessments of worker performance. Direct empirical evidence of retaliation by employees or contractors in response to “bad treatment,” in the form of poor performance, negligence, or sabotage, can be found in Lord and Hohenfeld (1979); Greenberg (1990); Giacalone and Greenberg (1997); Krueger and Mas (2004); and Mas (2006a, 2006b).

11. Note that the experimental evidence of Falk, Fehr, and Fischbacher (2003) is consistent with the idea that whether a person feels well treated depends not only on the outcome that occurs but also on what other outcomes were available (see also Camerer and Thaler [1995]).

12. The notion of a reference point has played an important role in the recent behavioral economics literature, including that concerned with contractual relationships. Kahneman, Knetsch, and Thaler (1986) provide evidence that for transactions between firms and consumers customers use past prices as a reference point for judging the fairness of a transaction. See also Okun (1981), Frey (1997, Chapter 2), Gneezy and Rustichini (2000), and Falk, Fehr, and Zehnder (2006) for related ideas. Akerlof and Yellen (1990) consider the importance of reference groups in the determination of a fair wage. Benjamin (2006) analyzes the implications of reference points for optimal incentive schemes, and Carmichael and MacLeod (2003) for the hold-up problem. Our paper owes a lot to the above literature but differs from it in supposing that a contract governing a transaction is a reference point for the transaction itself.

then one party may feel entitled to a and the other to b. We do not model why these differences in entitlements arise, but we have in mind the kinds of effects described in the self-serving bias literature.<sup>13</sup> To capture conflict as simply as possible, we suppose that each party feels entitled to the *best* outcome permitted by the contract. However, as Section VII will make clear, our analysis does not depend on such an extreme view of entitlements.

The final piece of the story is that getting less than what you are entitled to causes aggrievement and leads to retaliation and “shading,” that is, stinting on consummate performance. Let  $u_B, u_S$  denote the buyer and seller’s gross payoffs from the actual contractual outcome. Define the buyer’s aggrievement level  $a_B$  to equal the maximum gross payoff he could have achieved, taken over all contractually feasible outcomes, minus  $u_B$ . The seller’s aggrievement level  $a_S$  is defined analogously. (See Section III and the Appendix for more detail.) Denote by  $\sigma_B$  the monetary loss that the buyer imposes on the seller through shading; analogously,  $\sigma_S$  is the loss the seller imposes on the buyer. Then we suppose that the buyer and seller’s net payoffs can be written as

$$(1) \quad U_B = u_B - \sigma_S - \text{Max}\{\theta a_B - \sigma_B, 0\},$$

$$(2) \quad U_S = u_S - \sigma_B - \text{Max}\{\theta a_S - \sigma_S, 0\},$$

where  $0 < \theta \leq 1$ . The last term in (1) and (2) captures the idea that aggrievement of \$1 causes a direct psychic loss to the party experiencing it of  $\theta$ , but that the party can offset this by shading, that is, in effect by transferring the hurt back to the other party, up to the point where the aggrievement disappears. Given (1) and (2), it is optimal for the buyer to choose  $\sigma_B = \theta a_B$  and the seller  $\sigma_S = \theta a_S$ , and so

$$(3) \quad U_B = u_B - \theta a_S, \quad U_S = u_S - \theta a_B.$$

13. For example, each party may feel that he or she brings special skills to the trading relationship, or that he or she has taken an (unmodeled) action that has contributed to this relationship and that he or she deserves to be rewarded for these things. Virtue is in the eye of the beholder and so each party may exaggerate the importance of his or her own contribution. For contributions to the self-serving bias literature, see, for example, Hastorf and Cantril (1954); Messick and Sentis (1979); Ross and Sicoly (1979); and Babcock et al. (1995) and for discussions, see Babcock and Loewenstein (1997) and Bazerman (1998, pp. 94–101). For models of self-serving biases, see Rabin (1995) and Benabou and Tirole (2006). Note that conflicting notions of entitlement may also arise because of differences in information about the total surplus available. See Ellingsen and Johannesson (2005).



Note that implicit in our formulation is the assumption that the buyer and seller experience aggrievement equally and have the same ability to transfer it to the other party, and that there is no upper bound on shading; in effect  $\theta$  represents both the desire and the ability to shade. We discuss this further below.<sup>14</sup>

The shading decisions  $\sigma_B$ ,  $\sigma_S$  are made simultaneously by B and S and are not observable to an outsider. Hence they are not contractible, even at date 1 (recall our assumption that consummate performance can never be enforced judicially). We also suppose that shading is infeasible if the parties do not trade at date 1 (trade can be shaded, but the absence of trade cannot be shaded).<sup>15</sup>

It may be useful to give some examples of shading. There are many ways one trading partner can hurt another. A seller can shade by cutting quality: in the wedding example, she can stint on some of the ingredients of the wedding cake. Or the seller may withhold cooperation. The buyer may want to talk through some last-minute concerns about the wedding. The cost to the seller may be low, and she would normally oblige. But if the seller feels aggrieved she may refuse this request at considerable cost to the buyer. A third example would be “working to rule”: the seller abides by the strict terms of the contract and offers no more.<sup>16</sup>

Buyers can also shade. Although it is harder to imagine a buyer cutting back on quality, it is easy to think of situations where a buyer refuses to make minor concessions or to cooperate

14. Embodied in the above formulation is the idea that aggrievement is measured relative to gross payoffs, not net payoffs. Arguably, parties might measure aggrievement in terms of net payoffs, in the sense that aggrievement equals the difference between the maximum payoff a party could have achieved, taken over all contractually feasible outcomes, and his or her net payoff. If  $\theta < 1$ , this alternative formulation leads to a fixed point in net payoffs. The analysis does not change substantively.

15. This assumption is not crucial; see footnote 27.

16. For further discussion and examples of seller shading, see Lord and Hohenfeld (1979); Goldberg and Erickson (1987, p. 388); Greenberg (1990); Giacalone and Greenberg (1997); Krueger and Mas (2004); and Mas (2006a). For a vivid account of how getting less than what you think you are entitled to can lead to feelings of aggrievement and the desire to shade, see Kidder (1999). One approach to solving the problem of seller shading is for the buyer to withhold some part of his payment until after the transaction is complete, that is, to offer a bonus or tip to the seller for consummate performance. One well-known problem with this is that in a one-shot situation the buyer has an incentive to claim that performance is not consummate even if it is in order to avoid paying the tip. Note that this is true even if the seller has an opportunity to retaliate after the nonpayment of the tip, as long as the shading or retaliation parameter  $\theta < 1$  (the buyer loses  $\theta t$  but gains  $t$ , where  $t$  is the tip). In practice tips are paid, probably because of social norms (or because the relationship is repeated). However, it is unclear that a norm-induced tip will elicit consummate performance: if the seller knows that she is going to get somewhere between 15% and 20% pretty much regardless of performance, her incentive to provide consummate performance is limited. For a more positive view of the effectiveness of tips and bonus schemes, see Scott (2003).

(for example, the buyer may refuse to talk through some of the seller's last-minute concerns). The buyer can also make life difficult for the seller by quibbling about details of performance, by delaying payment, or by giving a bad reference. Thus, although the assumption that B and S can shade symmetrically (e.g., have the same parameter  $\theta$ ) is strong, we view it as a natural starting point for our analysis. As we will discuss in Section VII, we do not believe that this assumption is crucial. For example, a model in which the buyer experiences aggrievement, as in equation (1), but is forced to "eat" the aggrievement rather than being able to shift it to the seller, that is,  $\sigma_B = 0$ , is likely to yield similar results.

At this point, it is useful to illustrate the model with a simple example. Suppose that B requires one unit of a standard good—a widget—from S at date 1. Assume that it is known at date 0 that B's value is 100 and S's cost is zero: there is no uncertainty. What is the optimal contract?

The answer found in the standard literature is that, in this setting without noncontractible investments, no *ex ante* contract is necessary: the parties can wait until date 1 to contract. To review the argument, imagine that the parties do wait until date 1. Assume that Nash bargaining occurs and they divide the surplus 50:50; that is, the price  $p = 50$ . Of course, a 50:50 division may not represent the competitive conditions at date 0. For simplicity, suppose that there is one buyer and many sellers at date 0, so that in competitive equilibrium B receives the entire surplus. Then S will make a lump-sum payment of 50 to B at date 0: in effect S pays B up front for the privilege of being able to hold B up once the parties are in a situation of bilateral monopoly.

This "no contract" solution, combined with a lump-sum payment, no longer works in our context. To see why, suppose for the moment that "no contract" means that trade can occur at any price between zero and 100 (we revisit this assumption in Section V). (Prices above 100 are irrelevant because B will reject the widget and prices below zero are irrelevant because S will refuse to supply.) But this means that when the parties reach date 1 there is much to argue about.<sup>17</sup> The best contractual outcome possible for

17. If B's value of 100 and S's cost of zero were objective (i.e., verifiable), the parties might well agree that the fair outcome is to split the difference and set  $p = 50$ . We have in mind a more complex situation, where, because value and cost are observable but not verifiable, there is some flexibility in how the parties interpret these variables; this opens the door to conflict. While we do not formalize this notion of flexibility or fuzziness, it would clearly be desirable to do so in future work.

B is a zero price and our assumption is that he will feel entitled to it, and the best contractual outcome possible for S is a price of 100 and our assumption is that she will feel entitled to it. In spite of these conflicting feelings of entitlement, the parties will settle on some price  $p$  between 0 and 100, and trade will occur. However, each party will feel aggrieved and will shade. Because B feels aggrieved or shortchanged by  $p$ , he shades by  $\theta p$ , and since S feels aggrieved or shortchanged by  $(100 - p)$ , she shades by  $\theta(100 - p)$ . Thus the final payoffs are

$$(4) \quad U_B = 100 - p - \theta(100 - p) = (1 - \theta)(100 - p),$$

$$(5) \quad U_S = p - \theta p = (1 - \theta)p,$$

and total surplus is given by

$$(6) \quad W = (1 - \theta)100.$$

We see that, independent of  $p$ , there is a loss of  $100\theta$ .<sup>18</sup>

What can be done to eliminate this loss? The first point to note is that *ex post* Coasian renegotiation at date 1 does not do the job. The reason is that shading is not contractible, and thus a contract not to shade is not enforceable. To put it another way, if B offers to pay S more not to shade, then although this will indeed reduce S's shading because S will feel less aggrieved, it will increase B's shading because B will feel more aggrieved! In fact, it is clear from (6) that changes in  $p$  do not affect aggregate shading, which is given by  $100\theta$ .

Note that the conclusion that the loss from shading equals  $100\theta$  remains true even if the parties replace renegotiation at date 1 by a mechanism. For example, suppose B and S agree at date 0 that B will make a take-it-or-leave-it offer to S at date 1. The best offer for B to make is  $p = 0$ . However, S will feel that B could and should have offered  $p = 100$  because S is entitled to this. Thus S will be aggrieved by 100, and will shade by  $100\theta$ . Hence the loss from shading is again  $100\theta$ .

Although these approaches do not work, there is a very simple solution to the shading problem. The parties can write a contract at date 0 that fixes  $p$  at some level between 0 and 100; for example, if there are many sellers and only one buyer at date 0, then it

18. Note the role of the assumption that  $\theta \leq 1$ . If  $\theta > 1$ , the shading costs are so large that the parties will not trade at all at date 1 in the absence of a date 0 contract. Although we rule out the case  $\theta > 1$ , this does not mean that it is uninteresting.

would be natural to set  $p = 0$ . Then there is nothing to argue about at date 1. Neither party will feel aggrieved or shortchanged because each receives exactly what he or she bargained for and expected. Hence no shading occurs and total surplus equals 100.<sup>19</sup>

As we have argued earlier, a contract that fixes price works because it anchors the parties' expectations and feelings of entitlement: the contract is a reference point. An obvious question to ask is, what changes between dates 0 and 1? Why does a date 0 contract that fixes  $p$  avoid aggrievement, whereas a date 1 contract that fixes  $p$  does not? Our view is that the *ex ante* market plays a crucial role here. Because the date 0 market is more competitive than the date 1 market, it provides a relatively objective measure of what B and S bring to the relationship. For example, if the date 0 market is perfectly competitive and the market price is  $\hat{p}$ , then S accepts that  $\hat{p}$  is a reasonable price because no seller receives more, and B accepts that  $\hat{p}$  is a reasonable price because no seller is willing to supply for less. More generally, if the date 0 market is not perfectly competitive—imagine that there is a range of prices  $[p, \bar{p}]$  in the “market,” where  $0 < p < \bar{p} < 100$ —then although B will feel entitled to  $p$  and S to  $\bar{p}$ , the shading costs of aggrievement will be  $\theta (\bar{p} - p)$ ; this is less than the shading costs of  $100\theta$  that would arise if the contract were left until date 1.

Note that we are supposing that the *existence* of the date 0 market is not enough: B and S must embody the information from this market in a date 0 contract. We take the view that, if B and S pass up the opportunity to write a contract at date 0, then by the time date 1 arrives, the date 0 market has no particular salience, self-serving biases about individual values can come into play [see footnote 13], and the result will be argument, aggrievement, and shading. In effect, we are supposing that the contractual process itself is a key force in anchoring entitlements.

To the extent that the role of the contract is to embody and anchor entitlements, the fact that the contract is legally binding is perhaps of secondary importance. Much of our analysis goes through if the contract is viewed as a nonbinding agreement.<sup>20</sup> See

19. Note that we are ignoring “efficiency wage” considerations in our analysis. Regardless of date 0 market conditions, B might well think that it makes sense to offer S a price in excess of cost in order to encourage better performance (see, e.g., Shapiro and Stiglitz [1984]). However, note that efficiency wage ideas are not inconsistent with our approach. Our view is that, whatever the level of the price, it still makes sense for B and S to fix price in advance in order to avoid argument about the right price later.

20. However, legal enforcement may be important in ensuring perfunctory performance, including B paying S for goods or services received at date 1.

in particular the discussion of agreements to agree in Section III. Note, however, that the solemnity that accompanies the writing of a legally binding contract may help to give weight to the expectations and entitlements embodied in that contract.

The example analyzed in this section is very special because a date 0 contract that fixes price achieves the first-best. The first-best is no longer achievable if either (a)  $v$  and  $c$  are uncertain or (b) the nature of the good (the widget) is uncertain. We study case (a) in Section III and case (b) in Section IV.

### III. THE CASE WHERE VALUE AND COST ARE UNCERTAIN

In this section we consider the case where B wants one unit of a standard good—a widget—from S at date 1 but there is uncertainty about B's value  $v$  and S's cost  $c$ . This uncertainty is resolved at date 1. There is symmetric information throughout, so that  $v$ ,  $c$  are observable to both parties. However,  $v$  and  $c$  are not verifiable, and so state-contingent contracts cannot be written.

We make an important simplifying assumption. We suppose that trade occurs at date 1 if and only if both parties want it; that is, trade is voluntary. To put it another way, if no trade occurs an outsider (e.g., a judge) cannot tell whether this is because the seller refused to supply the widget or the buyer refused to accept it.<sup>21</sup> As a result, a party cannot be punished for breach of contract. We are confident that the main ideas of this section generalize to the case where specific performance is possible, but the details become more complicated.

Note that the model can also be interpreted as applying to the case where the parties write an "agreement to agree" at date 0. That is, suppose that the parties intend to use the date 0 agreement as a framework for future negotiation (this corresponds to the refinement process in Figure I), but for some reason are not yet ready to sign a binding contract. The usual legal presumption is that either party can opt out of such an agreement if future negotiations fail. Thus the voluntary trade assumption holds.<sup>22</sup>

In this setting the simplest kind of contract consists of a no-trade price  $p_0$  and a trade price  $p_1$ . Given the voluntary trade assumption, trade will occur ( $q = 1$ ) if and only if  $v - p_1 \geq -p_0$  and

21. This assumption is taken from Hart and Moore (1988).

22. On agreements to agree generally, and on whether they are binding in particular, see, for example, Corbin (1993, Chapters 2 and 4) and Farnsworth (1999, pp. 207–222).

$p_1 - c \geq p_0$ ; that is,

$$(7) \quad q = 1 \Leftrightarrow v \geq p_1 - p_0 \geq c.$$

From (7) it is clear that only the difference between  $p_1$  and  $p_0$  matters, and so, given the existence of lump-sum transfers, we can normalize  $p_0$  to be zero.<sup>23</sup>

It is worth comparing (7) to the first-best trading rule, given by

$$(8) \quad q = 1 \Leftrightarrow v \geq c.$$

Obviously, trade occurs less often under (7) than under (8).

We need to deal with one further issue before we proceed. After the uncertainty about  $v$  and  $c$  is resolved, suppose  $v > c$  but either  $v < p_1 - p_0$  or  $c > p_1 - p_0$ . At this stage, the parties might want to renegotiate their contract. Renegotiation does not fundamentally change our results and so, for the moment, we ignore it; we return to it in Section VI.

Because we want to allow for contractual flexibility, we shall wish to generalize beyond simple contracts. One way to introduce flexibility is to suppose that the contract specifies a no-trade price  $p_0$  and an interval of trading prices  $[p, \bar{p}]$ . Suppose for simplicity that B chooses the trade price at date 1. Then

$$(9) \quad q = 1 \Leftrightarrow \exists \underline{p} \leq p_1 \leq \bar{p} \quad \text{s.t.} \quad v \geq p_1 - p_0 \geq c.$$

In other words, trade occurs if and only if B can find a price in the range  $[\underline{p}, \bar{p}]$  such that the parties want to trade (B will choose the lowest such price). Actually, it is clear that the same trading rule (9) holds if S chooses  $p_1$  (S will choose the highest price in the range  $[\underline{p}, \bar{p}]$  that guarantees trade); moreover, the level of shading will be the same given that the parties have the same  $\theta$ . This feature—that the mechanism for choosing the outcome doesn't matter—is special to the model of this section: it will importantly not hold in the model of Section IV.

It follows from (9) that, again, only the difference between  $p_1$  and  $p_0$  matters, and so we can normalize  $p_0 = 0$  and rewrite (9) as

$$(10) \quad q = 1 \Leftrightarrow v \geq c, \quad v \geq \underline{p}, c \leq \bar{p}.$$

More general contracts than  $p_0 = 0$ ,  $p_1 = \text{some } p$  in  $[\underline{p}, \bar{p}]$  are in fact possible. For example, a contract could permit  $p_1$  to lie in

23. Of course, under the agreement-to-agree interpretation,  $p_0$  is necessarily zero.

some set other than an interval, or it could allow  $p_0$  and  $p_1$  both to vary. In the Appendix we show that (with a slight refinement of our assumptions) our main ideas extend to the case where a contract consists of an arbitrary set of  $(p_0, p_1)$  pairs and a mechanism—a game—for choosing among them.

Given a contract  $[\underline{p}, \bar{p}]$  (that is,  $p_0 = 0$ ,  $p_1 = \text{some } p \text{ in } [\underline{p}, \bar{p}]$ ), what determines aggrievement? Our hypothesis is that each party feels entitled to the best outcome permitted by the contract. However, each party also recognizes that, given the voluntary trade assumption, he or she cannot hope to obtain more than 100% of the gains from trade. This means that S feels entitled to  $p = \text{Min}(v, \bar{p})$  and B feels entitled to  $p = \text{Max}(c, \underline{p})$ . (Another way to think about it is that if S had complete control over the price but had to stick within the contract, she would choose  $p = \text{Min}(v, \bar{p})$ , and if B had complete control over the price but had to stick within the contract, he would choose  $p = \text{Max}(c, \underline{p})$ .) Thus aggregate aggrievement equals  $\{\text{Min}(v, \bar{p}) - \text{Max}(c, \underline{p})\}$ . An optimal contract maximizes expected surplus net of shading costs. (Lump-sum transfers are used to reallocate surplus.) Thus an optimal contract solves

$$(11) \quad \begin{aligned} & \text{Max}_{\underline{p}, \bar{p}} \int [v - c - \theta\{\text{Min}(v, \bar{p}) - \text{Max}(c, \underline{p})\}] dF(v, c), \\ & \quad v \geq c \\ & \quad v \geq \underline{p} \\ & \quad c \leq \bar{p} \end{aligned}$$

where  $F$  is the distribution function of  $(v, c)$ .

The trade-off is clear. A large interval  $[\underline{p}, \bar{p}]$  makes it more likely that trade will occur if  $v \geq c$ . (If  $\underline{p} = -\infty$ ,  $\bar{p} = \infty$ , the trading rule becomes the first-best one:  $q = \bar{1} \Leftrightarrow v \geq c$ .) However, it also increases expected shading costs.

We refer to a contract where  $\underline{p} = \bar{p}$  as a *simple* contract, and a contract where  $\underline{p} < \bar{p}$  as a *nonsimple* contract. We start off with some cases where the first-best is achievable with a simple contract.

**PROPOSITION 1.** A simple contract achieves the first-best if (i) only  $v$  varies; (ii) only  $c$  varies; or (iii) the smallest element of the support of  $v$  is at least as great as the largest element of the support of  $c$ .

The proof of Proposition 1 is immediate. If only  $v$  varies, choose a simple contract with  $p = c$ . If only  $c$  varies, choose a

simple contract with  $p = v$ . If (iii) holds, choose a simple contract with  $p$  between the smallest  $v$  and largest  $c$ .

In some cases one needs a nonsimple contract to achieve the first-best.

EXAMPLE 1. Suppose that there are two states of the world. In  $s_1$ ,  $v = 9$ ,  $c = 0$ . In  $s_2$ ,  $v = 20$ ,  $c = 10$ . In other words, either  $v$  and  $c$  are both low or they are both high:

	s1	s2
$v$	9	20
$c$	0	10

Obviously, one cannot get the first-best with a simple contract because there is no price  $p$  that lies both between 0 and 9 and between 10 and 20. However, a contract that specifies an interval of trading prices  $[9, 10]$  ( $\underline{p} = 9$ ,  $\bar{p} = 10$ ), with B choosing the price, does achieve the first-best. To see why, note that in  $s_1$  B will choose  $p = 9$  because this is the lowest available price. S will not be aggrieved because, even if S could choose the price, she would not pick a price above 9, given that this would cause B not to trade. In  $s_2$  B picks  $p = 10$  because this is the lowest price consistent with S being willing to trade. S is again not aggrieved because she couldn't hope for a higher price than 10, given that 10 is the highest available price. Thus, the contract,  $\underline{p} = 9$ ,  $\bar{p} = 10$  achieves trade in both states without any shading.

Note that in this example any price range smaller than  $[9, 10]$  would fail to generate trade in one of the states, and any price range larger than  $[9, 10]$  would cause aggrievement in at least one of the states.

We now turn to an example where the first-best cannot be achieved even with a nonsimple contract.

EXAMPLE 2. The example is the same as the previous one except that there is a third state,  $s_3$ , where  $v$  is high and  $c$  is low:

	s1	s2	s3
$v$	9	20	20
$c$	0	10	0



The first-best cannot be achieved because, to ensure trade in s1, s2, we need  $\underline{p} \leq 9$ ,  $\bar{p} \geq 10$ . But such a price range leads to aggrievement and shading in s3.

There are three possible candidates for a second-best optimal contract:

a.  $\underline{p} = \bar{p} = 9$ .

This contract yields trade in s1 and s3 but not in s2. Since there is nothing to argue about—the price is fixed at 9—there is no shading. Total surplus is given by

$$W_a = 9\pi_1 + 20\pi_3,$$

where  $\pi_1, \pi_3$  are the probabilities of s1, s3, respectively.

b.  $\underline{p} = \bar{p} = 10$ .

This contract yields trade in s2 and s3 but not in s1. Because there is nothing to argue about—the price is fixed at 10—there is no shading. Total surplus is given by

$$W_b = 10\pi_2 + 20\pi_3,$$

where  $\pi_2$  is the probability of s2.

c.  $\underline{p} = 9, \bar{p} = 10$ .

This contract yields trade in all three states, but there is aggregate aggrievement of 1 in s3. Total surplus is given by

$$W_c = 9\pi_1 + 10\pi_2 + (20 - \theta)\pi_3.$$

Obviously, which of these contracts is optimal depends on the probabilities  $\pi_1, \pi_2, \pi_3$ , and  $\theta$ . Contract (a) is optimal if  $\pi_2$  is small, contract (b) is optimal if  $\pi_1$  is small, and contract (c) is optimal if  $\pi_3$  or  $\theta$  is small.

The reader may wonder whether more general contracts than  $p_0 = 0, p \in [\underline{p}, \bar{p}]$ , can do better. In particular, can “Maskin mechanisms” help?<sup>24</sup> Maskin mechanisms are a way, in effect, of making observable information verifiable. Note that if the state were verifiable, it would be easy to achieve the first-best. For example, a contract that specified  $p = 9$  in s1 and s3 and  $p = 10$  in s2 would do the job since in each state there would be nothing to argue about. Call this contract (d).

In the Appendix we show that more general contracts do not help in our situation. Suppose that, as in a Maskin mechanism, each party reports the state of the world. If they agree, the price

24. See Maskin (1999).

is as in contract (d), say. If they disagree, something unpleasant happens. The problem is that in  $s_3$  S would like B to play the mechanism as if it were  $s_2$  and will be aggrieved by 1 if B refuses to go along with this. On the other hand, B will be aggrieved by 1 if S refuses to play the mechanism as if it were  $s_3$ . Either way, aggregate aggrievement in  $s_3$  is 1, which yields total surplus equal to  $W_c$ , as in contract (c). The general point is that under our assumptions aggrievement is determined by the entire set of terminal nodes of a mechanism, not just the equilibrium ones (see the Appendix for more details).<sup>25</sup>

It may be useful to talk more generally about state contingency (or, more accurately, lack of state contingency). Why can agreements between two parties who will both learn the state of the world not be made state contingent? In principle, one could imagine B and S having the following conversation at date 0 about contract (c). B could tell S that he will pay 9 at date 1 in all circumstances *unless* S will not trade at this price, in which case B will raise the price to 10. B could explain to S that she should not feel aggrieved in  $s_3$  when B does not raise the price to 10, because B said that he would stick with 9. To put it a little more formally, a contract that makes price a function of an observable but unverifiable state of the world should not cause aggrievement, because both parties observe the state and can see whether the other party is sticking to the contract.

There is no doubt that this argument has some force, and indeed it is not uncommon for contracting parties to have informal understandings about what to do if certain observable events occur, for example, it rains at the wedding. However, events such as the weather are pretty objective—indeed close to verifiable. We believe that state-contingent agreements are more problematic if, as in Example 2, the state in question is a (more) subjective value-cost pair. Subjectivity opens the door to differing interpretations. For example, between dates 0 and 1, S may convince herself that her skills or (unmodeled) actions contribute greatly to the trading opportunity at date 1. S may feel that she deserves to be rewarded

25. It is worth noting that, if third parties are permitted, the first-best can be achieved in Example 2. Consider a contract that fixes the trade price and makes both B and S pay a large amount to a third party in the absence of trade (i.e., the no-trade price is large and positive for B and large and negative for S). This leads to trade in all states, and no aggrievement, because the consequences of not trading are dire. However, this arrangement works only because trade is efficient in every state. In a more general example where trade is efficient in some states but not others, third parties do not guarantee the first-best. In what follows we ignore third parties.

for this (self-serving biases may be at work). Whatever speech B has made at date 0, B can, if he so chooses, recognize S's contribution by raising the price to 10; that is, this is consistent with the contract. In other words, B can pretend that S's cost is 10 even if it is not. If B refuses to recognize S's contribution and offers only 9, our assumption is that S will take this to be an ungenerous act and will respond by shading.<sup>26</sup>

This brings to a close our discussion of the case where parties induce flexibility by specifying a price range.<sup>27</sup> It is not clear how common this case is. One reason is that in practice the parties may be able to ensure trade when  $v$  and  $c$  vary through specific performance. Note, however, that price ranges are observed in the case of agreements to agree.<sup>28</sup> In the next section we consider a model where the uncertainty concerns the nature of the good to be provided. We will show that this model can shed light on the employment relationship.

#### IV. THE CASE WHERE THE NATURE OF THE GOOD IS UNCERTAIN

In this section we consider the case where there is uncertainty about the nature of the good or service B requires from S. For example, S might provide secretarial services for B, and B might not know in advance whether he wanted S to type letters or file papers. We will actually use a more colorful example. We will suppose that B is arranging an evening with friends and wants S to perform music. The nature of the music may depend on eventualities that will occur between dates 0 and 1, for example, who is coming to the evening, and what music S is rehearsing for other performances.

26. In reality there is a continuum of possibilities between completely verifiable states at one extreme and completely subjective states at the other. The more objective the state, the easier it is to avoid aggrievement by writing a state-contingent contract. We have simplified matters drastically by considering only the two extremes: verifiability, which permits the writing of state contingent contracts, and nonverifiability, which does not. In future work it would be desirable to explore the territory in between.

27. In the model of this section we have supposed that shading occurs only in the presence of trade. The no-trade/no-shade assumption can easily be relaxed, however. Proposition 1 continues to hold, but now it is easier to find cases where the first-best cannot be achieved. (In the following example we drop the assumption that a party feels entitled to no more than one hundred percent of the gains from trade.) Suppose that there are two states: in  $s_1$ ,  $v = 40$  and  $c = 30$  (trade is efficient); in  $s_2$ ,  $v = 10$  and  $c = 20$  (trade is inefficient). Under our previous assumptions a contract with  $p = 35$ , say, achieved the first-best because there was nothing to argue about in  $s_1$  and there was no trading or shading in  $s_2$ . Now any price  $30 \leq p < 40$  that allows trade in  $s_1$  causes S to be aggrieved in  $s_2$  (S loses money because B refuses to trade) and leads to shading. Thus the first-best cannot be achieved.

28. See, for example, Corbin (1993, Chapter 4.3); Ben-Shahar (2004, pp. 424–425).

TABLE I

	s1 (Prob $\pi_1$ )	s2 (Prob $(1 - \pi_1 - \pi_4)/2$ )	s3 (Prob $(1 - \pi_1 - \pi_4)/2$ )	s4 (Prob $\pi_4$ )
Bach	$(v, c)$	$(v, c)$	$(v - \Delta, c - \delta)$	$(v - \Delta, c - \delta)$
Shostakovich	$(v, c)$	$(v - \Delta, c - \delta)$	$(v, c)$	$(v - \Delta, c - \delta)$

To make matters as simple as possible, we will assume that there are two types of music/composers that it might be efficient for S to play: Bach and Shostakovich. In the Appendix we also allow for convex combinations of Bach and Shostakovich, but in the text we will not need to do this. Each composer can take on one of two value-cost combinations, given by  $(v, c)$  and  $(v - \Delta, c - \delta)$ , respectively, where  $v > v - \Delta > c > c - \delta$ ; that is, the value-cost supports of the composers overlap. (Everything is measured in money terms.) In other words, a composer can be “high value-high cost” or “low value-low cost.” We do not insist on stochastic independence of the two value-cost combinations, but we do impose symmetry; that is, the probability that Bach is “high value-high cost” and Shostakovich is “low value-low cost” is the same as the probability of the reverse. Thus, there are four states of the world (see Table I).

We start with the case  $\Delta > \delta$ . This implies that the high value-high cost composer yields more surplus than the low value-low cost composer and should be chosen whenever available. Thus the first-best has any music in states s1 and s4, Bach in s2, and Shostakovich in s3. Expected total surplus is  $W = v - c - \pi_4 (\Delta - \delta)$ .

What is the optimal second-best contract given that the state is observable but not verifiable? We continue to assume voluntary trade and set  $p_0 = 0$ . We also focus on contracts that deliver symmetric outcomes; that is, whatever composer occurs in s2, the “mirror image” composer occurs in s3, and the prices are the same in the two states.

It will simplify the presentation to start with the case  $\pi_1 = \pi_4 = 0$ , that is, s2 and s3 each occur with probability 1/2. We will see that this case is actually too simple, but it is useful for building up intuition.

There are four natural candidates for an optimal contract: no contract, a contract that fixes price and lets B choose the composer, a contract that fixes price and lets S choose the composer, and a contract that fixes price *and* composer. We consider these in turn.

a. No contract

The parties can always wait until date 1 to contract, by which time they will know whether s2 or s3 has occurred. They will then bargain over the division of surplus,  $v - c$ . The analysis is similar to that in Section II: whatever price between  $c$  and  $v$  is agreed to, the total amount of aggrievement will be  $(v - c)$ , and so shading costs will be  $\theta(v - c)$ . Hence net surplus is

$$W_a = (1 - \theta)(v - c).$$

b. A contract that fixes the price  $p$  so that  $c \leq p \leq v - \Delta$  and lets B choose the composer at date 1

Given that price is fixed, B will choose the highest value composer at date 1: Bach in s2, Shostakovich in s3. Because  $\Delta > \delta$ , this is the efficient choice. However, in each state, the seller will be aggrieved that B did not choose *her* favorite composer: Shostakovich in s2, Bach in s3. The seller will be shortchanged by  $\delta$ , the difference in the costs between the two composers, and so shading costs are  $\theta\delta$ . Total surplus is

$$W_b = v - c - \theta\delta.$$

c. A contract that fixes the price  $p$  so that  $c \leq p \leq v - \Delta$  and lets S choose the composer at date 1

Given that price is fixed, S will be inclined to choose the lowest cost composer at date 1, which is inefficient. B will be aggrieved by  $\Delta$ , the difference in value between his favorite composer and S's choice, and will shade so that S's payoff falls by  $\theta\Delta$ . Note that if  $\theta\Delta > \delta$ , S will be *worse* off than if she had chosen the high-cost composer, and so she will choose the high-cost composer after all; in effect, we are back to contract (b) (with S being aggrieved by  $\delta$  because she really wants to choose the low-cost composer). On the other hand, if  $\theta\Delta < \delta$ , S will stick with the low-cost choice, and the surplus is

$$W_c = v - \Delta - c + \delta - \theta\Delta.$$

d. A contract that fixes the price  $p$  so that  $c \leq p \leq v - \Delta$  and fixes the composer

Suppose the composer is fixed at Bach, say. This yields the efficient choice of composer half the time, and so the surplus is

$$W_d = \left(\frac{1}{2}\right)(v - c) + \left(\frac{1}{2}\right)(v - \Delta - c + \delta) = v - c - \left(\frac{1}{2}\right)\Delta + \left(\frac{1}{2}\right)\delta.$$

Note that there is no cost of shading in contract (d) because, with price and composer fixed, there is nothing to be aggrieved about.

How do contracts (a)–(d) compare? Because  $v - \Delta > c$  and  $\Delta > \delta$ , it is easy to see that  $W_b > W_a$ . (If  $\delta \simeq 0$ ,  $W_b \simeq v - c$ ; i.e., contract (b) achieves approximately the first-best.) Also, it is clear that  $W_b > W_c$  (in contract (c) the composer is less efficient than in (b) and there is more shading). So the choice is between contracts (b) and (d). Algebra tells us that (b) is better if and only if

$$(12) \quad \Delta > (1 + 2\theta)\delta.$$

The analysis so far is a little misleading. There is a contract that performs better than either (b) or (d), and in fact achieves the first-best. This contract is a variation of (b), in which the constraint  $c \leq p \leq v - \Delta$  is dropped. Specifically, consider the contract in which the price  $p = v$  and B chooses the composer. B will make the efficient choice in each state (as in contract (b)), but in addition S will not be aggrieved. The reason is that B exactly breaks even: any composer who is more favorable to S than Bach in s2 and Shostakovich in s3 would cause B to refuse to trade; that is, such a composer would violate B's participation constraint.

There is something very fragile about the contract just described. If there is any chance that B's value falls below  $v$ , it will lead to no trade. In the next proposition we return to the case where states s1 and s4 have positive probability. The proposition tells us that, as long as  $\pi_4$  is not too low, fixing  $p$  close to  $v$  is a bad idea. The proposition also requires  $\pi_1$  not to be too low in order to rule out subtle contracts that can also do better than (b) and (d). In the Appendix we establish formally the following result:

PROPOSITION 2. Assume that  $v > v - \Delta > c > c - \delta$ , and  $\Delta > \delta$ .

Suppose in addition that

$$\frac{\pi_4}{1 - \pi_1} \geq \frac{m}{(v - c - \Delta + \delta + m)},$$

where  $m = \min\{\theta\delta, (1/2)(\Delta - \delta)\}$ , and

$$\frac{\pi_1}{1 - \pi_4} \geq \frac{\delta}{\Delta + \delta}.$$

Then the optimal second-best contract fixes  $c \leq p \leq v - \Delta$ . In addition, if  $\Delta > (1 + 2\theta)\delta$ , B is given the right to choose

the composer, whereas, if  $\Delta < (1 + 2\theta)\delta$ , the parties fix the composer, at Bach, say.

Proposition 2 illuminates the different roles played by price and music in the model of this section. Price has no allocative role—its choice is a zero-sum game—and so, in order to avoid aggrievement, it is better to fix it in advance. Music does serve an allocative role and so, if  $\Delta/\delta$  is large or  $\theta$  is small, it makes sense to leave it open. Moreover, if  $\Delta/\delta$  is large or  $\theta$  is small, B should choose the composer because B will make an efficient choice, and, given that S cares relatively little, aggrievement will be low.

Note that there are two implicit assumptions underlying Proposition 2. First, aggregate uncertainty is small ( $v - \Delta > c$ ), and so price does not have to vary across the four states in order to ensure that both parties wish to trade, as it did in Section III. Second, there is no systematic relationship between composer and cost. In contrast, if Shostakovich, say, were on average costlier for S to play than Bach, then it would be optimal to have a higher price for Shostakovich than Bach in order to reduce S’s aggrievement in states where Shostakovich was chosen. In other words, a generalized version of the model can explain why price should vary with the service S provides if there are systematic differences in costs.<sup>29</sup>

Let’s now turn to the case where  $\Delta < \delta$ ; that is, the low-value-low-cost composer yields more surplus than the high-value-high-cost composer. The argument goes through as above except that now it is never optimal for B to choose the composer, but it may be optimal for S to choose the composer: Contract (c) may be optimal, but contract (b) is not. We have

PROPOSITION 3. Assume  $v > v - \Delta > c > c - \delta$ , and  $\Delta < \delta$ . Suppose in addition

$$\frac{\pi_1}{1 - \pi_4} \geq \frac{m'}{(v - c + m')}$$

29. It is worth revisiting our assumptions about aggrievement and shading at this point. Take contract (b), where price is fixed and B chooses the composer. Why is S aggrieved in s2 or s3 when B chooses the high-cost composer? In Sections II and III we offered one justification: S may feel that she has contributed to surplus and should be rewarded with the low-cost composer. Here we offer an alternative justification based on subjective views of valuation. Suppose that the state is s2. S can tell herself the following. It’s true that B thinks that Bach is worth  $\Delta$  more to him than Shostakovich, whereas the incremental cost to me is only  $\delta$ , and B therefore feels justified in choosing Bach. However, I, S, think that, even though B doesn’t realize this, the true value of Bach is close to  $v - \Delta$ . (Self-serving biases are behind this belief.) Given this, I do not think that B’s request is reasonable, and if he insists on Bach, I will respond by shading on performance.

where  $m' = \min\{\theta\Delta, (1/2)(\delta - \Delta)\}$ , and

$$\frac{\pi_4}{1 - \pi_1} \geq \frac{\Delta}{\delta + \Delta}.$$

Then the optimal second-best contract fixes  $c \leq p \leq v - \Delta$ . In addition, if  $\delta > (1 + 2\theta)\Delta$ , S is given the right to choose the composer, whereas, if  $\delta < (1 + 2\theta)\Delta$ , the parties fix the composer, at Bach, say.

We believe that Propositions 2 and 3 can throw light on a classic question: the nature of the employment relationship and the difference between an employee and an independent contractor. In early work, Coase (1937) and Simon (1951) argued that a key feature of the employment relationship is that an employer tells an employee what to do. This view was challenged by Alchian and Demsetz (1972), and the more recent literature has emphasized asset ownership as the distinguishing aspect of these relationships (see Grossman and Hart [1986] and Hart and Moore [1990]).<sup>30</sup> The current model allows us to return to the ideas of Coase and Simon. We interpret the case where B chooses the composer as an employment relationship and the case where S chooses the composer as independent contracting.<sup>31</sup> That is, if B hires S's musical services for the evening, with the understanding that B will tell S what to do, then S is working for B. In contrast, if B engages S to provide an evening of music, with the details of exactly how this is to be done left up to S, then S is an independent contractor.<sup>32</sup>

Propositions 2 and 3 tell us that when  $\theta$  is small, if B cares more about the composer, that is,  $\Delta > \delta$ , then employment is better (if  $\delta \simeq 0$ , an employment contract achieves approximately the first-best); whereas if S cares more about the composer, that is,  $\Delta < \delta$ , then independent contracting is better (if  $\Delta \simeq 0$ , independent contracting achieves approximately the first-best). In both cases it is optimal for the parties to fix the price in advance.

30. But see Wernerfelt (1997).

31. This notion of independent contracting differs from Simon's. Simon views independent contracting as corresponding to the case where the price and composer are both fixed.

32. The distinction between an employee and an independent contractor should not be taken too literally. An independent contractor will sometimes do what a buyer tells her to, and an employee sometimes will not. Still, in general terms, the notion that an employee is subject to the authority of a boss whereas an independent contractor is not seems valid. For a discussion, see, for example, Coase (1937, pp. 403–404).



Although these results are in the spirit of Coase and Simon, they differ from Simon's formal argument in important ways. Simon would also argue that B should choose the composer if B cares more about the composer than S. However, in Simon's model it is not clear why an *ex ante* contract is needed at all. Because his model has neither aggrievement nor noncontractible investment, the parties can rely on Coasian bargaining at date 1. Also, a contract that achieves the first-best in Simon's model is one where B has the right to make a take-it-or-leave-it offer to S; that is, B proposes a price-composer pair, and S can accept or reject it. In other words, in Simon's model there are many optimal contracts (a continuum, in fact), of which the employment contract is just one.

This is not true in our model. For example, consider the contract in which B offers a price-composer pair. B will suggest price equal to cost, and there will be aggrievement and shading in all states because S will feel entitled to price equal to value. Thus this contract performs strictly worse than the employment contract.

In other words a virtue of our model is that it can explain why, given  $\theta > 0$ , the employment contract is uniquely optimal when  $\Delta > \delta$  and  $\theta$  is small; why independent contracting is uniquely optimal when  $\Delta < \delta$  and  $\theta$  is small; and why in all the cases considered in this section it makes sense (in the absence of systematic cost differences across composers or tasks) for the parties to fix price *ex ante*, that is, to take price off the table.

## V. EXTERNAL REFERENCE POINTS

So far we have assumed that a prior contract is the only reference point for the transaction at date 1. In this section we relax this assumption. Our analysis is preliminary and speculative.

It is not difficult to think of situations where parties look outside a contract to determine whether they are being treated fairly. A familiar case is where someone is hired as an employee at a particular wage, and sometime later someone else with comparable or even inferior skills is hired by the same employer at a higher wage, perhaps because market conditions have changed. The first person will almost certainly feel unhappy about this even though his or her wage was determined fairly and competitively at the time.<sup>33</sup>

33. For an interesting discussion of this kind of phenomenon and its implications for labor market practices, see Akerlof and Yellen (1990). For evidence on the

One way to capture the idea of “external” reference points is as follows. Return to the model of Section III, where the parties trade a standard good, but there is uncertainty about  $v$  and  $c$ . Suppose that in each state of the world there is a range of “reasonable” prices for the good, determined exogenously, and given by  $[p_{\min}, p_{\max}]$ . The interpretation is that this range is based on comparable transactions: trades in other markets at date 1, prices of previous transactions, prices embodied in new contracts written between dates 0 and 1, etc. Any price between  $p_{\min}$  and  $p_{\max}$  can be justified to outsiders as being reasonable, whereas other prices cannot.<sup>34</sup>

In order to simplify matters, we will assume that the  $[c, v]$  and  $[p_{\min}, p_{\max}]$  intervals always intersect; that is, whenever  $v \geq c$ ,  $v \geq p_{\min}$  and  $c \leq p_{\max}$ . This assumption captures the idea that external reference points and internal value and cost are never too far apart.

The  $[p_{\min}, p_{\max}]$  range plays two roles. First, the range may affect entitlements in the *presence* of a contract. Second, the range may affect bargaining in the *absence* of a contract. Consider the first role. Suppose that the parties’ date 0 contract specifies the range of trading prices  $[\underline{p}, \bar{p}]$ . We saw in Section III that, on the basis of this, S feels entitled to receive  $\text{Min}(v, \bar{p})$  and B to pay  $\text{Max}(c, \underline{p})$ . We assume that the external reference points  $[p_{\min}, p_{\max}]$  modify these entitlements only if (i)  $p_{\min} > \text{Min}(v, \bar{p})$  or (ii)  $\text{Max}(c, \underline{p}) > p_{\max}$ . In the first case the price S feels entitled to receive is raised to  $p_{\min} (\leq v)$ , whereas in the second case the price B feels entitled to pay is lowered to  $p_{\max} (\geq c)$ .

In other words, S feels entitled to receive more than  $\text{Min}(v, \bar{p})$  if (and only if) all external prices lie above  $\text{Min}(v, \bar{p})$ , that is, everybody else in the market is receiving more, and B feels entitled to pay less than  $\text{Max}(c, \underline{p})$  if (and only if) all external prices lie below  $\text{Max}(c, \underline{p})$ , that is, everybody else in the market is paying less. Note that this formulation gives precedence to an existing contract in the sense that external reference points come into play only when contract prices are far apart from what’s going on elsewhere. In future work it would be interesting to explore alternative ways of modeling the interaction between external reference points and prior contracts.

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importance of external reference points and their effects on “shading” behavior by employees, see Babcock, Wang, and Loewenstein (1996).

34. We do not suppose that the  $[p_{\min}, p_{\max}]$  range is verifiable, however; hence it cannot be made part of an enforceable contract.

In summary, S feels entitled to receive  $\text{Max}(\text{Min}(v, \bar{p}), p_{\min})$  and B to pay  $\text{Min}(\text{Max}(c, \underline{p}), p_{\max})$ .

Let us continue with the case where the parties write a date 0 contract  $[\underline{p}, \bar{p}]$ . The trading rule is given by (10) and the expected surplus by

$$(13) \quad W = \int_{\substack{v \geq c \\ v \geq \underline{p} \\ c \leq \bar{p}}} [v - c - \theta\{\text{Max}(\text{Min}(v, \bar{p}), p_{\min}) - \text{Min}(\text{Max}(c, \underline{p}), p_{\max})\}] dF(v, c, p_{\max}, p_{\min}),$$

where we rewrite the distribution function  $F$  to reflect the fact that  $p_{\min}$  and  $p_{\max}$  can also depend on the state of the world. Note that (13) coincides with (11) when  $p_{\min} = -\infty$ ,  $p_{\max} = \infty$ . However, shading costs are higher than before when  $\bar{p} < p_{\min}$  or  $\underline{p} > p_{\max}$ . Otherwise the tradeoff between flexibility and rigidity is essentially as in Section III: a large  $[\underline{p}, \bar{p}]$  range makes it more likely that trade will occur, but also leads to more shading.

Matters become more interesting if the parties write no date 0 contract. This is where the second role of the external reference range  $[p_{\min}, p_{\max}]$  comes in. Previously we supposed that “no contract” was equivalent to setting  $\underline{p} = -\infty$ ,  $\bar{p} = \infty$ , that is, to a very flexible contract. However, we now take the view that when the parties bargain at date 1 in the absence of a date 0 contract, they never consider a price below  $p_{\min}$  or a price above  $p_{\max}$  because such prices look unreasonable to outsiders (they might not even be enforced by a court). In other words, it is as if the parties had written an initial contract with  $\underline{p} = p_{\min}$  and  $\bar{p} = p_{\max}$ : the parties bargain in the intersection of the  $[c, v]$  and  $[p_{\min}, p_{\max}]$  ranges, and S feels entitled to receive  $\text{Min}(v, p_{\max})$  and B to pay  $\text{Max}(c, p_{\min})$ . Given our simplifying assumption that  $v \geq p_{\min}$  and  $c \leq p_{\max}$  whenever  $v \geq c$ , trade will always occur when  $v > c$ , and so the expected surplus is given by

$$(14) \quad W = \int_{v \geq c} [v - c - \theta\{\text{Min}(v, p_{\max}) - \text{Max}(c, p_{\min})\}] dF(v, c, p_{\max}, p_{\min}).$$

It is easily seen that (14) is different from what is obtained by substituting  $\underline{p} = -\infty$ ,  $\bar{p} = \infty$  into (13). To emphasize the point, with external reference points, “no contract” is not the same as a highly flexible contract.

What determines the choice between writing a date 0 contract and writing “no contract,” that is, leaving things to date 1? It is good to write an *ex ante* contract if  $p_{\min}$  is small and  $p_{\max}$  is large. In particular, if  $p_{\min} = -\infty$  and  $p_{\max} = \infty$ , one can do at least as well as with “no contract” by writing a contract with  $\underline{p} = -\infty$ ,  $\bar{p} = \infty$  (compare (13) and (14)); and one can usually do better by limiting the  $[\underline{p}, \bar{p}]$  range. Another case where it is better to write a date 0 contract is where the range  $[p_{\min}, p_{\max}]$  does not vary with the state of the world—in this case, one can do at least as well as with no contract by setting  $\underline{p} = p_{\min}$ ,  $\bar{p} = p_{\max}$ .

What about cases where “no contract” is optimal? The leading one is where the range  $[p_{\min}, p_{\max}]$  is small. Under these conditions, trade always occurs when it is efficient (by assumption, a price can be found in the intersection of the  $[p_{\min}, p_{\max}]$  and  $[c, v]$  ranges whenever  $v \geq c$ ), and shading costs are low. For example, if  $p_{\min} = p_{\max} = \hat{p}$ , “no contract” achieves the first-best outcome.

A concrete example may be useful. Consider Example 1 of Section III. Suppose that  $p_{\min} = p_{\max} = \hat{p} = 4.5$  in  $s_1$  and  $p_{\min} = p_{\max} = \hat{p} = 15$  in  $s_2$ . Previously the date 0 contract  $\underline{p} = 9$ ,  $\bar{p} = 10$  achieved first-best. However, this is no longer true: in  $s_1$  B will feel aggrieved that he pays 9 rather than the (external) price 4.5, and so will shade by  $4.5\theta$ ; and in  $s_2$  S will feel aggrieved that she receives 10 rather than the (external) price 15, and so will shade by  $5\theta$ .

In contrast, “no contract” does achieve the first-best outcome. Under no contract, at date 1 B and S agree on a price of 4.5 in  $s_1$  and a price of 15 in  $s_2$ —there is nothing to argue about because  $p_{\min} = p_{\max}$ —and there is no grievement or shading in either state.

We conclude by mentioning a possible application of the model to explaining contract length. Take our example of a wedding that will occur in six months. In this case the range of reasonable catering prices  $[p_{\min}, p_{\max}]$  is plausibly quite large (there are many different types of weddings and caterers) and is unlikely to change much over the next six months. According to our analysis, this is a situation where it is better to write an *ex ante* contract rather than “no contract.” On the other hand, imagine that the wedding will occur five years from now. There may be a great deal of uncertainty

about future catering costs and future market prices for catering services (and the two may be highly correlated) and, to the extent that the latter acts as a reference point for entitlements, fixing a price, or a range of prices, now may create aggrievement with high probability. It may be better to take a wait-and-see attitude and postpone contracting. Combining the two cases, that is, considering a situation of two weddings, one in six months and the other in five years, yields the beginnings of a theory of contract length.

The above just skims the surface of what is potentially a very interesting and rich set of issues. We leave the details to future research.

## VI. RENEGOTIATION

We now relax the no-renegotiation assumption. We will in fact consider three views of the renegotiation process. We will see that our results are modified but not entirely changed by the possibility of renegotiation. We focus on the models of Sections III and IV.

One view of renegotiation is that, after the contract refinement process illustrated in Figure I occurs, the parties will always renegotiate to an efficient outcome, and that the parties will rationally anticipate this. How does this affect our analysis?

Start with the model of Section III. Suppose B and S write a contract consisting of the price range  $[p, \bar{p}]$ . Then after the uncertainty about  $v, c$  is resolved at date 1, it is possible that  $v > c$  and yet either  $v < \underline{p}$  or  $c > \bar{p}$ . In other words, trade is efficient but won't occur under the contract.

According to the first view of renegotiation, B and S will write a new contract. B will feel entitled to  $p = c$  and S to  $p = v$ . Total shading is  $\theta(v - c)$ , and net surplus is  $(1 - \theta)(v - c)$ . Note that renegotiation does not achieve the first-best given  $\theta > 0$ .

This alters the analysis a little. Take Example 2. Contract (c) is unchanged because no renegotiation occurs. However, the surplus in contracts (a), (b) rises. Under (a), renegotiation will take place if s2 occurs. Under (b), renegotiation will take place if s1 occurs. Thus total surplus under (a), (b) is now

$$W'_a = 9\pi_1 + 10(1 - \theta)\pi_2 + 20\pi_3,$$

$$W'_b = 9(1 - \theta)\pi_1 + 10\pi_2 + 20\pi_3.$$

Contract (a) or (b) might now beat contract (c) even if, in the absence of renegotiation, it did not.

How does this view of renegotiation affect the model of Section IV? Suppose  $\Delta > \delta$ . There were two candidates for an optimal contract, (b) and (d). In contract (b) price is fixed and B chooses the composer. In (d) both price and composer are fixed.

Contract (b) leads to an efficient *ex post* outcome (apart from shading), and so no renegotiation will occur. However, contract (d) leads to inefficiency in either s2 or s3, and so now renegotiation will occur in one of these states. For example, if the contract specifies Bach and s3 occurs, S will agree to switch to Shostakovich in return for a side payment. The gains from renegotiation are  $(\Delta - \delta)$ , and because there will be aggrievement about how these are split, a fraction  $\theta$  of them will be lost to shading.

One problem with this first view of renegotiation is that it makes a strong assumption about the renegotiation process and entitlements within a state. Consider the switch from Bach to Shostakovich in s3 in contract (d). It is supposed that S feels entitled at most to 100% of the surplus from the switch, that is, to an increase in price from  $p$  to  $p + \Delta$ , and B feels entitled at most to 100% of the surplus from the switch, that is, to an increase in price from  $p$  to  $p + \delta$ . But in principle B and S could use the renegotiation to demand even more: S could argue that, because price is “on the table,”  $p$  should move all the way up to  $v$ , and B could argue that the price should move all the way down to  $c$ . In other words, each party could demand 100% of *all* the surplus. (Recall the voluntary trade assumption: each party has the option to quit.) Moreover, each may feel aggrieved if he or she doesn’t get this.

We now consider a second view of renegotiation that allows for this possibility. It takes a “thin end of the wedge” approach. Suppose that if one party proposes a renegotiation involving a price change, then both parties recognize that any price change is now possible. Assume that the parties will agree to the renegotiation only if both parties are made better off. Then contract (d) will be renegotiated in s3 only if

$$(v - c)(1 - \theta) \geq v - c - \Delta + \delta,$$

which will not be satisfied if, say,  $\Delta \simeq \delta$ . We see that this second view of renegotiation puts some friction into the process: it

makes it less likely that the parties will switch from an inefficient composer to an efficient composer.

Note that this second view of renegotiation coincides with the first view for the model of Section III. The reason is that renegotiation occurs only if the contract leads to no trade, in which case all the surplus is up for grabs anyway.

In our opinion, both of the above views of renegotiation are rosy. Each view supposes that the possibility of changing price in one state will not affect parties' feelings of entitlement in other states. But this is questionable. Return to Example 2 in Section III. Under contract (a), the price is raised to at least 10 in  $s_2$  as a result of renegotiation. Given that price is flexible, why would S not feel entitled to a price change in  $s_3$ ? Of course, if S does think this way, then it is as if the contract specified that the price could be in (at least) the  $[9,10]$  range in the first place, and we are back to contract (c).

In our opinion, an intellectually more coherent position is that any flexibility in the trading price must be built into the initial contract (assuming an initial contract is written at all—see Section V). That is, one can set  $p = 9$  or  $p = 10$  or  $p \in [9, 10]$ , but one cannot set  $p = 9$  and then change it to  $p = 10$ .

Moreover, as we have discussed elsewhere, we believe that this position is consistent with legal practice and social custom.<sup>35</sup> The courts regard contract renegotiations with some suspicion and may overturn them if they believe that opportunism or duress has played a role. (Social attitudes and norms often mirror the law.) To this end, the courts require that renegotiation must be in “good faith,” but, because this is difficult to monitor, they will often substitute the requirement that the renegotiation can be justified objectively; for example, the price increases because the seller is supplying an additional service and her costs have risen.<sup>36</sup> In the model of Section III, no extra service is provided, and so there is no objective justification for a price change, say from  $p = 9$  to  $p = 10$ .<sup>37</sup> Similarly, there is no justification for a price change in the model of Section IV when S switches from Bach to Shostakovich,

35. See Hart and Moore (2004).

36. See Restatement (Second) of Contracts, Section 89(a)(1979); Muris (1981, particularly p. 530); Jolls (1997, pp. 228–301); Farnsworth (1999, pp. 276–295); and Shavell (2005).

37. In fact, without some constraint on price changes, a long-term contract would have little meaning. Almost every contract is incomplete in the sense that some *ex ante* noncontracted-for cooperation is required *ex post* for the contract to succeed. If each party can demand a large side payment for that cooperation

given that Shostakovich is not objectively (i.e., verifiably) more costly than Bach.

Under this third view of renegotiation, no renegotiation will occur at all in the models of Sections III and IV. Thus our preceding analysis holds.

## VII. SUMMARY AND CONCLUSIONS

In this paper, we have developed a theory of contracts based on the view that a contract provides a reference point for two parties' trading relationship. The idea is that a contract written early on when an external measure of the parties' contributions to the relationship was provided by competitive markets can continue to govern the parties' feelings of entitlement later when they become locked in to each other. The anchoring of entitlements in turn limits disagreement, aggrievement, and the dead-weight losses from shading. We have shown that our theory yields a trade-off between contractual rigidity and flexibility, provides a basis for long-term contracts in the absence of noncontractible investments, and throws light on the nature of the employment relationship. We have also shown that an extension of our theory that allows for external reference points can explain why parties sometimes deliberately write "no contract."

Our theory is based on strong assumptions. Before considering how these might be improved on and relaxed, let us say a little more about why we made them. In principle, one could study the trade-off between rigidity and flexibility using more traditional approaches. For example, standard rent-seeking arguments suggest that a flexible contract that "leaves money on the table" will generate inefficiency *ex post* as the parties fight over the surplus.<sup>38</sup> Similarly, influence-cost arguments suggest that mechanisms will be costly given that one party will waste resources trying to influence the other party's decision.<sup>39</sup> However, these theories suffer from the following weakness. If, as is usually supposed, *ex post* trade is perfectly contractible, why can the parties not negotiate around the wasteful rent-seeking and influence activities and move straight to the *ex post* efficient outcome (assuming symmetric information)?

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that is completely unrelated to costs—you want a glass of water that will cost you \$1,000—the initial contract will be vitiated.

38. See, for example, Tullock (1967).

39. See, for example, Milgrom (1988).



The main motivation for introducing shading, that is, for dropping the assumption that *ex post* trade is contractible, and for making associated behavioral assumptions is to avoid this conclusion.<sup>40</sup> In addition, our model is tractable and yields intuitive formulae for the costs of flexibility. For example, in Section IV, we saw that letting one party choose the outcome (the composer) will lead to little inefficiency if the other party is approximately indifferent about the choice. It is not clear that more traditional approaches generate such a simple (and we think reasonable) conclusion.

We should make it clear, however, that we are more than happy to consider alternatives in future work. We mention one. Consider a contract that admits two outcomes, *a* and *b*, and gives the buyer the right to choose between them. If the buyer prefers *a* and the seller *b*, the buyer may have to spend time persuading the seller of the reasonableness of the choice *a* in order to ensure consummate performance by the seller. These persuasion costs are a plausible alternative to the shading costs we have focused on. Modeling persuasion costs is not easy, but it is an interesting topic for future research.

Let us turn now to how our behavioral assumptions could be refined and relaxed. Our model has a number of “black box” features. We have made strong and somewhat *ad hoc* assumptions about entitlements, self-serving biases, and shading behavior. We have not derived these from first principles. Opening up the behavioral black box and showing that these assumptions are consistent with utility-maximizing behavior is an important topic for future research.

In advance of providing firmer microfoundations, it is worth asking how sensitive our results are to the particular behavioral assumptions we have made. Take the assumption that each party feels entitled to the best outcome permitted by the contract. An alternative specification would be that a party’s entitlement is based on his (rational) expectation of what he receives in equilibrium (along the lines of Koszegi and Rabin [2006]). This does not change the analysis that much as long as entitlements are based on variables specified in the contract, such as price. Consider Example 2. Under the flexible contract (c), *S* expects to be paid

40. But see Bajari and Tadelis (2001). Bajari and Tadelis consider a model of the trade-off between flexibility and rigidity, where rigidity, in the form of a fixed price, is good because it encourages efficient cost reduction by the seller *S*, but bad because it impedes *ex post* adjustment. Our model has *ex post* characteristics somewhat similar to those of Bajari and Tadelis’s but ignores *ex ante* incentives for cost minimization.

$9\pi_1 + 10\pi_2 + 9\pi_3$ , and so is aggrieved in  $s_3$  when she receives only 9. Thus there is shading and the first-best outcome is not achieved.<sup>41</sup> Note, however, that the analysis would change significantly if entitlements were defined relative to net payoffs. Then a contract in which B makes a take-it-or-leave-it offer to S will yield no aggrievement for S because S's net payoff is always zero, and so S is never disappointed. Given that B obtains all the gains from trade, it is plausible (and indeed we have assumed) that B is not aggrieved either. A model based on these behavioral assumptions would obviously not generate the trade-off between rigidity and flexibility analyzed here.

We have also supposed that shading by B and S is symmetric. As mentioned in the text, it is easier to think of examples of S's shading than of B's shading. One way to generalize our analysis is to suppose that the buyer's and seller's  $\theta$  parameters in equations (1) and (2) are different: if  $\theta_B < \theta_S$ , then B both desires and is able to shade less. If  $0 < \theta_B < \theta_S$ , we conjecture that it will still be optimal to restrict the range of prices in the model of Section III and to fix price in the model of Section IV. The main change is that seller control of price will be optimal in the Section III model, and seller control of the composer may be optimal in the Section IV model even if  $\Delta > \delta$ ; that is, independent contracting is more likely to be optimal when the buyer can't shade much.

It should be acknowledged that, if  $\theta_B = 0$ , that is, if B does not shade at all, the model as it stands collapses: the first-best outcome could be achieved by giving S the right to make a take-it-or-leave-it offer to B. S would choose the efficient price-output or price-quality combination, thereby extracting all the surplus, and, according to standard subgame perfection arguments, B would accept such an offer. Even in this case, there are ways to rescue the model. One possibility is to suppose that although B cannot shade, that is,  $\sigma_B = 0$ , B experiences aggrievement, that is,  $\theta_B > 0$  in equation (1), but B is forced to "eat" the aggrievement rather than being able to shift it to S. The total deadweight loss from a flexible contract will still be  $\theta_B a_B + \theta_S a_S$ , as in our model. This approach would bring us closer to that part of the literature that

41. A subtlety that arises under the Koszegi-Rabin formulation is that in some states parties will receive more than their entitlements. The model goes through as long as parties who receive more than their entitlements do not "overprovide" consummate performance to the point where this makes up for their perfunctory performance when they receive less than their entitlements. For some experimental/empirical evidence consistent with such an asymmetry, see Charness and Rabin (2002); Offerman (2002); and Mas (2006b).

emphasizes loss aversion.<sup>42</sup> A second possibility is to appeal to the ultimatum game literature, which argues that B will not accept S's offer unless S gives B a reasonable fraction of the surplus. Knowing this, S will allocate some of the surplus to B, but because S feels entitled to *all* the surplus, she will be aggrieved and will shade.<sup>43</sup>

A further assumption that we have made is that only the outcome and not the process matters for people's feelings of entitlement and well-being. This is strong. Take the employment contract in Section IV, in which the price is fixed and B has the right to choose the composer. If B chooses Bach in state  $s_2$ , which S doesn't like, S may nonetheless accept and not feel aggrieved about this choice, given that B had the *right* to make it. In other words, S might feel differently about the outcome "Bach" if it were the result of a previously agreed process than if the outcome were arrived at in some other way, for example, through bargaining.<sup>44</sup>

Generalizing the model to allow for the role of process is highly desirable. Note that we do not think that a well-designed process will completely eliminate the costs of flexibility. In the employment example, S is likely to accept Bach only if she views B's choice as "reasonable." Convincing S of this may be costly for B; see the above discussion of persuasion costs. Thus, our view is that an appropriately constructed model that allows for the role of process will still exhibit an interesting trade-off between contractual flexibility and rigidity.

In the Introduction we motivated the paper by pointing out some limitations of existing models of the firm. We believe that the model developed here can help to overcome some of those limitations and can be applied to organizational and contract economics more generally. We have used the model to understand the nature of the employment relationship and why parties deliberately write "no contract." We believe that there are many other possibilities. We end by mentioning a few of these. First, the model may throw light on the role of the courts in filling in the gaps of incomplete contracts. The idea is that a contractual term provided

42. See, for example, Kahneman and Tversky (1979).

43. There are at least two other ways to avoid the "first-best" conclusion when B cannot shade. One is to suppose that B must make an *ex ante* noncontractible investment, so that complete hold-up by S is undesirable. A second is to suppose that S is wealth constrained and so cannot compensate B in advance for the 100% of the surplus that S will obtain *ex post*.

44. We are grateful to Birger Wernerfelt and Klaus Schmidt for discussions on this issue.

by the parties may affect entitlements, whereas one provided by an outsider—the courts—may not. This may have efficiency consequences. Second, along related lines, the model may help to explain why parties choose not to index contracts to inflation in order to generate real wage flexibility. If real wages fall because prices rise, this can be blamed on an outsider—for example, the government—whereas if nominal wages are reduced by an employer, this may generate anger. Finally, the model of Section IV, extended from two to many people, may help us to understand how authority should be allocated, that is, who, out of a group of individuals, should be boss. We believe that this last application may be a useful step in allowing incomplete contracting ideas to be applied to the very interesting and important topic of the internal organization of firms.

#### APPENDIX

In this Appendix, first, we refine our assumption about what determines a party's level of grievement; second, we present a result giving circumstances under which we can restrict attention to contracts where the no-trade price  $p_0$  is zero and one party unilaterally chooses the terms of trade; third, we prove Proposition 2.

We assume that when he or she thinks how aggrieved to feel,

- A1. a party conjures with mixed strategies in the contractual mechanism (and with correlated strategies if the mechanism has simultaneous moves).
- A2. a party imagines a commitment to trade on the part of the other party, whatever the outcome of the randomization.

However, no one believes he or she can force the other party beyond the other party's participation constraint. Specifically, no one thinks he or she can push the other party's expected payoff below what the other party could get from simply refusing to trade.

To understand the role played by assumptions A1 and A2, look at a slight variant of Example 2 from Section III:

	s1	s2	s3
$v$	9	20	10
$c$	0	10	9

The only change is that in state s3 the  $(v, c)$  pair equals (10, 9) rather than (20, 0). All the analysis of contracts (a)–(c) from Section III still pertains, except that now they yield expected total

surpluses of

$$W_a = 9\pi_1 + \pi_3,$$

$$W_b = 10\pi_2 + \pi_3,$$

$$W_c = 9\pi_1 + 10\pi_2 + (1 - \theta)\pi_3,$$

respectively. As before, in general none of these contracts achieves first-best.

Consider a contract with holes in which  $p_0 = 0$  and B chooses  $p_1$  from a set of three discrete prices,  $\{8 \frac{1}{2}, 9 \frac{1}{2}, 10 \frac{1}{2}\}$ . Without assumptions A1 and A2, this contract achieves first-best because in each state only one  $p_1$  out of the three allowable prices delivers trade (remember that trade is voluntary, so each party has to be better off than not trading at  $p_0 = 0$ ). But, given assumptions A1 and A2, there will be aggrievement and hence shading in state s3. When B chooses  $p_1 = 9 \frac{1}{2}$ , S feels aggrieved that B did not choose a 50:50 lottery between  $p_1 = 9 \frac{1}{2}$  and  $p_1 = 10 \frac{1}{2}$ , with B committing to trade whatever the outcome of the lottery. The 50:50 odds are such that before the lottery, B would be no worse off than not trading, given that he values the widget at 10. At a price of  $9 \frac{1}{2}$ , then, S feels aggrieved by  $\frac{1}{2}$ . Equally, B feels aggrieved by  $\frac{1}{2}$  too. Even though he has the contractual right to choose  $p_1$ , and chooses  $9 \frac{1}{2}$ , he would prefer to choose a 50:50 lottery between  $p_1 = 8 \frac{1}{2}$  and  $p_1 = 9 \frac{1}{2}$ , with S committing to trade whatever the outcome: before the lottery, S would be no worse off than not trading, given that the widget costs her 9. In aggregate, shading in state s3 amounts to  $(\frac{1}{2} + \frac{1}{2})\theta$ , which is the same as under contract (c) in Section III. Worse, in state s1, when B chooses  $p_1 = 8 \frac{1}{2}$ , S feels aggrieved that B did not choose a 50:50 lottery between  $p_1 = 8 \frac{1}{2}$  and  $p_1 = 9 \frac{1}{2}$ , with B committing to trade whatever the outcome, so that in this state there is shading. Similarly, there is shading in state s2. All in all, thanks to assumptions A1 and A2, our contract “with holes” is strictly dominated by contract (c).

If the no-trade price  $p_0$  varies with the strategies, and cannot simply be normalized to zero, then it is a little less obvious how participation constraints should be factored into the parties’ thinking. Consider a contract in which B chooses  $(p_0, p_1)$  from a set of three pairs:  $(1, 9)$ ,  $(\frac{1}{2}, 9 \frac{1}{2})$ , or  $(0, 10)$ . What would happen if either party refused to trade? B would minimize  $p_0$  by choosing  $(p_0, p_1) = (0, 10)$ . So, in reckoning how low he or she can push the other’s payoff, each party thinks in terms of a default no-trade

price of  $p_0^* = 0$ . Precisely,  $p_0^*$  is the right-hand side (RHS) of S's participation constraint; and  $(-p_0^*)$  is the RHS of B's participation constraint. Knowing this, we can invoke assumptions A1 and A2 to calculate aggrievement levels in each state. In particular, in state s3, B chooses  $(p_0, p_1) = (1/2, 9\ 1/2)$  but is actually aggrieved by  $1/2$  because he would prefer to choose  $(p_0, p_1) = (1, 9)$ , with S committing to trade—this would not violate S's participation constraint given  $p_0^* = 0$ . S is also aggrieved by  $1/2$  because she would prefer B to choose  $(p_0, p_1) = (0, 10)$  and commit to trade. In aggregate, shading in state s3 amounts to  $(1/2 + 1/2)\theta$ —the same as under contract (c). One can show that our contract delivers the same total surplus as contract (c) in states s1 and s2 too.<sup>45</sup>

But this raises the question: what might a more general contract be able to achieve? Below, we present Proposition 4 giving circumstances under which nonzero values of  $p_0$  do not help and we can restrict attention to contracts where one party unilaterally chooses the terms of trade.

A general contract C can be viewed as a stochastic mechanism mapping from a pair of messages  $\beta$  and  $\sigma$ , reported by B and S, respectively, onto *either* a pair of (no-trade, trade) prices,  $(p_0, p_1)$ , or onto simply a no-trade price,  $p_0$ . In other words, following the report of messages  $\beta$  and  $\sigma$ , there is an exogenous lottery to determine (i) if trade is allowed or not; (ii) the terms of trade/no-trade. If trade is allowed then it occurs if and only if both parties want it (at price  $p_1$ ). Otherwise, there is no trade (at price  $p_0$ ). (Remember that we are assuming no renegotiation, so if the mechanism specifies no trade then that outcome is final.)

In effect, then, a mechanism allows probabilistic trade—a surrogate for fractional trade (our widget is assumed to be indivisible).

Under contract C,  $p_0^*$  (the default no-trade price used to determine the RHSs of the parties' participation constraints)

45. If we do not invoke assumptions A1 or A2, our contract looks attractive. It could be argued that because B is choosing the pair  $(p_0, p_1)$ , he is never aggrieved. And the contract has been designed so that in state s3 S is aggrieved by only  $1/2$ . She would increase her payoff by  $1/2$  if, instead of B choosing  $(p_0, p_1) = (1/2, 9\ 1/2)$  leading to trade at  $p_1 = 9\ 1/2$ , B were to choose  $(p_0, p_1) = (1, 9)$  leading to no trade at  $p_0 = 1$ ; equally, S would increase her payoff by  $1/2$  if B were to choose  $(p_0, p_1) = (0, 10)$ , leading to trade at  $p_1 = 10$ . Shading in state s3, then, amounts to  $(1/2)\theta$ —half that under contract (c). Likewise, in state s1 there is shading of  $(1/2)\theta$  because S would prefer B to choose  $(p_0, p_1) = (1/2, 9\ 1/2)$  leading to trade at  $p_1 = 9\ 1/2$ ; and in state s2 there is shading of  $\theta$  because S would prefer B to choose  $(p_0, p_1) = (1, 9)$  leading to no trade at  $p_0 = 1$ . Overall, expected total surplus from our contract is  $(9 - [1/2]\theta)\pi_1 + (10 - \theta)\pi_2 + (1 - [1/2]\theta)\pi_3$ , which means that if, for example,  $\pi_1 + 2\pi_2 < \pi_3$  and  $\theta = 1$ , our contract would dominate contracts (a), (b), and (c) in Section III.

is the value of the zero-sum game over the  $p_0$ 's specified in the mechanism—under the supposition that one or other party “quits,” that is, always chooses to veto trade, so that the specified  $p_1$ 's are irrelevant. Let  $(\tilde{\beta}^*, \tilde{\sigma}^*)$  be the (possibly mixed) equilibrium strategies of this zero-sum message game.

We consider, for each state  $(v, c)$ , a (possibly mixed strategy) subgame perfect equilibrium of the game induced by contract C. Let  $q(v, c)$  be the probability of trade in equilibrium, and  $p(v, c)$  the expected payment from B to S. Because trade is voluntary,  $q(v, c) > 0$  only if  $v \geq c$ . If there is more than one equilibrium, we pick the one that maximizes  $q(v, c)$ .

No party is worse off than if he or she quit:

LEMMA.

$$\begin{aligned} vq(v, c) - p(v, c) &\geq -p_0^*, \\ p(v, c) - cq(v, c) &\geq p_0^*. \end{aligned}$$

*Proof.* Consider B. In state  $(v, c)$  he could deviate from his equilibrium message-reporting-cum-trading strategy to report  $\tilde{\beta}^*$  and always refuse to trade. Were he to do so, his payoff would (weakly) drop from  $vq(v, c) - p(v, c)$  to, say,  $(-\hat{p}_0)$ , where  $\hat{p}_0$  is the ensuing (expected) no-trade price. But  $\hat{p}_0$  cannot be strictly more than  $p_0^*$ , because  $\tilde{\sigma}^*$  is a best reply to  $\tilde{\beta}^*$  for S in the zero-sum game over the  $p_0$ 's. This proves the first inequality in the Lemma. The second follows symmetrically—reversing the roles of B and S. QED

For future reference, let  $H \subseteq [0, 1] \times R$  denote the convex hull of  $(0, 0)$  and all pairs  $\{q(v, c), p(v, c) - p_0^*\}$ , where, notice, we are netting prices by subtracting  $p_0^*$ . In the space of quantity ( $q$ ) and net price ( $p - p_0^*$ ), the set H might look as shown in Figure A.I.

Invoking assumptions A1 and A2, in state  $(v, c)$  we define B's [resp. S's] “aspiration level”  $b(v, c)$  (resp.  $s(v, c)$ ) to be his (resp. her) maximum payoff across all correlated message pairs and trading rules, subject to the constraint that S [resp. B] gets no less than  $p_0^*$  [resp.  $(-p_0^*)$ ].

In particular, B and S each imagine that they could jointly pre-commit to the (mixed) message-cum-trading equilibrium strategies pertaining to some other state, or some convex combination thereof. Hence

$$(15) \quad b(v, c) \geq \max_{q,p} \{vq - p \mid (q, p - p_0^*) \in H \text{ and } p - cq \geq p_0^*\},$$

$$(16) \quad s(v, c) \geq \max_{q,p} \{p - cq \mid (q, p - p_0^*) \in H \text{ and } vq - p \geq -p_0^*\}.$$

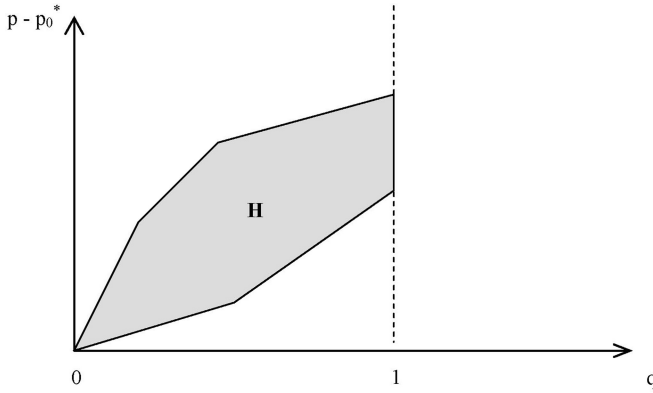


FIGURE A.I

Note that, thanks to the lemma,

$$\begin{aligned}
 b(v, c) &\geq vq(v, c) - p(v, c), \\
 s(v, c) &\geq p(v, c) - cq(v, c);
 \end{aligned}$$

that is, aspiration levels are at least as high as equilibrium pay-offs.

In each state  $(v, c)$ , once equilibrium play is over, B shades by reducing S's payoff down to

$$p(v, c) - cq(v, c) - \theta\{b(v, c) - [vq(v, c) - p(v, c)]\}.$$

And S shades by reducing B's payoff down to

$$vq(v, c) - p(v, c) - \theta\{s(v, c) - [p(v, c) - cq(v, c)]\}.$$

Hence, in the special case  $\theta = 1$  (the case considered in Proposition 4 below), total surplus in this equilibrium equals

$$(17) \quad 2(v - c)q(v, c) - b(v, c) - s(v, c).$$

Now consider contract  $\hat{C}$ , in which  $p_0 \equiv 0$  and one party (say B—it doesn't matter who) chooses from a set of exogenous lotteries, each corresponding to a different point  $(q, p) \in H$ :

$$\left\{ \begin{array}{l} \text{with probability } q, \text{ trade is allowed at } p_1 = \frac{p}{q}, \\ \text{with probability } 1 - q, \text{ trade is not allowed.} \end{array} \right.$$

At first sight contract  $\hat{C}$  may look a little strange, but that is because it is dealing with probabilistic trade. Note that for



$q = 1$ —corresponding to the right-hand edge of the set  $H$  in Figure A.1—contract  $\hat{C}$  is nothing more than our “standard” contract in which B chooses a trading price  $p_1$  from an interval  $[p, \bar{p}]$ . To put this another way, if the upper and lower edges of the set  $H$  in Figure A.1 were linear rather than piecewise linear,  $H$  would correspond to a standard contract.

PROPOSITION 4. Suppose  $\theta = 1$ . Then contract  $\hat{C}$  yields at least as much total surplus in each state as does contract C.

*Proof.* Under contract  $\hat{C}$ , in state  $(v, c)$ , B’s aspiration level is

$$\begin{aligned} \hat{b}(v, c) &= \max_{q,p} \{vq - p \mid (q, p) \in H \text{ and } p - cq \geq 0\} \\ (18) \quad &\leq p_0^* + b(v, c) \end{aligned}$$

by (15). And S’s aspiration level is

$$\begin{aligned} \hat{s}(v, c) &= \max_{q,p} \{p - cq \mid (q, p) \in H \text{ and } vq - p \geq 0\} \\ (19) \quad &\leq -p_0^* + s(v, c) \end{aligned}$$

by (16). In each state  $(v, c)$ , B chooses the lottery corresponding to a point  $(q, p) \in H$  to maximize his net payoff (i.e., net of S’s shading), taking into account that S may not be willing to trade at

$$p_1 = \frac{p}{q}$$

for  $q \neq 0$ . That is, given  $\theta = 1$ , B chooses  $(q, p) \in H$  to maximize

$$vq - p - \{\hat{s}(v, c) - [p - cq]\} \quad \text{subject to } p - cq \geq 0.$$

If  $v > c$ , in effect B will maximize the probability of trade,  $q$ , subject to  $(q, p) \in H$  for some  $p \geq cq$ . Call this maximum  $\hat{q}(v, c)$ . But from the definition of the set  $H$ ,

$$(q(v, c), p(v, c) - p_0^*) \in H;$$

and from the second inequality in the lemma,

$$p(v, c) - p_0^* \geq cq(v, c).$$

Hence  $\hat{q}(v, c)$  is at least  $q(v, c)$  whenever  $v > c$ .

If  $v < c$ , B will choose  $(q, p) = (0, 0)$ ; in this case set  $\hat{q}(v, c) = 0$ .

Combining these two cases, we have

$$(20) \quad (v - c)[\hat{q}(v, c) - q(v, c)] \geq 0 \text{ in all states } (v, c).$$

Just as total surplus in state  $(v, c)$  was given by expression (17) under contract  $C$ , so too under contract  $\hat{C}$  it is given by

$$(21) \quad 2(v - c)\hat{q}(v, c) - \hat{b}(v, c) - \hat{s}(v, c).$$

But, making use of inequalities (18)–(20), we see that the expression in (21) is no less than that in (17). QED

In words, Proposition 4 states that, without loss of generality,  $p_0$  can be normalized to zero and one party (B, say) can be given control over the terms of trade. The subset  $H$  of  $[0, 1] \times R$  is the “design variable.” It is this set that the contract specifies, taking any shape (along the lines of that in Figure A.1)—but it must be convex and, for  $q = 0$ , come to a point at the origin (i.e., when  $q = 0$ ,  $p = p_0^* = 0$ ).

Of course, the weakness of this result is that it applies only to the limit case  $\theta = 1$ . However, Proposition 4 is suggestive of other, more general results. For example, it may be quite general that assumptions A1 and A2 are enough to allow us to ignore the possibility of nonzero values of  $p_0$ . The proposition as it stands may apply if  $\theta$  is close enough to 1. And for lower values of  $\theta$ , somewhat more complex allocations of control rights over the terms of trade (not merely giving unilateral control to either B or S) may turn out to be optimal. All this awaits further research. Meantime, the proposition gives us some reassurance that, by restricting attention (as we do in Section III) to standard contracts in which  $p_0 = 0$  and B chooses  $p_1$  from an interval  $[p, \bar{p}]$ , we are not missing out on some sophisticated contract that achieves first-best.

We now turn to Section IV and the proof of Proposition 2. Think of composers as lying in the  $[0, 1]$  interval, with  $\lambda = 0$  corresponding to Bach and  $\lambda = 1$  corresponding to Shostakovich. In state  $s_2$ , the value of composer  $\lambda$  to B is  $v - \lambda\Delta$ , and the cost to S is  $c - \lambda\delta$ . (That is,  $\lambda$  is equivalent to a convex combination of Bach and Shostakovich.) In state  $s_3$ , the value of  $\lambda$  to B is  $v - (1 - \lambda)\Delta$ , and the cost to S is  $c - (1 - \lambda)\delta$ . We restrict attention to deterministic contracts in which the no-trade price is zero.

As a preliminary, we should observe that if no music is played in state  $s_4$ , then in the other three states the first-best could be achieved using a contract that fixes the price at  $v$  and has B choose the composer. In state  $s_2$ , B would choose  $\lambda = 0$  (as first-best requires), but there would be no aggrievement on the part of S, because at price  $v$  no other composer would satisfy B’s participation constraint. Likewise, in state  $s_3$ , B would choose

$\lambda = 1$  and there would be no aggrievement. In state s1, there would be no aggrievement either (B could choose any composer). At this high price B would be unwilling to trade in state s4. Overall, expected total surplus would be  $(1 - \pi_4)(v - c)$ . For small enough  $\pi_4$ , this would be the optimal contract. But we see this as a peculiar case, which we can later confirm is ruled out if  $\pi_4/(1 - \pi_1)$  is above the lower bound in Proposition 2. (Incidentally, this is the role of state s4 in the model when  $\Delta > \delta$ . State s1 plays an analogous role when  $\Delta < \delta$ .)

From now on, we suppose that music *is* played in state s4, at price  $p_4$ , which must lie at or below B's value,  $v - \Delta$ . It is straightforward to confirm that in states s1, s2, and s3, music is also played under an optimal contract. In state s2, suppose composer  $\lambda_2$  is played at price  $p_2$ . We restrict attention to symmetric contracts, so that in state s3 composer  $1 - \lambda_2$  is played at price  $p_2$ .

The method we will use to characterize an optimal contract is to include in our mathematical program only those constraints that are critical. At the end, we will need to confirm that the (many) missing constraints are satisfied. In particular, for now we shall ignore the question of how to implement a particular choice of composer and price in each state (e.g., should B or S have control, or is a more sophisticated mechanism needed?).

Let  $a_2$  be the total level of aggrievement (B's plus S's) in state s2 when  $\lambda_2$  is played at price  $p_2$ . (By symmetry,  $a_2$  is also the total level of aggrievement in state s3.) Now S may prefer to switch from composer  $\lambda_2$  to composer  $1 - \lambda_2$  at the same price  $p_2$  (which *is* admissible in the contract, because that is what occurs in state s3), to reduce her costs from  $c - \lambda_2\delta$  to  $c - (1 - \lambda_2)\delta$ , unless this switch would violate B's participation constraint,  $v - (1 - \lambda_2)\Delta - p_2 \geq 0$ , in which case the best S could wish for is to switch to composer  $(v - p_2)/\Delta$  at price  $p_2$  and reduce her costs from  $c - \lambda_2\delta$  to  $c - ((v - p_2)/\Delta)\delta$  (the intermediate composer is equivalent to a suitable lottery of composers  $\lambda_2$  and  $1 - \lambda_2$ , and we appeal to assumptions A1 and A2). Thus

$$(22) \quad a_2 \geq \delta \min \left\{ 1 - 2\lambda_2, \frac{v - p_2}{\Delta} - \lambda_2 \right\}.$$

Let  $a_1$  be the total level of aggrievement in state s1, where all composers cost  $c$  and yield value  $v$ . We know that  $p_2$  cannot strictly exceed  $v$ ; but suppose  $p_2 \geq v - \Delta$ . Then, given that  $p_4 \leq v - \Delta$ , any price in the interval  $[v - \Delta, p_2]$  is contractually feasible

(with a suitable lottery). Invoking assumptions A1 and A2, we therefore have

$$(23) \quad a_1 \geq p_2 - v + \Delta.$$

If  $p_2 < v - \Delta$ , the inequality (23) still holds: the RHS is negative.

If  $a_4$  is the total level of aggrievement in state  $s_4$ , consider the relaxed program: Choose  $\lambda_2, p_2, a_1, a_2$ , and  $a_4$  to maximize

$$(24) \quad \begin{aligned} W \equiv & \pi_1[v - c - \theta a_1] + (1 - \pi_1 - \pi_4)[v - c - \lambda_2(\Delta - \delta) - \theta a_2] \\ & + \pi_4[v - c - \Delta + \delta - \theta a_4] \end{aligned}$$

subject to (22), (23), and the constraint that total aggrievement is always nonnegative:

$$(25) \quad a_1 \geq 0, \quad a_2 \geq 0, \quad a_4 \geq 0.$$

In a solution to this relaxed program, the tighter of the lower bound constraints on  $a_1$  will bind. Likewise for  $a_2$ . And  $a_4 = 0$ .

Now consider the role of  $p_2$ , which affects  $W$  in (24) only via  $a_1$  and  $a_2$ . Via  $a_1$ , the slope of  $W$  with respect to  $p_2$  is  $(-\pi_1\theta)$  if  $p_2 \geq v - \Delta$ , and is zero otherwise. Via  $a_2$ , the slope of  $W$  with respect to  $p_2$  is at most  $(1 - \pi_1 - \pi_4)\theta\delta/\Delta$ , and is zero if  $p_2 < v - (1 - \lambda_2)\Delta$ . Hence, from the lower bound on  $\pi_1/(1 - \pi_4)$  in Proposition 2,  $p_2$  should be as small as possible. However, there is no merit in pushing  $p_2$  below  $v - \Delta$ , because this would not affect  $W$ .

Next, consider the role of  $\lambda_2 \in [0, 1]$ , given  $p_2 = v - \Delta$ . Now  $\lambda_2$  affects  $W$  only through the middle term in (24), and via  $a_2$ . Values of  $\lambda_2$  above  $1/2$  are clearly not optimal. If  $\Delta > (1 + 2\theta)\delta$ ,  $\lambda_2$  should be zero, whereas if  $\Delta < (1 + 2\theta)\delta$ ,  $\lambda_2$  should equal  $1/2$ . These are two conditions that appear in Proposition 2.

Where does this leave us? On the one hand, if  $\Delta > (1 + 2\theta)\delta$  we can implement the above solution to the relaxed program (viz.,  $p_2 = v - \Delta$ ,  $\lambda_2 = 0$ ,  $a_1 = a_4 = 0$ , and  $a_2 = \delta$ ) using a contract in which the price is fixed at  $v - \Delta$  and B chooses the composer. (Actually, any fixed price between  $c$  and  $v - \Delta$  would yield the same  $W$ .) On the other hand, if  $\Delta < (1 + 2\theta)\delta$ , we can implement the solution (viz.,  $p_2 = v - \Delta$ ,  $\lambda_2 = 1/2$ , and  $a_1 = a_2 = a_4 = 0$ ) using a contract in which the price is again fixed at  $v - \Delta$ , but so too is the composer, at  $\lambda_2 = 1/2$ . (Actually in this latter case, it does not matter which composer is fixed; it could instead be Bach,  $\lambda_2 = 0$ .) The fact that in all cases the solution to the relaxed program can be implemented using *some* contract vindicates our earlier decision to ignore the implementation constraints.

Proposition 2 is proved.

QED

The reader may wonder why the auxiliary condition  $\pi_1/(1 - \pi_4) \geq \delta/(\Delta + \delta)$  is needed in Proposition 2. Consider the following variant of a simple employment contract: the basic wage is  $v - \Delta$  in return for performing  $\lambda = 1/2$ , but B can pay a supplement  $\Delta/2$  in return for asking S to perform some other  $\lambda$  in  $[0, 1]$ . In states  $s_1$  and  $s_4$ , B will pay the basic wage only and  $\lambda = 1/2$  will be performed. And in state  $s_2$  [resp.  $s_3$ ], B will pay the supplement and ask S to perform  $\lambda = 0$  [resp.  $\lambda = 1$ ]—note that without factoring in the impact of shading by S, B is indifferent about paying the supplement in states  $s_2$  and  $s_3$ , but it can be checked that S shades even more if B does not pay it. In each of states  $s_1$ ,  $s_2$ , and  $s_3$ , S would wish that B had paid the supplement and asked her to perform  $\lambda = 1/2$ . So she is aggrieved by  $\Delta/2$  in state  $s_1$  and by  $\delta/2$  in states  $s_2$  and  $s_3$ . (In state  $s_2$ , it would be unreasonable for S to wish that B had asked her to perform any  $\lambda > 1/2$  because that would violate B's participation constraint. Similarly, in state  $s_3$ , any  $\lambda < 1/2$  would be unreasonable.) In state  $s_4$ , S cannot wish that B pay more than his value,  $v - \Delta$ , so there is no aggrievement. Overall, then, the contract yields expected total surplus

$$\pi_1[v - c - \theta(\Delta/2)] + (1 - \pi_1 - \pi_4)[v - c - \theta(\delta/2)] + \pi_4[v - c - \Delta + \delta].$$

This can be strictly greater than the expected total surplus yielded by any simple employment contract if the auxiliary condition  $\pi_1/(1 - \pi_4) \geq \delta/(\Delta + \delta)$  is not satisfied. For example, if  $v = 20$ ,  $c = 10$ ,  $\Delta = 6$ ,  $\delta = 2$ ,  $\pi_1 = 0.1$ , and  $\pi_4 = 0.5$ , then the above contract yields an expected total surplus  $8 - (7\theta/10)$ , whereas the best simple employment contract (viz., B chooses any  $\lambda$ , and the wage is fixed at  $v - \Delta$ ) yields only  $8 - (4\theta/5)$ .

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