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# SIDE-CONTRACTING IN ECONOMIC RELATIONSHIPS: LEGAL SOLUTIONS

Christine M. Jolls*

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Harvard Law School
Cambridge, MA 02138

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*J.D. Candidate, Harvard Law School, and Economics Ph.D. Candidate, M.I.T.

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## ABSTRACT

Economics work on contracting has focused on characterizing optimal incentive contracts for parties in various economic relationships. Recently, several authors have pointed out that subsets of the original set of parties to a contract may find it profitable to enter into side contracts among themselves once the original contract is in place. Such side contracts often alter contractors' incentives in a way that disrupts the operation of otherwise optimal incentive schemes. This paper argues, however, that examination of the side-contracting problem in light of contract and other bodies of law suggests that the case for concern about side-contracting has been overstated. On the one hand, if side-contracting is thought to be sustained by entry into legally enforceable contracts, then the side-contracting problem either is solved by existing legal rules or is solvable by the parties under the rules of contract law. On the other hand, if side-contracting is thought to be sustained by reputation effects, then existing legal rules may well deter side-contracting and, moreover, in a reputational environment side-contracting very often will not arise in the first place. The paper's formal economic analysis focuses on a model of a business partnership, but other settings, including those examined in previous work, are discussed as well.


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## I. Introduction

Economics work on contracting has focused on characterizing optimal incentive contracts for parties in various economic relationships. The traditional approach implicitly assumes that only the original contract between the parties affects their incentives. One consequence is that the traditional approach ignores the possibility of "side-contracting" -- contracting among subsets of the set of parties to the original contract once this original contract is in place. Recent work by Tirole (1986), Holmstrom and Milgrom (1990), and Varian (1990) has introduced the possibility of side-contracting into the analysis. These authors conclude that side-contracting often may reduce contractors' welfare in important types of economic relationships. Specifically, side-contracting disrupts the operation of otherwise optimal incentive schemes.

This paper argues, however, that examination of the side-contracting problem in light of contract and other bodies of law suggests that the case for concern about side-contracting has been overstated. On the one hand, if side-contracting is thought to be sustained by entry into legally enforceable contracts, then the side-contracting problem either is solved by existing legal rules or is solvable by the parties under the rules of contract law. On the other hand, if side-contracting is thought to be sustained by reputation effects, then existing legal rules may well deter side-contracting and, moreover, in a reputational environment side-contracting very often will not arise in the first place.

The first possibility is that side-contracting is sustained by entry into legally enforceable contracts. Here, the side-contracting problem often will be solved by agency, antitrust, tort, or some other body of law. In particular, legal rules often will bar side-contractors from enforcing their agreement in a court. For example, if a side contract between co-employees harms the employer, as in the work by Tirole, Holmstrom and Milgrom, and Varian noted above, and the employees are agents, in the legal sense, of the employer, then the side contract violates the employees' fiduciary duties to their employer. In this case, a court called upon to enforce the side contract presumably would refuse to do so. Likewise, a side contract that violated antitrust law would not be enforced by a court. In such a situation, each prospective side-contractor knows that she will never be able to collect from other side-contractors in situations in which other side-contractors owe the first side-contractor duties under the side contract. Therefore, entry into a legally enforceable side contract is precluded. As explained below, this is enough to solve the side-contracting problem.

Even in the absence of legal rules barring enforcement of a side contract, the parties to an original contract may always preclude such enforcement by incorporating certain contractual terms into this original contract. As explained below, parties to a contract always have available to them terms that have the effect of preventing legal enforcement of side contracts. Such contractual terms, like legal rules barring enforcement of side contracts, solve the side-contracting problem.

The second possibility is that side-contracting is sustained by reputation effects: side-contractors perform their obligations, not because of legal compulsion, but to maintain their reputations for trustworthiness (see generally Charny 1990). Side-contracting of this sort, with possibly non-monetary exchanges -- involving respect, performance of personal favors, or simple affection -- has been the subject of informal discussion in previous work on side-contracting (see Tirole 1986, 186; Holmstrom and Milgrom 1990, 101-103). However, agency, antitrust, tort, and other legal prohibitions on certain types of side contracts not only prevent enforcement of such side contracts in courts, as discussed above, but also tend to deter entry into such side contracts more generally. The reason is that if a side contract is illegal, then the side-contractors may face stiff legal penalties if their contract happens to be detected.

Moreover, wholly apart from legal rules, side-contracting sustained by reputation effects is importantly limited in the following sense: in many situations, if reputation effects would suffice to sustain side-contracting, then such reputation effects will deter parties from entering into side contracts in the first place. That is, a reputation-based story works only in contexts in which side-contractors are, on the one hand, sufficiently concerned with maintaining their reputations in each other's eyes and, on the other hand, not particularly concerned about negative reputational consequences in relationships with non-side-contracting parties.

As this Introduction has indicated, the specific goal of this paper is to show that, due to the existence of legal rules and contractual terms that prevent subsequent entry into legally enforceable side contracts, and to the legal deterrents to reputation-based side-contracting and the limitations on situations in which a reputation-based story can be told, the case for concern about side-contracting appears to have been overstated. More generally, though, the paper is part of a larger inquiry into the degree to which contract and other bodies of law enable contractors to commit not to have their incentives determined by contracts other than their original contract. The importance of such commitment to contractors' ability to realize gains from relationships has been widely recognized in economics (see Tirole 1986; Dewatripont 1988; Hart and Moore 1988; Hart and Tirole 1988; Dewatripont 1989; Fudenberg and Tirole 1990; Holmstrom and Milgrom 1990; Laffont and Tirole 1990; Varian 1990; Laffont and Tirole 1993). However, the role of legal rules in enabling such commitment has not received attention. This paper focuses on the role of legal rules in enabling commitment not to engage in side-contracting. Elsewhere I examine the role of legal rules in enabling commitment not to take advantage of welfare-reducing but ex post profitable modification opportunities (see Jolls 1993), and in the future I hope to study the role of legal rules in enabling commitment not to engage in contracting with outside parties (see Section V.C, below, for further discussion).

This paper's formal economic analysis focuses on a partnership model, in which side-contracting occurs between one or more of the partners and an "accountant" with whom the partnership deals. Entry into legally enforceable side contracts seems more plausible in this setting than in settings in which side-contracting occurs between co-employees, as in the organizations studied by Tirole (1986), Holmstrom and Milgrom (1990), and Varian (1990). However, the paper's conclusions about solutions to the side-contracting problem, both when side-contracting is sustained by entry into legally enforceable contracts and when side-contracting is sustained by reputation effects, carry over to the organizations studied in previous work, as discussed at the end of Section III and in Section IV.

The remainder of the paper is organized as follows. Section II shows how side-contracting may disrupt the operation of otherwise optimal incentive schemes in the partnership setting.

The conclusion mirrors that of previous work on side-contracting (see Tirole 1986; Holmstrom and Milgrom 1990; Varian 1990). Section III focuses on the situation in which side-contracting is sustained by entry into legally enforceable contracts and shows that the side-contracting problem either is solved by existing legal rules or is solvable by the parties under the rules of contract law. Section IV considers the sustainability of side-contracting by reputation effects and explains that existing legal rules may well deter side-contracting and that, moreover, there are important limitations on the situations in which a reputation-based story can be told. Finally, Section V contains discussion and concluding remarks.

## II. The Side-Contracting Problem

This section shows how side-contracting may disrupt the operation of otherwise optimal incentive schemes in a model of a partnership. Sub-section A describes the model; sub-section B identifies optimal contracts under the assumption of no side-contracting; and sub-section C describes the effect of introducing side-contracting.

### A. *Model.*

The partnership model is in the spirit of Holmstrom's (1982) team production model; the principal difference is that side-contracting between the parties to the original contract is allowed for. The parties in the model are a group of N risk-neutral partners ($N \geq 2$), who jointly own a productive technology, and a risk-neutral accountant, whose role will become clear below. These parties agree to an original contract at date 0. The inputs to the technology are the partners' effort levels $e_1, \ldots, e_N$, which are chosen at date 1 and are unobservable and nonverifiable. Finally, at date 2, the partnership's performance, which is observable and verifiable, is realized. Side-contracting opportunities arise between dates 0 and 1. (As explained in footnote 4, there is no need to worry about side-contracting after date 1.)

For $i = 1, \ldots, N$, let $g_i(e_i)$ denote partner i's disutility of effort level choice $e_i$ in monetary terms; $\forall i$, $g_i$ is assumed to be differentiable and to satisfy $dg_i/de_i > 0$, $d^2g_i/de_i^2 > 0$, $g_i(0) = 0$, and

$\lim_{\{e_i \to 0\}} \partial g_i/\partial e_i = 0$. Each party has utility equal to his net monetary payment and has reservation utility 0. Throughout let $e_{-i} \equiv (e_1, \ldots, e_{i-1}, e_{i+1}, \ldots, e_N)$, and let x denote the partnership's performance (measured by the monetary value of the partnership's output).

A date 0 contract specifies an incentive scheme $[m_1(x), \ldots, m_N(x)]$, where $m_i(x)$ is the monetary payment to partner i when the partnership's performance is x. (The incentive scheme can only be contingent on x as the partnership's performance is the only verifiable information in the model.) Given an incentive scheme $[m_1(x), \ldots, m_N(x)]$, budget balance requires that $m_A(x) = x - \Sigma_i m_i(x)\ \forall x$, where $m_A(x)$ is the monetary payment to the accountant when performance is x and where, here and throughout Section III, "$\Sigma_i$" means "$\Sigma_{i = 1, \ldots, N}$".[1] It is assumed that any incentive scheme $[m_1(x), \ldots, m_N(x)]$ is enforceable by courts in the sense that, for given x and for each of the parties, the courts can tell whether the party has received the payment due to the party under the incentive scheme and, if the party has not received this payment, can mandate that it be made.

Two versions of the model will be studied below. In the first version, the partnership's performance is a deterministic function $\underline{x}(e_1, \ldots, e_N)$ with range $[0, +\infty)$, where:

A1: $\underline{x}(e_1, \ldots, e_N)$ is differentiable and satisfies $\partial\underline{x}/\partial e_i > 0\ \forall i$, $\partial^2\underline{x}/\partial e_i^2 < 0\ \forall i$, $\underline{x}(0) = 0$, and $\lim_{\{e_i \to 0\}} \partial\underline{x}/\partial e_i = +\infty\ \forall i$.

In this case the first-best involves date 1 actions $(e_1^*, \ldots, e_N^*)$, where

$$(1) \qquad (e_1^*, \ldots, e_N^*) \in \underset{\{e_i \in [0, +\infty)\}_{i = 1, \ldots, N}}{\operatorname{argmax}} \{\underline{x}(e_1, \ldots, e_N) - \Sigma_i g_i(e_i)\}.$$

By the assumptions on $\underline{x}$ and $\{g_i\}_{i = 1, \ldots, N}$, for each i and $e_{-i}$ the value of $e_i$ that solves the Kuhn-Tucker condition

$$\partial\underline{x}(e_i, e_{-i})/\partial e_i - dg_i(e_i)/de_i \leq 0, = 0 \text{ for } e_i > 0$$

[1] If budget balance is not satisfied, then an incentive scheme lacks credibility in the sense that ex post, once a particular outcome in which, say, heavy punishment is called for has occurred, it is in all parties' interest not to waste the available value (as will occur if all parties are penalized heavily) (see Holmstrom 1982, 327).

is unique and strictly positive. It follows that any solution $(e_1^*, \ldots, e_N^*)$ to the maximization in (1) is interior, i.e., has $e_i^* > 0\ \forall i$.

In the second version of the model, performance is a stochastic function $x(e_1, \ldots, e_N; \omega)$ with range $[0, +\infty)$, where $\omega$ is the "state of nature," a random variable with continuous density f, and where:

A1′: $x(e_1, \ldots, e_N; \omega)$ is differentiable in $e_i\ \forall i$ and satisfies $\partial x/\partial e_i > 0\ \forall i$, $\partial^2 x/\partial e_i^2 < 0\ \forall i$, $x(0, \ldots, 0; \omega) = 0\ \forall \omega$, and $\lim_{\{e_i \to 0\}} \partial x/\partial e_i = +\infty\ \forall i$.

The social problem in the stochastic version of the model is

$$(2) \qquad \max_{\{e_i \in [0, +\infty)\}_{i=1,\ldots,N}} \{\textstyle\int_\omega x(e_1, \ldots, e_N; \omega)f(\omega)d\omega - \Sigma_i g_i(e_i)\}.$$

The first-best involves date 1 actions $(e_1^{**}, \ldots, e_N^{**})$ solving (2). By the assumptions on $x$ and $\{g_i\}_{i=1,\ldots,N}$, for each i and $e_{-i}$ the value of $e_i$ that solves the Kuhn-Tucker condition

$$\int_\omega[\partial x(e_i, e_{-i}; \omega))/\partial e_i]f(\omega)d\omega - dg_i(e_i)/de_i \leq 0, = 0 \text{ for } e_i > 0$$

is unique and strictly positive. Therefore, any solution $(e_1^{**}, \ldots, e_N^{**})$ to (2) is interior, i.e., has $e_i^{**} > 0\ \forall i$.

B. *No side-contracting.*

The traditional approach to analyzing contracting relationships is to "assume[] that agents act noncooperatively, that is, without side-contracting" (Holmstrom and Milgrom 1990, 90).[2] Thus, all that the parties do is choose their date 1 actions. Hence, in the partnership model, a profile of the post-date 0 game between the parties can be written $(e_1, \ldots, e_N, \varnothing)$, where $\varnothing$ denotes the null action of the accountant. Payoff functions in this game are $m_i(x) - g_i(e_i)$ for partner i, $i = 1, \ldots, N$, and $m_A(x)$ for the accountant. For given incentive scheme

[2] Unless otherwise indicated, the terms "principal" and "agent" are used as they are commonly used in economics, and not to connote the existence of an agency relationship in the legal sense.

$[m_1(x), \ldots, m_N(x)]$, let $G(m_1, \ldots, m_N)$ denote the associated post-date 0 game. The equilibrium requirement is that date 1 play be a Nash equilibrium of $G(m_1, \ldots, m_N)$.

Consider first the deterministic version of the model. Under the no-side-contracting assumption, it is always possible to find an incentive scheme under which the first-best is attained in Nash equilibrium:

Theorem (Holmstrom 1982). For any function $\underline{x}$ satisfying A1 and any $(e_1^*, \ldots, e_N^*)$ satisfying (1) given $\underline{x}$, there exists an incentive scheme $[m_1(x), \ldots, m_N(x)]$ such that the reservation utility constraints are satisfied when $(e_1^*, \ldots, e_N^*, \varnothing)$ is played and such that $(e_1^*, \ldots, e_N^*, \varnothing)$ is a Nash equilibrium of $G(m_1, \ldots, m_N)$.

Holmstrom's proof involves constructing an incentive scheme that imposes a group penalty if output is less that it would be under $(e_1^*, \ldots, e_N^*, \varnothing)$. More specifically, let $x^* \equiv \underline{x}(e_1^*, \ldots, e_N^*)$ and $e^* \equiv (e_1^*, \ldots, e_N^*, \varnothing)$, and consider the following incentive scheme:

(3) $m_i(x) = \{b_i \text{ if } x \geq x^*; 0 \text{ otherwise}\}, i = 1, \ldots, N,$

where $(b_1, \ldots, b_N)$ is chosen so that

(4) $\Sigma_i b_i = x^*$; and

(5) $b_i > g_i(e_i^*), i = 1, \ldots, N.$

It is possible to choose $(b_1, \ldots, b_N)$ satisfying both (4) and (5) as $x^* - \Sigma_i g_i(e_i^*) > 0$ by the interiority of $(e_1^*, \ldots, e_N^*)$. Now, when $e^*$ is played, partner i's expected utility is $b_i - g_i(e_i^*)$, which is positive by (5), and the accountant's expected utility is $x^* - \Sigma_i b_i$, which is equal to 0 by (4). Therefore, the reservation utility constraints are satisfied. Meanwhile, it is straightforward to verify that with the incentive scheme in (3) - (5), $e^*$ is a Nash equilibrium of $G(m_1, \ldots, m_N)$.

The reason for including the accountant in the original contract should now be clear. Without the accountant, the partners cannot punish themselves when performance falls short of $x^*$, as budget balance requires that, for every x, the payments specified by the incentive scheme sum to x.

It will be convenient to refer to an incentive scheme of the form in (3) - (5) as a group penalty scheme and to a date 0 contract specifying such a scheme as a group penalty contract. (Note that both of these definitions are for the $\underline{x}$ and $(e_1^*, \ldots, e_N^*)$ we have fixed.)

The first-best result also holds in the stochastic version of the model, at least as long as the partners have sufficient wealth. In particular:

Result 1. For any function $x$ satisfying A1′ and any $(e_1^{**}, \ldots, e_N^{**})$ solving (2) given $x$, if each partner has wealth of at least $\int_\omega x(e_1^{**}, \ldots, e_N^{**}; \omega)f(\omega)d\omega$, then there exists an incentive scheme $[m_1(x), \ldots, m_N(x)]$ such that the reservation utility constraints are satisfied when $(e_1^{**}, \ldots, e_N^{**}, \varnothing)$ is played and such that $(e_1^{**}, \ldots, e_N^{**}, \varnothing)$ is a Nash equilibrium of $G(m_1, \ldots, m_N)$.

To see that result 1 holds, let $x^{**} \equiv \int_\omega x(e_1^{**}, \ldots, e_N^{**}; \omega)f(\omega)d\omega$ and $e^{**} \equiv (e_1^{**}, \ldots, e_N^{**}, \varnothing)$, and consider the following payment scheme, involving "selling the partnership" to each partner:

(6) $$m_i(x) = \{x - p_i\}, \quad i = 1, \ldots, N;$$

where $(p_1, \ldots, p_N)$ is chosen so that

(7) $$\Sigma_i p_i = (N-1)x^{**}; \text{ and}$$

(8) $$x^{**} - p_i > g_i(e_i^{**}), i = 1, \ldots, N.$$

It is possible to choose $(p_1, \ldots, p_N)$ satisfying both (7) and (8) as the inequality $Nx^{**} - \Sigma_i p_i > \Sigma_i g_i(e_i^{**})$ is sufficient for (8) to hold for some $(p_1, \ldots, p_N)$, and

$$Nx^{**} - \Sigma_i p_i - \Sigma_i g_i(e_i^{**}) = x^{**} - \Sigma_i g_i(e_i^{**}) > 0,$$

where the equality is by (7) and the inequality follows from the interiority of $(e_1^{**}, \ldots, e_N^{**})$. As well, the assumption on partners' wealth ensures that, $\forall i$, partner i can pay $p_i$ up front. Now, when $e^{**}$ is played, partner i's expected utility is $x^{**} - p_i - g_i(e_i^*)$, which is positive by (8), and the accountant's expected utility is $\Sigma_i p_i - (N-1)x^{**}$, which is equal to 0 by (7). To verify that, under the specified incentive scheme, $e^{**}$ is a Nash equilibrium of $G(m_1, \ldots, m_N)$, observe that for each partner i, given that the other parties are following $e^{**}$, partner i's problem is

$$\max_{e_i \in [0, +\infty)} \left\{\int_{\omega} x(e_i, e_{-i}^{**}; \omega) f(\omega) d\omega - g_i(e_i)\right\},$$

which has solution $e_i^{**}$ by the definition of $(e_1^{**}, \ldots, e_N^{**})$ as a solution to (2).

Throughout, an incentive scheme of the form in (6) - (8) is called a "sell the partnership" scheme, and a date 0 contract specifying such a scheme is called a "sell the partnership" contract. (Again, these definitions are for the $x$ and $(e_1^{**}, \ldots, e_N^{**})$ we have fixed.) Note again the role of the accountant.

With no side-contracting, then, first-best effort level choices comprise a Nash equilibrium of the post-date 0 game under contracts that, in the case of the deterministic version of the model, impose group penalties when output falls short of its first-best level and, in the case of the stochastic version of the model, make each partner a residual claimant.[3]

C. *Side-contracting.*

As noted in the Introduction, Tirole (1986), Holmstrom and Milgrom (1990), and Varian (1990) have generalized the traditional approach to contract design by introducing the possibility of side-contracting. In the partnership model, side-contracting opportunities arise between dates 0 and 1.[4]

[3] As is standard in contract theory, it is assumed that the parties will reach agreement on an optimal date 0 contract (see generally Hart and Holmstrom 1987, 74).

[4] Side-contracting between dates 1 and 2 cannot be profitable because once the partners have chosen their date 1 effort levels, date 2 output (or its expected value) and all parties' payoffs (or expected payoffs) are fixed. (To be sure, between dates 1 and 2 the parties do not yet know any of these figures. However, this does not create opportunities for profitable side contracts because all parties are risk-neutral by assumption.) Because the payoffs (or expected payoffs) of the members of any group of non-side-contracting parties are fixed after date 1, the total surplus available to any group of side-contracting parties is fixed after date 1.

Previous analyses of side-contracting have, likewise, focused on side-contracting between dates 0 and 1.

Side contracts generally have been taken to be unobservable to non-side-contracting parties, and the analysis below maintains this assumption. (The case of observable side contracts, which seems to be of little practical interest, is discussed in remark 2(g), below, and in footnote 19.)

With side-contracting in the picture, the post-date 0 game is a dynamic game of imperfect information: parties not only choose their actions at date 1, but also may enter into unobservable side contracts prior to date 1. The equilibrium requirement in this case has been taken to be that optimal no-side-contracting date 1 play maximize each player's payoff under the original contract *and* profitable side contracts involving the player, into which she is assumed to enter (see Tirole 1986, 192-193; see also Holmstrom and Milgrom 1990, 94). This equilibrium requirement is captured more formally by Bernheim, Peleg and Whinston's (1987) coalition-proof equilibrium concept. Loosely, a coalition-proof equilibrium is a Nash equilibrium satisfying the additional condition that no "sustainable" joint deviation by a subset of players can produce gains for each player in the subset, where a joint deviation by two players is sustainable if neither player can gain by deviating again, and a joint deviation by $k > 2$ players is sustainable if none of the k players can gain by deviating again and no sustainable joint deviation by a proper subset of the k players can produce gains for each player in the proper subset. Coalition-proof equilibrium thus rules out profiles under which profitable side contracts are not agreed to and, as well, requires that parties' date 1 action choices be best responses given the date 0 contract and any side contracts that have been entered into. Coalition-proof equilibrium is a weakening of Aumann's (1959) strong equilibrium, which requires that *no* joint deviation by a subset of players, whether or not sustainable against subsequent deviations, can produce gains for each player in the subset. Coalition-proof equilibrium, unlike strong equilibrium, does not permit joint deviations under which one or more deviators' date 1 effort level choices are *not* best responses given the date 0 contract and any side contracts that have been entered into. Thus, coalition-proofness captures the importance of *contracts* in influencing players' behavior (see also remark 2(b), below).[5]

Formally, coalition-proof equilibrium is defined recursively as follows (see Bernheim, Peleg, and Whinston 1987, 6):

(i) In a single-player game, a pure strategy profile is a coalition-proof equilibrium if the player's strategy maximizes her payoff.

(ii) Let $n > 1$ be the number of players in the game, and assume that coalition-proof equilibrium has been defined for games with fewer than n players. Then, in an n-player game, a pure strategy profile is a coalition-proof equilibrium if

  (a) for all proper subsets J of the set of players, the strategies of the players in J form a coalition-proof equilibrium in the game induced by holding fixed the strategies of players not in J;

  (b) the profile is not Pareto-dominated by any alternative profile satisfying (a).

To apply this definition, it is useful to expand the recursion. Appendix 1 gives the resulting definition for an n-player game. For any subset J of players, let s(J) be the k-tuple of strategies specified by s for players in J, and let s(\J) be the (n – k)-tuple of strategies specified by s for players not in J. As well, for any J, let $\underline{k}$ be the number of partners in J, order the partners so that partners $1, \ldots, \underline{k}$ are in J, and define $\underline{x}(e_1, \ldots, e_{\underline{k}}, e_{-\underline{k}}^*) \equiv \underline{x}(e_1, \ldots, e_{\underline{k}}, e_{\underline{k}+1}^*, \ldots, e_N^*)$ and $x(e_1, \ldots, e_{\underline{k}}, e_{-\underline{k}}^{**}; \omega) \equiv x(e_1, \ldots, e_{\underline{k}}, e_{\underline{k}+1}^{**}, \ldots, e_N^{**}; \omega)$.

Let $\underline{e}$ denote a vector of date 1 actions. A date 0 contract c *implements* $\underline{e}$ if there is a coalition-proof equilibrium of the post-date 0 game induced by c that satisfies the following conditions: (i) no party ever agrees to any side contracts and (ii) each party plays in accordance with $\underline{e}$ at date 1 as long as he has not entered into any side contracts prior to date 1.

With parties allowed to take advantage of side-contracting opportunities, group penalty and "sell the partnership" contracts fail to implement the first-best. In particular:

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[5] Note that use of Bernheim, Peleg, and Whinston's (1987) perfectly coalition-proof equilibrium would not change anything: with unobservable side contracts the only proper subgame of the post-date 0 game is the post-date 0 game itself. Note also that coalition-proofness can be applied to models with side-contracting without specifying a particular extensive form for the side-contracting process.

Proposition 1a. In the deterministic version of the partnership model with side-contracting, there does not exist a group penalty contract that implements $e^*$.

Proposition 1b. In the stochastic version of the partnership model with side-contracting, there does not exist a "sell the partnership" contract that implements $e^{**}$.

Proof. See Appendix 2.

Remark 1. (a) The intuition for the result in proposition 1a is that, under a group penalty contract, any partner i and the accountant can gain by agreeing to a side contract under which the accountant agrees to make a transfer to partner i when output is some $x < x^*$, so that under the original contract the accountant's payoff is x (rather than 0). Likewise, the intuition for the result in proposition 1b is that, under a "sell the partnership" contract, both partner i and the accountant can gain by agreeing to a side contract under which the accountant agrees to fully insure partner i with regard to the partnership's performance, thereby inducing partner i to exert no effort and, in turn, increasing the accountant's expected payoff (which is *decreasing* in expected date 2 output). Importantly, in both cases the failure of implementability is due to the existence of profitable side-contracting opportunities, and not merely to possible gains from joint deviations at date 1.

In both versions of the model, the side contract can be written so that neither side-contractor can gain by a second deviation, as required for coalition-proofness.

(b) As the proof of proposition 2a, below, indicates, the result in proposition 1a holds only if at least one opportunity for partner-accountant side-contracting exists: if only partners are able to side-contract, then any group penalty contract implements the first-best. However, the same is *not* true of the result in proposition 1b: in the stochastic version of the model, even if side-contracting is possible only among partners, "sell the partnership" contracts may fail to implement the first-best (due to the existence of profitable side-contracting opportunities). To see this, assume that side-contracting is possible only between partners, fix a "sell the partnership" contract, and let $\underline{s}^{**}$ be any profile of the induced post-date 0 game under which no party ever agrees to any side contracts and each party plays in accordance with $e^{**}$ at date 1 as long as she has not entered into any side contracts prior to date 1. $\underline{s}^{**}$ may not be coalition-proof because the total surplus available to the partners in J will be greater under an alternative k-tuple of strategies for them than under $\underline{s}^{**}(J)$, given $\underline{s}^{**}(\backslash J)$. The total surplus available to the partners in J under a k-tuple of strategies for players in J involving $(e_1, \ldots, e_{\underline{k}})$, given $\underline{s}^{**}(\backslash J)$, is

(9) $$\Sigma_{i=1,\ldots,\underline{k}} \{\int_\omega x(e_1, \ldots, e_{\underline{k}}, e_{-\underline{k}}^{**}; \omega)f(\omega)d\omega - g_i(e_i)\}.$$

(Because the accountant takes no action at date 1 and cannot side-contract (by assumption), the total surplus available to partners in J is just the sum of the payments to them under the date 0 contract.) Now, to see that $(e_1^{**}, \ldots, e_{\underline{k}}^{**})$ does not maximize (9) over $\{e_i \in [0, +\infty)\}_{i=1,\ldots,\underline{k}}$, note that $(e_1^{**}, \ldots, e_{\underline{k}}^{**})$ is defined by

$$\{\int_\omega[\partial x(e_i, e_{-i}^{**}; \omega)/\partial e_i]f(\omega)d\omega - dg_i(e_i)/de_i\} \mid_{e_i = e_i^{**}} = 0, \qquad i = 1, \ldots, \underline{k}.$$

Meanwhile, a maximand $(e_1', \ldots, e_{\underline{k}}')$ of (9) over $\{e_i \in [0, +\infty)\}_{i=1,\ldots,\underline{k}}$ must satisfy the necessary first-order conditions

$$\{\underline{k}\int_\omega[\partial x(e_1', \ldots, e_{i-1}', e_i, e_{i+1}', \ldots, e_{\underline{k}}', e_{-\underline{k}}^{**}; \omega)/\partial e_i]f(\omega)d\omega - dg_i(e_i)/de_i\} \mid_{e_i = e_i'} = 0,$$

$$i = 1, \ldots, \underline{k}.$$

(c) Note that the only profiles considered in the proof of proposition 1a are profiles under which no player ever agrees to any side contracts and each player plays in accordance with $e^*$ at date 1 as long as she has not entered into any side contracts prior to date 1. In particular, the proof does not consider all profiles under which (i)′ no side contracts are entered into on the path and (ii)′ $e^*$ is played at date 1 on the path. This is a consequence of conditions (i) and (ii) in the definition of implementability. With regard to profiles satisfying (i)′and (ii)′ but not (i) and (ii), it is straightforward to establish that partner i and the accountant can both gain from a joint deviation, but is not possible to show that neither can gain by deviating again. (For example, partner j's strategy may involve agreeing to a side contract that partner i suddenly finds attractive given his play under the joint deviation with the accountant.) Note that no profile satisfying the weaker conditions (i)′ and (ii)′ is a *strong* equilibrium. See remark 2(b), below, for a discussion of the problem with the strong equilibrium concept in side-contracting models.

The same comments apply to the stochastic version of the model.

This section's conclusion, that side-contracting disrupts the operation of otherwise optimal incentive schemes in the partnership model, indicates that the analysis of Tirole (1986), Holmstrom and Milgrom (1990), and Varian (1990) generalizes to organizational settings other than those studied by these authors. However, as explained in the next two sections, examination of the side-contracting problem in light of contract and other bodies of law indicates that the case for concern about side-contracting appears to have been overstated.

## III. Contractually-Sustained Side-Contracting: Legal Solutions

This section identifies legal solutions to the side-contracting problem in situations in which side-contracting is sustained by entry into legally enforceable contracts. Previous work on side-contracting has assumed that unobservable side-contracting is not amenable to control by means of legal rules or contractual terms. For example, Holmstrom and Milgrom (1990, 85) say of (unobservable) side contracts, "[T]he [non-side-contracting party] cannot control [the side contracts] directly, because he cannot observe them." Similarly, Tirole (1986, 192) takes the view that unobservable side-contracting gives rise to unconstrained side-contracting opportunities.

However, with side-contracting sustained by entry into legally enforceable contracts, unobservability of side contracts to non-side-contracting parties does *not* imply that side-contracting cannot be controlled by means of legal rules or contractual terms. Intuitively, the need to be able to enforce a side contract in court has the practical effect of making the side contract observable.

The first possibility, and the possibility with the greatest practical significance, is that legal rules bar enforcement of the side contract. In the partnership model, each partner is an agent, in the legal sense, of the others. Accordingly, the partners are under duties not to act to benefit themselves at other partners' expense (in legal terms, the partners owe fiduciary duties to one another).[6] Since side-contracting benefits side-contracting partners at non-side-contracting partners' expense, engaging in such behavior would violate the former partners' fiduciary duties. Thus, a court very likely would refuse to enforce a side contract in the partnership setting.[7]

Even if legal rules do not bar enforcement of a side contract, contract law provides an extremely simple means by which parties to an original contract can prevent subsequent entry into legally enforceable side contracts without the consent of all of the original parties. In particular, the original parties can include in their contract covenants by each party not to sue any of the other parties on obligations created by future side contracts. A covenant not to sue is a promise by a party not to bring suit against any of one or more parties to enforce specified obligations to the first party (see, for example, *Restatement (Second) of the Law of Contracts* §285(1)). If the promisor on a covenant not to sue takes a beneficiary of this covenant to court for breach of an obligation covered by the covenant, then the court will rule for the beneficiary (see *Restatement (Second) of the Law of Contracts* §285(2) and comment a to §285; Corbin 1951, 5A: 600; Williston 1936, 2: 710; Williston 1937, 15: 468).[8] Thus, with the above-described covenants not to sue included in the parties' original contract, this contract precludes subsequent entry into legally enforceable side contracts: each party will know that if he goes to court to try to enforce a side contract with another party, the second party will direct the court to

[6] "[I]n all proceedings connected with the conduct of the partnership every partner is bound to act in the highest good faith to his copartner . . . ." Page v. Page, 359 P.2d 41, 44 (Cal. 1961).

[7] Another possibility that has been suggested to me is that a court might refuse to enforce a side contract on the ground that entry into the side contract constituted tortious interference with the original contract, rendering the side contract void as against public policy.

[8] In legal terms, courts grant specific performance of covenants not to sue. The rationale for granting specific performance is as follows (see *Restatement (Second) of the Law of Contracts* §285(2) and comment a to §285; Corbin 1951, 5A: 600; Williston 1936, 2: 710-11; Williston 1937, 15: 468). If, instead of providing that the beneficiary prevails in the suit brought by the promisor, the law provided that the promisor could proceed with the suit against the beneficiary for breach of the side contract, then the beneficiary would simply turn around and sue the promisor for breach of the covenant not to sue. The beneficiary's damages in the latter suit would be precisely the amount recovered by the promisor in the former suit. Thus, providing that the beneficiary prevails in the initial suit is the simpler way to achieve the ultimate result.

the first party's covenant not to sue the second party, contained in the parties' original contract, and the second party will not have to perform.[9]

Covenants not to sue, like other contractual provisions, can be modified by mutual agreement of the parties to the original contract. (This modifiability cannot be eliminated by including further contractual terms, specifying that the covenants not to sue cannot be modified (see Jolls 1993, 10-13).) However, modifiability of the covenants not to sue turns out not to diminish their efficacy. The reason is that at least one party to the original contract will always be hurt by side contracts that profit the side-contractors and, thus, at least one party to the original contract will refuse to consent to modification of the original contract's covenants not to sue.[10]

If the proposed contractual mechanism, involving covenants not to sue in the original contract, solves the side-contracting problem, then legal rules that bar enforcement of side

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[9] A practical example of use of contractual provisions to deter other contracts is provided by insurance contracts. Such contracts sometimes provide that they are void if the insured ever holds other insurance during the contract term. (The problem with concurrent insurance policies is that they diminish the insured's incentives to take care.) For an example, see the contract at issue in Northern Assurance Co. of London v. Grand View Bldg. Assoc., 183 U.S. 308 (1902).

[10] The key here is that a covenant by one party not to sue another on side contract obligations *cannot* be modified with just the consent of these two parties. The covenant is part of the contract between all of the parties, hence is a promise to all of the parties. As well, parties other than the explicit beneficiary of the covenant not to sue have an economic interest in this covenant (because they have an economic interest in preventing side-contracting).

A recent decision of the U.S. Court of Appeals for the D.C. Circuit, U.S. v. Bell Atlantic Corp., 969 F.2d 1231 (D.C.Cir. 1992), a case involving the consent decree entered into by AT&T upon its break-up, is instructive. The regional Bell Operating Companies ("BOC's") sought review of Judge Green's denial of a modification of the consent decree supported by the BOC's and the Justice Department but opposed by AT&T. (As both Judge Silberman's majority opinion for the Court of Appeals and Judge Williams' dissent indicate, modification of a consent decree is governed by the rules of contract law.) The major issue on appeal was whether AT&T's opposition affected the BOC's' ability to get the modification they desired. The desired modification involved the consent decree's line-of-business restrictions on the activities in which the BOC's are permitted to engage. The court agreed with Judge Green that because the terms of the consent decree made AT&T a party to the entire decree and AT&T had an economic interest in maintaining the line-of-business restrictions, AT&T's opposition to the proposed modification prevented the modification from being "uncontested." (Judge Williams dissented, finding the language of the consent decree ambiguous and contemporaneous statements of the decree's objectives supportive of the conclusion that AT&T was not a party to the line-of-business provisions.)

In the partnership model, all parties clearly have economic interests in covenants by one party not to sue another. (The same is true in the non-partnership settings discussed at the end of Section III.) Thus, as long as the language of the covenants not to sue in the original contract clearly specifies that each party is a party to each covenant, modification of any covenant not to sue will require the consent of all parties.

contracts also solve the side-contracting problem: the only difference between the two proposed solutions is that the former involves an additional condition, that the covenants not to sue be immune to modification. Thus, it is sufficient to show that inclusion of the above-described covenants not to sue in the original contract solves the side-contracting problem.

Let C be the set of date 0 contracts that include covenants by each party not to sue any other party on any performance-contingent side contract obligations. (The covenants not to sue could cover all side contract obligations, but limiting their coverage to performance-contingent obligations is less restrictive. See remark 2(f) for an even less restrictive alternative.)[11] As well, let $C_{GP}$ be the set of contracts in C specifying group penalty schemes, and let $C_{SP}$ be the set of contracts in C specifying "sell the partnership" schemes. It follows from the discussion above that, under any date 0 contract in $C_{GP}$ or $C_{SP}$, entry into legally enforceable side contracts requires the consent of all parties to the date 0 contract. Finally, let A2 denote the assumption that, for every subset J of players, $(e_1^{**}, \ldots, e_{\underline{k}}^{**})$ is the unique solution to:

$$(10) \qquad e_i \in \underset{e_i' \in [0,+\infty)}{\operatorname{argmax}} \left\{ \int_{\varepsilon} x(e_1, \ldots, e_{i-1}, e_i', e_{i+1}, \ldots, e_{\underline{k}}, e_{-\underline{k}}^{**}; \omega) f(\omega) d\omega - g_i(e_i') \right\}, i = 1, \ldots, \underline{k}.$$

(A $\underline{k}$-tuple $(e_1, \ldots, e_{\underline{k}})$ satisfies (10) if and only if none of the $\underline{k}$ partners can gain by deviating from $(e_1, \ldots, e_{\underline{k}})$ given the play for players not in J specified by $e^{**}(\backslash J)$.) A2 is discussed in remarks 2(a) and 2(d).

<u>Proposition 2a</u>. In the deterministic version of the partnership model with side-contracting, suppose that N (the number of partners) is equal to 2. Any $c \in C_{GP}$ implements $e^*$.

<u>Proposition 2b</u>. In the stochastic version of the partnership model with side-contracting, suppose that A2 is satisfied. Any $c \in C_{SP}$ implements $e^{**}$.

<u>Proof</u>. See Appendix 2.

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[11] By assumption, the partnership's performance is the only information in the model on which parties can contract. (I assume that each set of parties has at most one side-contracting opportunity, so that a side contract may not have terms contingent on the existence or terms of future side contracts between the same parties.) In a world with additional verifiable information, the covenants not to sue in the original contract would need to cover side contract obligations contingent on information correlated with the partnership's performance as well as performance-contingent side contract obligations.

Remark 2. (a) The basic intuition for the results in Propositions 2a and 2b is that only legally enforceable side contracts -- which are barred by date 0 contracts in the set C -- disrupt the operation of otherwise optimal incentive schemes. Side contracts that can be performed immediately and, thus, need not be legally enforceable cannot be *contingent* and, therefore, will not alter anyone's incentives. Thus, preventing entry into legally enforceable side contracts is all that is needed to solve the side-contracting problem.

Thus, for example, the result in proposition 2a follows from the fact that side contracts contingent on the partnership's performance are no longer possible, due to the covenants not to sue contained in $c \in C_{GP}$. To be sure, for any i, partner i and the accountant can both gain by deviating to strategies under which the accountant makes an uncontingent transfer to partner i before date 1 and partner i chooses effort level $e_i < e_i^*$ rather than effort level $e_i^*$ at date 1. However, this deviation is not sustainable because partner i can gain by deviating again -- specifically, by choosing effort level $e_i^*$ rather than effort level $e_i < e_i^*$ at date 1. (Partner i has already pocketed the uncontingent transfer by date 1 and, thus, choosing effort level $e_i^*$, which produces a payment of $b_i - g_i(e_i^*)$ under the original contract, is preferable to choosing effort level $e_i < e_i^*$, which produces a payment of $-g_i(e_i)$ under this contract.)

Likewise, the key to the result in proposition 2b is that, while, for example, partners $1, \ldots, \underline{k}$ and the accountant can all gain by deviating to strategies under which the accountant makes uncontingent transfers to partners $1, \ldots, \underline{k}$ before date 1 and each partner $i \in \{1, \ldots, \underline{k}\}$ chooses effort level 0 rather than effort level $e_i^{**}$ at date 1, this deviation is not sustainable because partners $1, \ldots, \underline{k}$ can gain by a second deviation, to playing in accordance with $e^{**}$ at date 1, and A2 ensures that this second deviation is sustainable. With regard to the imposition of A2, if A2 does not hold, then coalition-proofness may fail *even in the absence of profitable side-contracting opportunities*. In particular, if for some subsets J of players there are multiple solutions to (10), then it may be possible for a subset of players to produce gains for each player in the subset by means of a sustainable deviation not involving any side-contracting. (For example, we cannot rule out $(e_1{'}, e_2{'}) \neq (e_1^{**}, e_2^{**})$ satisfying (10) such that partners 1 and 2 both prefer $(e_1{'}, e_2{'})$ to $(e_1^{**}, e_2^{**})$.) In this case, a "sell the partnership" contract need not implement the first-best even in the no-side-contracting case. See paragraph (d) for further discussion of A2.

(b) The discussion in paragraph (a) points up the sense in which Aumann's strong equilibrium is too restrictive: it rules out the equilibria exhibited in the proofs of propositions 2a and 2b due to the presence of gains from joint deviations, even though, as just explained, these joint deviations themselves are not robust to further deviations.[12] In effect, strong equilibrium makes the presence or absence of enforceable side contracts irrelevant by allowing players to commit to strategies from which the players prefer to deviate.

(c) Note that proposition 2a assumes that there are only two partners. With more than two partners, joint deviations can involve more than one partner, and ruling out a profitable joint deviation involving more than one partner requires exhibiting a *sustainable* subsequent joint deviation by the partners that benefits all the deviating partners. (That is, while an argument analogous to that in the proof of proposition 2a shows that the partners involved in the original joint deviation can all gain by a second joint deviation involving these partners, this is not enough; the second joint deviation must be shown to be sustainable against further deviations.) Note that if the analogue to A2 holds in the deterministic version of the model, then the result in proposition 2a holds for any N (because the assumption ensures that a joint deviation by players 1, . . . , $\underline{k}$ to playing in accordance with e* at date 1 is sustainable (see paragraph (a) above)).

(d) A sufficient condition for A2 to hold is that the cross-partial derivatives of $x$ are all 0, that is, $\partial^2 x/\partial e_i \partial e_{i'} = 0 \ \forall i, i' \neq i$. To see this, observe that when the condition on the cross-partial derivatives holds, for each partner i the solution to

$$\max_{e_i' \in [0, +\infty)} \left\{ \int_\omega x(e_i', e_{-i}; \omega) f(\omega) d\omega - g_i(e_i') \right\}$$

[12] Bernheim, Peleg, and Whinston (1987, 3) have described this "inconsistency in the [s]trong [equilibrium] concept" as follows: "[W]hile the whole set of players must originally be concerned with arriving at an agreement that is immune to deviations by any coalition, no deviating group of players . . . faces a similar restriction."

is the same for all $e_{-i}$. Meanwhile, this solution is unique for each partner i by our assumptions on $x$ and $\{g_i\}_{i=1,\ldots,N}$. Thus, for every subset J of players, there is a unique solution to (10). By the definition of $(e_1^{**}, \ldots, e_k^{**})$ for given J, for every subset J of players this solution to (10) must be $(e_1^{**}, \ldots, e_k^{**})$.

(e) The only part of the proof of proposition 2a that relies on the presence of covenants not to sue in contracts contained in $C_{GP}$ is the part concerning joint deviations by a partner and the accountant. This verifies the statement in remark 1(b) that, in the deterministic version of the model, partner-only side-contracting does not interfere with implementability of $e^*$ by group penalty schemes.

(f) The result in proposition 2a does not actually require that the date 0 contract contain covenants not to sue covering all performance-contingent side contract obligations. In particular, it is sufficient that side contract obligations of the accountant to a partner when $x < x^*$ and side contract obligations of a partner to the accountant when $x = x^*$ are covered by covenants not to sue. The only part of the proof of proposition 2a that is affected by the change in the covenants not to sue is the part concerning joint deviations by a partner and the accountant under which performance falls short of $x^*$. Letting all variables be defined as in the proof, partner i's payoff from conforming to the original joint deviation is now $t_i^*[\underline{x}(e_i, e_{-i}^*)] + T_i^* - g_i(e_i)$, whereas her payoff from deviating by playing $e_i^*$ rather than $e_i < e_i^*$ at date 1 is $t_i^*(x^*) + T_i^* + b_i - g_i(e_i^*)$. Now, the modified covenants not to sue imply $t_i^*[\underline{x}(e_i, e_{-i}^*)] \leq 0$ and $t_i^*(x^*) \geq 0$. Since $-g_i(e_i) < b_i - g_i(e_i^*)$, partner i gains by deviating, just as in the original proof.

(g) The results in propositions 2a and 2b continue to hold if side contracts are observable, rather than unobservable, to non-side-contracting parties. See footnote 19 for a discussion of situations in which observability may provide the parties with additional benefits.[13]

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[13] Note also that with observable side contracts, date 1 play begins a proper subgame of the post-date 0 game, so that a perfection refinement of coalition-proofness may be appropriate. (Bernheim, Peleg, and Whinston (1987, 10) incorporate such a refinement in their "perfectly coalition-proof equilibrium.") With such a refinement, partners' effort level choices must be best responses at date 1 whatever the pre-date 1 history. Playing in accordance with the optimal no-side-contracting date 1 action vector no matter what,

In short, then, in the partnership setting the side-contracting problem is susceptible to legal solutions when side-contracting is sustained by entry into legally enforceable contracts.

***Legal solutions to the side-contracting problem in non-partnership settings.***

As noted above, previous work on side-contracting indicates that the side-contracting problem arises in a variety of settings other than the partnership setting on which this paper's formal analysis focuses. As discussed below, the legal solutions identified above apply as well to other settings, including those studied by Tirole (1986), Holmstrom and Milgrom (1990), and Varian (1990).

*Example 1: principal-supervisor-agent organization.* In Tirole's (1986) model, the parties are a risk-neutral principal who owns a productive technology, a risk-averse supervisor who oversees the operation of the principal's business, and a risk-averse agent whose effort level is the input to the principal's technology and whose "efficiency" in working with the technology affects the firm's performance. At date 0, these parties agree to a contract specifying an incentive scheme for the supervisor and the agent. After date 0, but before date 1, the agent and, possibly, the supervisor observe the agent's "efficiency" in working with the principal's technology.[14] At date 1, the agent chooses the level of effort she will exert in working with the principal's technology. This effort level is unobservable and nonverifiable. Finally, at date 2, the supervisor chooses what information about the agent's efficiency to convey to the principal, and the firm's performance, which depends on the agent's efficiency and effort level, is realized. Both the supervisor's report and the firm's performance are observable and verifiable.

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as called for by the profiles in the proofs of propositions 2a and 2b, may not satisfy this best-response requirement (though it will if, for example, in the stochastic version of the model A2 is satisfied by virtue of $x$ satisfying $\partial^2 x/\partial e_i \partial e_{i'} = 0 \; \forall i, i' \neq i$ (see remark 2(d)). It should be straightforward, however, to construct profiles satisfying the best-response requirement to prove perfectly coalition-proofness (as opposed to mere coalition-proofness) for the case of observable side contracts. Again, though, this case seems of little realistic interest.

[14] The interpretation here is that the agent's efficiency is related specifically to the principal's technology and, therefore, is not discovered until the agent starts working with this technology.

Under the optimal no-side-contracting scheme in this model,[15] the supervisor reports the agent's efficiency truthfully and receives the same payoff whatever he reports, and the agent, if she has "high" rather than "low" efficiency, receives a higher payoff when the supervisor reports that he observed nothing than when the supervisor reports that the agent's efficiency is "high" (see Tirole 1986, 190-191). Thus, when the agent's efficiency is "high" and the supervisor observes this, the supervisor and agent can both profit by entering into a side contract under which the agent "bribes" the supervisor to report that he did not observe the agent's efficiency (Tirole 1986, 192). With the supervisor-agent side contract in place, the optimal no-side-contracting date 1 play (involving truthful reporting by the supervisor) no longer satisfies the best-response requirement. Thus, as in the partnership setting, side-contracting disrupts the operation of an otherwise optimal incentive scheme.

Also as in the partnership setting, however, the side-contracting problem is susceptible to legal solutions in situations in which side-contracting is sustained by entry into legally enforceable contracts. As explained above, agency law precludes enforcement of side contracts that benefit some parties at the expense of other parties to whom the former parties owe fiduciary duties. Here, the side-contractors are employees of the principal and thus, may well be agents of the principal in the legal sense, especially if they have the authority to act for the principal (see generally Jet Courier Service, Inc. v. Muler, 771 P.2d 486 (Colo. 1989) and cases cited therein). If an agency relationship in the legal sense exists, then a court presumably would refuse to enforce the supervisor-agent side contract described above. This is enough to solve the side-contracting problem because, as explained above, only legally enforceable (contingent) side contracts alter incentives.

Even if agency law does not bar enforcement of the supervisor-agent side contract, the discussion above of covenants not to sue establishes that the parties here can use contractual terms to prevent subsequent entry into legally enforceable side contracts without the consent of

[15] Both here and in the multi-agent organization model discussed below, optimality is to be understood not in a first-best sense, but rather in a constrained or second-best sense (where the constraints arise from the informational limitations in the models) (see generally Hart and Holmstrom 1987, 74).

all of the original parties. Because the supervisor-agent side contract makes the principal worse off (see Tirole 1986, 194), the principal will refuse to consent to any modification of covenants not to sue that enables entry into this side contract. Again, then, the side-contracting problem has a legal solution.

*Example 2: multi-agent organization.* Holmstrom and Milgrom's (1990) and Varian's (1990) multi-agent organization models involve a risk-neutral principal who owns a productive technology and two or more risk-averse agents who are hired by the principal to conduct her business and whose effort levels are inputs to the productive technology.[16] At date 0, these parties agree to a contract specifying an incentive scheme for the agents. At date 1, each agent chooses the level of effort he will exert. Effort level choices are unobservable and nonverifiable. Finally, at date 2, the firm's performance, which is observable and verifiable and depends on the agents' effort levels, is realized.

Not surprisingly, the optimal no-side-contracting scheme typically makes agents' compensation dependent on the firm's performance (see, e.g., Holmstrom and Milgrom 1990, 91). As long as there is some performance outcome in which, under the optimal no-side-contracting scheme, the agents' marginal utilities of income differ, mutually profitable reinsurance opportunities exist (see Varian 1990, 158). A reinsurance side contract naturally will alter the payoffs to various effort level choices. Hence, the optimal date 1 play that comprised a Nash equilibrium in the no-side-contracting case typically will no longer have this property once side-contracting is introduced.[17]

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[16] The multi-agent organization model attempts to describe more accurately than the simple principal-agent model (see Holmstrom (1979); Shavell (1979); Grossman and Hart (1983)) the relationship between the stockholders and the managers of a publicly-traded corporation: on the one hand, "the . . . stockholders . . . of [such a] corporation may be treated as [a single principal] even when stockholders disagree about the firm's objectives, since institutional procedures guarantee . . . collective decision[s]" (Bernheim and Whinston 1986, 924); on the other hand, it is appropriate to treat the managers of the corporation as individual agents. Still, the multi-agent organization model departs from what we observe in the real world by assuming that the principal and the agents write a common contract rather than a set of bilateral contracts (or no contracts at all).

[17] The discussion here is based on the assumption that side contracts cannot be contingent on any information other than that on which the original contract can be contingent. If side contracts can be

Once again, however, legal solutions to the side-contracting problem exist. As in the previous example, the side-contractors here are employees of a non-side-contracting party, and, thus, enforcement of side contracts might well be barred by agency law. As well, the contractual solution described above works here: by a revealed preference argument, the agents' entry into a reinsurance side contract makes the principal worse off (at least weakly) (see Holmstrom and Milgrom 1990, 94-95; Varian 1990, 158), and, thus, the principal has no reason to consent to any modification of covenants not to sue that enables the agents to enter into such a side contract.

Both the partnership model and the models in which side-contracting has been examined in previous work involve relationships within organizations. However, side-contracting issues arise in a wide variety of other contexts. A prominent example is the auction context.

*Example 3: auction.* The standard auction model (see generally Fudenberg and Tirole 1991, 10-11) shares the common structure of the models discussed above. At date 0, the parties -- bidders, of whom there are two or more, and an auctioneer -- agree to an original contract that specifies an auction mechanism. At date 1, bidders submit their bids. Then, at date 2, bids are revealed (and are verifiable), and the winner is announced. For simplicity, I assume that at least one bidder values the auctioned good more highly than the auctioneer (otherwise, the auction should not be held at all).

Optimality here requires simply that the auctioned good go to the party with the highest valuation for it in a Nash equilibrium of the date 1 game. An optimal mechanism is the second-price auction mechanism, under which the highest bidder gets the good and pays the second-highest bid (and under which the good is allocated randomly between the high bidders in the case of a tie): under this mechanism, the date 1 profile under which each bidder bids her valuation is a Nash equilibrium (see Fudenberg and Tirole 1990, 11), and it is clear that in this equilibrium the good goes to the party with the highest valuation for it.

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contingent on additional information, then they may be beneficial rather than harmful: see the discussion in Section V.A.

However, under the second price auction mechanism, the bidders can all gain by entering into a side contract under which each bidder agrees to bid the same extremely low amount. (Bids can be contracted upon because they are verifiable at date 2.) With the "low bid" side contract in place, the auctioned good is obtained by the bidders collectively at a lower price than otherwise, and the side contract can specify which bidder gets the good and can provide for appropriate transfers between the bidders. Clearly, the optimal no-side-contracting date 1 play (involving bids equal to valuations) no longer comprises a Nash equilibrium of the date 1 game.

As in the models of organizational settings, however, the side-contracting problem admits of legal solutions. The "low bid" side contract here is a per se illegal (under antitrust law) price-fixing contract. Too, the contractual solution is available, for bidders' entry into a "low bid" side contract obviously hurts the auctioneer, who, therefore, will refuse to consent to any modification of covenants not to sue that enables entry into such a side contract.

In sum, then, in both the partnership setting and in other settings, the side-contracting problem is susceptible to legal solutions when side-contracting is sustained by entry into legally enforceable contracts.

## IV. Reputation-Based Side-Contracting: Legal Solutions and Nonlegal Limitations

As discussed in the Introduction, side-contracting may be sustained not only by entry into legally enforceable contracts but also by informal cooperation between side-contractors interested in maintaining their reputations. While all of the formal analysis in previous work on side-contracting assumes that side-contracting is sustained by entry into legally enforceable contracts, reputation effects have received informal attention (see, e.g., Tirole 1986, 185-187; Holmstrom and Milgrom 1990, 88, 96, 101-103), and use of legally enforceable contracts in the formal analysis may have been intended as a proxy for reputation effects (see, e.g., Holmstrom and Milgrom 1990, 88).

However, there are important legal and nonlegal limitations on the reputation-based story. First, as described in Section III, in many settings side-contracting will violate agency, antitrust, tort, or some other body of law. For example, in the partnership, principal-supervisor-agent organization, and multi-agent organization settings, side-contracting may well violate fiduciary duties. Likewise, in the auction setting, side-contracting often will violate antitrust law. Thus, parties may be deterred from side-contracting by the threat of stiff penalties if the reputation-based side-contracting happens to be discovered, even though the parties are not dependent on courts for enforcement of side contracts.

Furthermore, and wholly apart from the illegality of certain side contracts, as a first approximation one would not expect side-contracting to arise at all in a reputational environment, for engaging in side-contracting hurts side-contractors' reputations with non-side-contracting parties. As an example, consider the deterministic version of the partnership model with two partners. Here, if side-contracting occurs, then its occurrence, and the culprits, are detectable as soon as the partnership's performance is realized. Thus, a reputation-based story would require that the side-contracting partner and the accountant are concerned about maintaining reputations with one another but not with maintaining reputations with the remaining partner.

More generally, it seems difficult to tell a reputation-based story in the partnership model, for it requires asymmetry between side-contractors' reputational concerns vis-a-vis side-contracting partners and their reputational concerns vis-a-vis non-side-contracting partners. (Even in the stochastic version of the model, non-side-contracting partners will begin to suspect side-contracting after a few periods have elapsed, and might well decide to leave the partnership to avoid being exploited.) Indeed, if anything reputation effects should prevent, rather than enable, side-contracting in the partnership model, for the accountant, as an outside party, is likely to be concerned with maintaining a reputation in the eyes of the outside world.

In a context such as that of the principal-supervisor-agent organization, however, it seems easier to tell a story in which side-contractors care a lot about their reputations with one another but are not particularly concerned about negative reputational consequences elsewhere. Tirole's paper identifies as the impetus for studying side-contracting in such an organization evidence from the sociology literature that employees at low and middle levels in organizations often behave cooperatively, so that, for example, it is typically difficult to get information from intermediate levels of a hierarchy. If, as in Tirole's model, the supervisor and the agent observe information that the principal does not, then reputation effects will be stronger in the supervisor-agent relationship than in relationships with the principal. (With more information available, deviations can be more easily detected and, thus, more readily deterred.) Here, a reputation-based story seems more plausible.[18]

In sum, then, reputation-based side-contracting may well be deterred by the threat of legal sanctions and, moreover, very often will not arise in the first place in reputational settings.

## V. Discussion and Concluding Remarks

### A. *Beneficial side-contracting.*

This paper has focused on situations in which side-contracting harms rather than helps the original parties as a group. However, if side contracts can be contingent on information in addition to that on which the original contract can be contingent, then side-contracting may be beneficial. In particular, in the multi-agent organization model discussed above, if the agents can write side contracts contingent on information other than the firm's performance (on which the original contract is contingent), then the agents can provide insurance that the principal is unable to provide and, thus, as a unit, can tolerate more risk than they otherwise could (see Holmstrom and Milgrom 1990, 97; Varian 1990, 158). Of course, this helps the principal, as it mitigates the standard insurance-incentives tradeoff.

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[18] Even here, however, as a formal matter reputation effects require either an infinite horizon or incomplete information about parties' "types" (see generally Fudenberg and Tirole 1991, ch. 9; Hart and Holmstrom 1987, 143-46). For a summary of the criticisms of the infinite horizon approach, see Hart and Holmstrom 1987, 143. The incomplete information approach also seems problematic here. In particular, as Fudenberg and Maskin (1986) have shown, if more than one party is a long-run player, then reputation equilibria are extremely sensitive to the exact specification of the incomplete information. The applications in which side-contracting has been explored are applications involving members of a firm, and here the assumption of multiple long-run players seems much more reasonable than the assumption of a single long-run player.

However, side-contracting contingent on information in addition to that on which the parties' original contract can be contingent requires that reputation effects sustain side-contracting, which in turn raises the issues discussed in Section IV. Furthermore, such side-contracting may well have costs as well as benefits. In the multi-agent organization model, the fact that agents behave as a unit when such side-contracting is possible prevents the use of relative performance evaluation (see Holmstrom and Milgrom 1990, 96-99). As well, side-contracting among agents makes it harder for the principal to control individual behavior (see Holmstrom and Milgrom 1990, 99-100). Thus, even side-contracting that is beneficial in some respects is likely to be costly in others, and, thus, the no-side-contracting situation may still be preferable.[19]

*B. Possible objections to contractual anti-side-contracting terms.*

Hart and Moore (1988, 774 n. 20) have noted two possible objections to using contractual terms to prevent subsequent entry into legally enforceable side contracts. The first is that it may cripple parties' ability to engage in (unmodeled) legitimate transactions. However, the covenants not to sue needed to prevent subsequent side-contracting can be expected to be limited in scope. For example, in the partnership model, the covenants not to sue need not apply to obligations other than those contingent on the partnership's performance and, moreover, in some cases need only apply to a subset of performance-contingent obligations (see

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[19] This paper, like previous work on side-contracting, has focused on the case in which side contracts are unobservable to non-side-contracting parties. However, if some side-contracting is beneficial, then observability of side contracts may allow the parties to do better than with unobservable side contracts. As noted by Holmstrom and Milgrom (1990, 90, 100-103), if non-side-contractors observe transfers made pursuant to side contracts (and can communicate this information to the courts, an assumption not stated explicitly by Holmstrom and Milgrom), then the original contract between the parties can provide for taxes on such transfers, payable by side-contractors to non-side-contractors. Taxing side contract transfers is a more precise instrument for contractual control of side-contracting than the simple prohibitions discussed in the text. Thus, if side contracts may be beneficial, then observability (and verifiability) of side contract transfers may allow the parties to do better than with unobservable side-contracting. However, in at least some cases, the optimal tax rate with observable side contract transfers is 1 (see Holmstrom and Milgrom 1990, 102), which amounts to a simple prohibition on side-contracting. Here, nothing turns on the observability of side-contracting.

remark 2(f)). It is *not* necessary to prohibit all transactions among subsets of parties to the original contract.

Moreover, contractual anti-side-contracting terms can be expected to be necessary only when reputation effects do not suffice to prevent side-contracting. Thus, such terms can be expected to be necessary only when the value associated with creating a reputation (with non-side-contracting parties) is not sufficiently high. This is more likely to be true when there is not an extensive the network of legitimate transactions among the parties.

The second possible objection noted by Hart and Moore is that contractual anti-side-contracting terms may be easily circumvented by structuring side contracts as elaborate networks of agreements among subsidiaries and intermediaries. However, covenants not to sue commonly are drafted to cover not only suits by the promisor against the beneficiary but also suits by any heir, assignee, or entity related to the promisor and suits against any heir, assignee, or entity related to the beneficiary (see, e.g., Williston 1979, 1: 78; PPG Industries v. Russell, 887 F.2d 820, 821 n. 1 (7th Cir. 1989)). Thus, as long as all of the subsidiaries and intermediaries are aware of both the contents of the original contract and the ultimate object of the network of agreements, covenants not to sue should continue to prevent subsequent entry into legally enforceable side contracts. In particular, the subsidiary or intermediary that wished to avoid contractual obligations would point the court to the covenants not to sue in the original contract and reveal to the court that the contested obligations were connected to a side-contracting scheme.

### C. *Future research: contracts with outsiders.*

This paper has focused on side-contracting among parties to an original contract. However, contracts between one or more of the parties to an original contract and an outside party carry a similar potential for interference with otherwise optimal incentive schemes. For example, in the multi-agent organization setting discussed above, an alternative to a reinsurance side contract between agents is a reinsurance contract between one or more agents and an outside party. The latter sort of reinsurance contract is profitable as well in the standard principal-agent model studied by Holmstrom (1979), Shavell (1979), and Grossman and Hart (1983). Likewise, reinsurance contracts with outside parties are likely to be profitable in the insurance context: an insured party often may wish to contract with a second insurer once his original insurance policy is in place.[20]

Such reinsurance contracts may well violate agency, tort, or some other body of law, so that a court would deny enforcement and, as well, entry into the contract might be deterred by the threat of legal sanctions. It is less clear whether entry into legally enforceable reinsurance contracts of the sorts just described could be precluded by means of contractual terms in the original contract. In the case of side-contracting among parties to an original contract, all side-contractors are aware of any contractual terms in the original contract, and, thus, such terms are sure to be enforced. In the case of contracts with outsiders, in contrast, enforcement of contractual terms cannot be ensured: the party who would gain by invoking the terms might be unaware of them. In practice, insurance contracts sometimes provide that they are void if the insured ever holds other insurance during the contract term (see footnote 9). The puzzle, however, is how such terms are enforced. In particular, enforcement requires that the agreement that the original contract seeks to prevent be discoverable by those who are not party to the agreement (for example, the first insurer), and it is not clear that this condition will always obtain.

## D. *Concluding remarks.*

Side-contracting often may disrupt the operation of otherwise optimal incentive schemes and has received attention from a number of authors. However, as this paper has shown, the case for concern about side-contracting appears to have been overstated. On the one hand, if side-contracting is thought to be sustained by entry into legally enforceable contracts, then the side-contracting problem either is solved by existing legal rules or is solvable by the parties

[20] Alternatives to reinsurance with a (private) insurer include reliance on government relief programs (see generally Kaplow 1991) and assistance from "nonmarket insurers" (family and friends) (see generally Arnott and Stiglitz 1991).

under the rules of contract law. On the other hand, if side-contracting is thought to be sustained by reputation effects, then existing legal rules may well deter side-contracting and, moreover, in a reputational environment side-contracting very often will not arise in the first place.

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## Appendix 1

This appendix gives a working definition of coalition-proofness, which results from expanding the recursion in the definition in the text. The appendix also states a useful fact about coalition-proofness.

<u>working definition of coalition-proofness</u>.

In an n-player game, a pure strategy profile s is a coalition-proof equilibrium if:

(1) each player's strategy maximizes the player's payoff given the strategies of the other (n – 1) players in the set of players;

(2) for each 2-player subset of the set of players, the corresponding pair of strategies satisfies the following conditions, given the strategies of the other (n – 2) players in the set of players:

(2.1) each strategy in the pair maximizes the corresponding player's payoff given the strategy of the other player in the 2-player subset;

(2.2) the pair of strategies is not Pareto-dominated by any alternative pair of strategies satisfying (2.1);

(3) for each 3-player subset of the set of players, the corresponding triple of strategies satisfies the following conditions, given the strategy of the other (n – 3) players in the set of players:

(3.1) each strategy in the triple maximizes the corresponding player's payoff given the strategies of the other 2 players in the 3-player subset;

(3.2) for each 2-player subset of the 3-player subset of the set of players, the corresponding pair of strategies satisfies the following conditions, given the strategy of the third player in the 3-player subset:

(3.2.1) each strategy in the pair maximizes the corresponding player's payoff given the strategy of the other player in the 2-player subset;

(3.2.2) the pair of strategies is not Pareto-dominated by any alternative pair of strategies satisfying (3.2.1);

(3.3) the triple of strategies is not Pareto-dominated by any alternative triple of strategies satisfying (3.1) - (3.2);

. . .

(k) for each k-player subset of the set of players, the corresponding k-tuple of strategies satisfies the following conditions, given the strategies of the other (n – k) players in the set of players:

(k.1) each strategy in the k-tuple maximizes the corresponding player's payoff given the strategies of the other (k – 1) players in the k-player subset;

(k.2) for each 2-player subset of the k-player subset of the set of players, the corresponding pair of strategies satisfies the following conditions, given the strategy of the other (k – 2) players in the k-player subset:

(k.2.1) each strategy in the pair maximizes the corresponding payoff given the strategy of the other player in the 2-player subset;

(k.2.2) the pair of strategies is not Pareto-dominated by any alternative pair of strategies satisfying (k.2.1);

. . .

(k.(k-1)) for each (k – 1)-player subset of the k-player subset of the set of players, the corresponding (k – 1)-tuple of strategies satisfies the following conditions, given the strategy of the kth player in the k-player subset:

(k.(k-1).1) each strategy in the (k – 1)-tuple maximizes the corresponding player's payoff given the strategies of the other (k – 2) players in the (k – 1)-player subset;

(k.(k-1).2) for each 2-player subset of the (k – 1)-player subset of the k-player subset of the set of players, the corresponding pair of strategies satisfies the following conditions, given the strategy of the other (k – 3) players in the (k – 1)-player subset:

(k.(k-1).2.1) each strategy in the pair maximizes the corresponding payoff given the strategy of the other player in the 2-player subset;

(k.(k-1).2.2) the pair of strategies is not Pareto-dominated by any alternative pair of strategies satisfying (k.(k-1).2.1);

. . .

(k.(k-1).(k-1)) the (k – 1)-tuple of strategies is not Pareto-dominated by any alternative (k – 1)-tuple of strategies satisfying (k.(k-1).1) - (k.(k-1).(k-2));

(k.k) the k-tuple of strategies is not Pareto-dominated by any alternative k-tuple of strategies satisfying (k.1) - (k.(k-1));

. . .

(n) s is not Pareto-dominated in the class of profiles satisfying (1) - (n-1).

useful fact about coalition-proofness.

Fix an n-player game and a candidate strategy profile s. For any subset J of players, let s(J) be the k-tuple of strategies specified by s for players in J, and let s(\J) be the (n – k)-tuple of strategies specified by s for players not in J. A sufficient condition for s to be coalition-proof is that for every subset J of players and every possible k-tuple s′(J) of strategies for players in J, either some player in J does not do better under s′(J) than under s(J), given s(\J), or s′(J) does not satisfy conditions (k.1) - (k.(k-1)) of the definition of coalition-proofness in Appendix 1.

remark. This fact follows from the coalition-proofness of strong equilibria (see Bernheim, Peleg, and Whinston 1987, 7) and the recursive structure of the coalition-proofness definition.

## Appendix 2

Proof of proposition 1a. Suppose to the contrary. Then there is a group penalty contract such that the induced post-date 0 game has a coalition-proof equilibrium, call it $s^*$, under which no player ever agrees to any side contracts and each player plays in accordance with $e^*$ at date 1 as long as she has not entered into any side contracts prior to date 1. We will show that $s^*$ cannot satisfy condition (2) of the definition of coalition-proofness in Appendix 1.

First note that (4) and (5), together with the fact that, $\forall i$, $g_i$ is everywhere nonnegative, imply $x^* > b_i \ \forall i$. So $x' \equiv (x^* + b_i)/2 < x^* \ \forall i$. Now imagine an alternative pair of strategies for some partner i and the accountant specifying that the two parties agree to a side contract, call it $SC^*$, under which the accountant must pay partner i $b_i$ when $x = x'$, and specifying that partner i plays $e_i'$ defined by $\underline{x}(e_i', e_{-i}^*) = x'$ at date 1 if $SC^*$ is agreed to and plays $e_i^*$ at date 1 otherwise. Also imagine that the pair of strategies calls for neither party to agree to any side contract other than $SC^*$. Let $s_a^*$ denote the profile specifying this alternative pair of strategies for partner i and the accountant and specifying the same strategies as $s^*$ for the other parties.

Both partner i and the accountant do better under $s_a^*$ than under $s^*$. Their respective payoffs are $b_i - g_i(e_i^*)$ and 0 under $s^*$ and $b_i - g_i(e_i')$ and $x' - b_i$ under $s_a^*$. $x' < x^*$ implies $e_i' < e_i^*$. So $b_i - g_i(e_i') > b_i - g_i(e_i^*)$. As well, $x' - b_i = (x^* - b_i)/2 > 0$.

It remains to show that neither partner i nor the accountant can gain by deviating from $s_a^*$.

partner i. Both deviations to strategies that involve agreeing not only to $SC^*$ but also to other side contracts, and deviations to strategies that involve agreeing to $SC^*$ but playing an action other than $e_i^*$ at date 1 when $SC^*$ is not agreed to, have no effect given the play of other parties under $s_a^*$. Meanwhile, if partner i deviates to any strategy that involves disagreeing rather than agreeing to $SC^*$, then, given the play of other parties under $s_a^*$, no side contract is entered into at all, and partner i's maximum payoff is $b_i - g_i(e_i^*)$, which is less than his payoff under $s_a^*$. Finally, partner i cannot gain by deviating to a strategy that involves agreeing to $SC^*$ but playing an action other than $e_i'$ at date 1 when $SC^*$ is agreed to. If partner i plays $e_i \geq e_i^*$, then his payoff, given other parties' play under $s_a^*$, is $b_i - g_i(e_i)$, and for $e_i \geq e_i^*$, $b_i - g_i(e_i) < b_i - g_i(e_i^*) < b_i - g_i(e_i')$. Meanwhile, if partner i plays $e_i \neq e_i'$ satisfying $e_i < e_i^*$, then his payoff, given other parties' play under $s_a^*$, is $-g_i(e_i) < 0$.

accountant. Deviating to a strategy that involves agreeing not only to $SC^*$ but also to other side contracts has no effect given the play of the partners under $s_a^*$. Meanwhile, if the accountant deviates to a strategy that involves disagreeing rather than agreeing to $SC^*$, then no side contract is entered into at all, and $e^*$ is played at date 1. The accountant's payoff is thus 0, which is less than $x' - b_i$.

Proof of proposition 1b. The proof proceeds exactly as did the proof of proposition 1a. In particular, let $s^{**}$ be the supposed coalition-proof equilibrium (of the post-date 0 game induced by a "sell the partnership" contract) under which no player ever agrees to any side contracts and each player plays in accordance with $e^{**}$ at date 1 as long as she has not entered into any side contracts prior to date 1. Then imagine an alternative pair of strategies for partner i and the accountant specifying that the two parties agree to a side contract, call it $SC^{**}$, under which the accountant must pay partner i $x^{**} - x$ when date 2 output is x and specifying that partner i plays $e_i = 0$ at date 1 if the side contract just described is agreed to and plays $e_i^{**}$ at date 1 otherwise. Also imagine that the pair of strategies calls for neither party to agree to any side contract other than $SC^{**}$. Let $s_a^{**}$ denote the profile specifying this alternative pair of strategies for partner i and the accountant and specifying the same strategies as $s^{**}$ for the remaining players.

Both partner i and the accountant do better under $s_a^{**}$ than under $s^{**}$. Their respective expected payoffs are $x^{**} - p_i - g_i(e_i^{**})$ and 0 under $s^{**}$ and $x^{**} - p_i - g_i(0)$ and $(N-1)[x^{**} - \int_\omega x(0, e_{-i}^{**}; \omega)f(\omega)d\omega]$ under $s_a^{**}$ (under $s_a^{**}$ expected date 2 output is the second term in the bracketed expression). Now, since $e_i^{**} > 0$, $x^{**} - p_i - g_i(0) > x^{**} - p_i - g_i(e_i^{**})$ and $(N-1)[x^{**} - \int_\omega x(0, e_{-i}^{**}; \omega)f(\omega)d\omega] > 0$.

It remains to show that neither partner i nor the accountant can gain by deviating from $s_a^{**}$.

partner i. Both deviations to strategies that involve agreeing not only to $SC^{**}$ but also to other side contracts, and deviations to strategies that involve agreeing to $SC^{**}$ but playing an action other than $e_i^{**}$ when $SC^{**}$ is not agreed to, have no effect given the play of other parties under $s_a^{**}$. Meanwhile, if partner i deviates to any strategy that involves disagreeing rather than agreeing to $SC^{**}$, then, given the play of other parties under $s_a^{**}$, no side contract is entered into at all, and partner i's maximum expected payoff is $x^{**} - p_i - g_i(e_i^{**})$, which is less than his payoff under $s_a^{**}$. Finally, partner i cannot gain by deviating to a strategy that involves agreeing to $SC^{**}$ but playing an action other than $e_i = 0$ at date 1 when $SC^{**}$ is agreed to, as partner i's expected payoff when $SC^{**}$ is agreed to is $x^{**} - p_i - g_i(e_i)$, and this is maximized at $e_i = 0$.

accountant. Deviating to a strategy that involves agreeing not only to $SC^{**}$ but also to other side contracts has no effect given the play of the partners under $s_a^{**}$. Meanwhile, if the accountant deviates to a strategy that involves disagreeing rather than agreeing to $SC^{**}$, then no side contract is entered into, and $e^{**}$ is played at date 1. The accountant's expected payoff is then 0, which is less than his expected payoff under $s_a^{**}$.

Proof of proposition 2a. Fix $c_{GP} \in C_{GP}$, and let $s^{*\prime}$ denote the profile of the post-date 0 game induced by $c_{GP}$ under which each party agrees to no side contracts and no modifications of the date 0 contract and plays in accordance with $e^*$ at date 1 no matter what. We use Appendix 1's fact about coalition-proofness to show that $s^{*\prime}$ is coalition-proof.

1-player subsets. For any 1-player subset J, given $s^{*\prime}(\backslash J)$ there is no strategy s(J) for the player in J such that any side contract is entered into. Thus if s(J) involves playing in accordance with $e^*$ at date 1, then the player in J receives the same payoff as under $s^{*\prime}(J)$. Meanwhile, if s(J) involves deviating from $e^*$ at date 1, then the player in J receives no more than her payoff under $s^{*\prime}(J)$ (see the Holmstrom theorem).

subset containing between 2 and N players. Fix an arbitrary subset J of players.

*SUBSET J CONTAINS ONLY PARTNERS.* We will show that the total surplus captured by the players in J under an alternative k-tuple s(J) cannot be greater than the total surplus captured by them under $s^{*\prime}(J)$, given $s^{*\prime}(\backslash J)$. This is sufficient to establish that at least one player in J does no better under s(J) than under $s^{*\prime}(J)$, given $s^{*\prime}(\backslash J)$, as there are no gains to be had from risk sharing (by the risk neutrality of the parties).

It is convenient to divide the analysis into two sub-cases, based on the level of date 2 output under the alternative k-tuple s(J). Let $(e_1, \ldots, e_{\underline{k}})$ be the vector of date 1 actions of partners $1, \ldots, \underline{k}$ under s(J).

*case 1: date 2 output under* s(J) *equals or exceeds* $x^*$. The total surplus captured by the players in J, given $s^{*\prime}(\backslash J)$, is $\Sigma_{i=1,\ldots,\underline{k}}[b_i - g_i(e_i^*)]$ under $s^{*\prime}(J)$ and $\Sigma_{i=1,\ldots,\underline{k}}[b_i - g_i(e_i)]$ under s(J). The maximum total surplus under s(J), given $s^{*\prime}(\backslash J)$, is thus the value of the objective function in the following program evaluated at a solution to the program:

$$\text{(A.1)} \qquad \max_{\{e_i \in [0,+\infty)\}_{i=1,\ldots,\underline{k}}} \{\Sigma_{i=1,\ldots,\underline{k}}[b_i - g_i(e_i)]\} \qquad \text{s.t.} \quad \underline{x}(e_1, \ldots, e_{\underline{k}}, e_{-\underline{k}}^*) \geq x^*.$$

Now $(e_1^*, \ldots, e_{\underline{k}}^*)$ must be a solution to this problem. For suppose to the contrary. Then there is $(e_1', \ldots, e_{\underline{k}}')$ satisfying $e_i' \geq 0\ \forall i \in \{1, \ldots, \underline{k}\}$ and $\underline{x}(e_1', \ldots, e_{\underline{k}}', e_{-\underline{k}}^*) \geq x^*$ such that:

$$\text{(A.2)} \qquad \Sigma_{i=1,\ldots,\underline{k}} g_i(e_i') < \Sigma_{i=1,\ldots,\underline{k}} g_i(e_i^*).$$

But (A.2) together with $\underline{x}(e_1', \ldots, e_{\underline{k}}', e_{-\underline{k}}^*) \geq x^*$ implies

$$\text{(A.3)} \qquad \underline{x}(e_1', \ldots, e_{\underline{k}}', e_{-\underline{k}}^*) - \Sigma_{i=1,\ldots,\underline{k}} g_i(e_i') - \Sigma_{i=\underline{k}+1,\ldots,N} g_i(e_i^*) > x^* - \Sigma_{i=1,\ldots,\underline{k}} g_i(e_i^*) - \Sigma_{i=\underline{k}+1,\ldots,N} g_i(e_i^*).$$

(A.3) in turn implies that $(e_1^*, \ldots, e_N^*)$ does not maximize the objective function in (1), a contradiction.

Thus, the maximum total surplus captured by the players in J under s(J), given $s^{*\prime}(\backslash J)$, is $\Sigma_{i=1,\ldots,\underline{k}}[b_i - g_i(e_i^*)]$.

*case 2: date 2 output under* s(J) *is less than* $x^*$. The total surplus captured by the players in J under s(J), $-\Sigma_{i=1,\ldots,\underline{k}} g_i(e_i)$, is less than the total surplus captured by the players in J under $s^{*\prime}(J)$, given $s^{*\prime}(\backslash J)$.

*SUBSET J CONTAINS THE ACCOUNTANT.* It is convenient to divide the analysis as above.

*case 1: date 2 output under* s(J) *equals or exceeds* $x^*$. By the reasoning above, it suffices to show that the total surplus captured by the players in J under s(J) cannot be greater than the total surplus captured by them under $s^{*\prime}(J)$, given $s^{*\prime}(\backslash J)$. Let $(e_1, \ldots, e_{\underline{k}})$ be the vector of date 1 actions of partners $1, \ldots, \underline{k}$ under s(J).

The total surplus captured by the players in J, given $s^{*\prime}(\backslash J)$, is $\Sigma_{i=1,\ldots,\underline{k}} [b_i - g_i(e_i^*)]$ under $s^{*\prime}(J)$ and $\underline{x}(e_1, \ldots, e_{\underline{k}}, e_{-\underline{k}}^*) - x^* + \Sigma_{i=1,\ldots,\underline{k}} [b_i - g_i(e_i)]$ under s(J). The maximum total surplus under s(J), given $s^{*\prime}(\backslash J)$, is thus the value of the objective function in the following program evaluated at a solution to the program:

$$\text{(A.4)} \qquad \max_{\{e_i \in [0,+\infty)\}_{i=1,\ldots,\underline{k}}} \quad \{\underline{x}(e_1, \ldots, e_{\underline{k}}, e_{-\underline{k}}^*) - x^* + \Sigma_{i=1,\ldots,\underline{k}} [b_i - g_i(e_i)]\} \qquad \text{s.t. } \underline{x}(e_1, \ldots, e_{\underline{k}}, e_{-\underline{k}}^*) \geq x^*.$$

Now $(e_1^*, \ldots, e_{\underline{k}}^*)$ must be a solution to this problem. For suppose to the contrary. Then there is $(e_1'', \ldots, e_{\underline{k}}'')$ satisfying $e_i'' \geq 0 \ \forall i \in \{1, \ldots, \underline{k}\}$ and $\underline{x}(e_1'', \ldots, e_{\underline{k}}'', e_{-\underline{k}}^*) \geq x^*$ such that:

$$\underline{x}(e_1'', \ldots, e_{\underline{k}}'', e_{-\underline{k}}^*) - \Sigma_{i=1,\ldots,\underline{k}} g_i(e_i'') > \underline{x}(e_1^*, \ldots, e_{\underline{k}}^*, e_{-\underline{k}}^*) - \Sigma_{i=1,\ldots,\underline{k}} g_i(e_i^*).$$

Subtracting $\Sigma_{i=k+1,\ldots,N} g_i(e_i^*)$ from both sides of this inequality yields (A.3) with $e_i' = e_i''$ for $i = 1, \ldots, \underline{k}$. This in turn implies that $(e_1^*, \ldots, e_N^*)$ does not maximize the objective function in (1), a contradiction.

Thus, the maximum total surplus captured by the players in J under s(J), given $s^{*\prime}(\backslash J)$, is

$$\underline{x}(e_1^*, \ldots, e_{\underline{k}}^*, e_{-\underline{k}}^*) - x^* + \Sigma_{i=1,\ldots,\underline{k}} [b_i - g_i(e_i^*)] = \Sigma_{i=1,\ldots,\underline{k}} [b_i - g_i(e_i^*)].$$

*case 2: date 2 output under* s(J) *is less than* $x^*$. Here we require $k = 2$ (which corresponds to the case where $N = 2$). J thus contains the accountant and partner i ($i \in \{1, 2\}$). We show that s(J) cannot satisfy condition (2.1) of the definition of coalition-proofness in Appendix 1. Let $t_i^*(x)$ be the net transfer to partner i when date 2 output is x, and $T_i^*$ the net uncontingent transfer to partner i, given the side contract (if any) to which the accountant and partner i agree under s(J). Now, the covenants not to sue contained in $c_{GP}$ imply $t_i^*(x) = 0 \ \forall x$. Thus, partner i's payoff under s(J), given $s^{*\prime}(\backslash J)$, is $T_i^* - g_i(e_i)$. Now imagine an alternative strategy for partner i specifying that partner i agrees to the same side contract with the accountant as is agreed to under s(J) but plays in accordance with $e^*$ at date 1. Partner i's payoff under this alternative strategy, given $s^{*\prime}(\backslash J)$ and the play of the accountant under s(J), is $T_i^* + b_i - g_i(e_i^*)$. Since $-g_i(e_i) < b_i - g_i(e_i^*)$, partner i gains from this deviation.

<u>(N+1)-player subset</u>. Because the first-best is attained under $s^{*\prime}$, there is no alternative (N+1)-tuple of strategies for the parties such that they all do better than under $s^{*\prime}$.

<u>Proof of proposition 2b</u>. Fix $c_{SP} \in C_{SP}$, and let $s^{**\prime}$ denote the profile of the post-date 0 game induced by $c_{SP}$ under which each party agrees to no side contracts and no modifications of the date 0 contract and plays in accordance with $e^{**}$ at date 1 no matter what. As in the proof of proposition 2a, we use Appendix 1's fact about coalition-proofness.

<u>1-player subsets</u>. For any 1-player subset J, given $s^{**\prime}(\backslash J)$ there is no strategy s(J) for the player in J such that any side contract is entered into. Thus if s(J) involves playing in

accordance with $e^{**}$ at date 1, then the player in J receives the same expected payoff as under $s^{**\prime}(J)$. Meanwhile, if s(J) involves deviating from $e^{**}$ at date 1, then the player in J receives no more than her expected payoff under $s^{**\prime}(J)$ (see result 1).

subsets containing between 2 and N players. We first show that an alternative k-tuple s(J) under which $e^{**}$ is not played at date 1 cannot satisfy condition (k.1) of the definition of coalition-proofness in Appendix 1. For $i = 1, \ldots, \underline{k}$, let $t_i^{**}(x)$ be the net transfer to to partner i when date 2 output is x, and $T_i^{**}$ the net uncontingent transfer to partner i, given the side contracts (if any) agreed to under s(J). Now, the covenants not to sue contained in $c_{SP}$ imply $t_i^{**}(x) = 0\ \forall x$. Thus, for $i = 1, \ldots, \underline{k}$, partner i's payoff under s(J), given $s^{**\prime}(\backslash J)$, where $(e_1, \ldots, e_{\underline{k}})$ is the vector of date 1 actions of partners $1, \ldots, \underline{k}$ under s(J), is

$$T_i^{**} + \int_{\omega} x(e_1, \ldots, e_{\underline{k}}, e_{-\underline{k}}^{**}; \omega) f(\omega) d\omega - g_i(e_i).$$

It follows that, for s(J) to satisfy condition (k.1) of the coalition-proofness definition, $(e_1, \ldots, e_{\underline{k}})$ must satisfy

$$\text{(A.5)} \qquad e_i \in \underset{e_i' \in [0, +\infty)}{\operatorname{argmax}} \left\{T_i^{**} + \int_{\omega} x(e_1, \ldots, e_{i-1}, e_i', e_{i+1}, \ldots, e_{\underline{k}}, e_{-\underline{k}}^{**}; \omega) f(\omega) d\omega - g_i(e_i')\right\},$$

$$i = 1, \ldots, \underline{k}.$$

But by A2, $(e_1, \ldots, e_{\underline{k}}) \neq (e_1^{**}, \ldots, e_{\underline{k}}^{**})$ cannot satisfy (A.5).

Meanwhile, if $e^{**}$ *is* played at date 1 under s(J), then expected date 2 output, and therefore the expected total surplus captured by players in J, is the same under s(J) as under $s^{**\prime}(J)$, given $s^{**\prime}(\backslash J)$.

(N+1)-player subset. Because the first-best is attained under $s^{**\prime}$, there is no alternative (N+1)-tuple of strategies for the parties such that they all do better than under $s^{**\prime}$.